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Pest Risk Analysis for

Agrilus bilineatus (Coleoptera: Buprestidae), two-lined chestnut borer

E. Jendek – EPPO Global Database (EPPO Code: AGRLBL) - Adult of *Agrilus bilineatus*, Ottawa (USA)

September 2019

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The risk assessment follows EPPO standard PM 5/5(1) *Decision-Support Scheme for an Express Pest Risk Analysis* (available at http://archives.eppo.int/EPPOStandards/pra.htm), as recommended by the Panel on Phytosanitary Measures. Pest risk management (detailed in ANNEX 1) was conducted according to the EPPO Decision-support scheme for quarantine pests PM 5/3(5). The risk assessment uses the terminology defined in ISPM 5 *Glossary of Phytosanitary Terms* (available at https://www.ippc.int/index.php).

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Based on this PRA, *Agrilus bilineatus* was added to the EPPO A2 Lists of pests recommended for regulation as quarantine pests in 2019. Measures for *Castanea* and *Quercus* plants for planting, and wood are recommended.

Pest Risk Analysis for *Agrilus bilineatus* (Coleoptera: Buprestidae), two-lined chestnut borer

PRA area: EPPO region
Prepared by: Expert Working Group (EWG) on *Agrilus fleischeri* and *A. bilineatus*
Date: 3-7 December 2018. Further reviewed and amended by EPPO core members and Panel on Phytosanitary Measures (see below). Comments by the Panel on Quarantine Pest for Forestry have also been considered.

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All personal communications in this PRA were obtained in July-December 2018 from the following experts: Callahan M (Auburn University Museum of Natural History, USA), Chapman E G (Department of Entomology, University of Kentucky, USA), Fauske G (NDSIRC - North Dakota State University - Department of Entomology, USA), Haack R A (US Forest Service Northern Research Station), Hızal E (Istanbul University Cerrahpasa, Department of Forest Entomology and Protection, Turkey), Jendek E (Faculty of Forestry and Wood Sciences, Czech University of Life Science), Johnson P J (South Dakota State University, Insect Biodiversity Lab, USA), Kondratieff B C (C. P. Gillette Museum of Arthropod Diversity, Colorado State University, Department of Bioagricultural Sciences and Pest Management, USA), Paulsen M J (University of Nebraska State Museum, USA), Petrice T R (US Forest Service Northern Research Station) and Üstün N (Ministry of Agriculture and Forestry, Bornova Plant Protection Research Institute, Turkey).

The first draft of the PRA was prepared by the EPPO Secretariat.

For the determination of ratings of likelihoods and uncertainties, experts were asked to provide a rating and level of uncertainty individually during the meeting, based on the evidence provided in the PRA and on the discussions in the group. Each EWG member provided anonymously a rating and level of uncertainty, and proposals were then discussed together in order to reach a final decision.

Following the EWG, the PRA was further reviewed by the following core members: Avendaño Garcia N and Guitian Castrillon J M (with the help of Fernandez Gallego M M), MacLeod A, Üstün N and Van Der Gaag D J.

The Panel on Phytosanitary Measures considered the management options in 2019-03. EPPO Working Party on Phytosanitary Regulation and Council agreed that *Agrilus bilineatus* should be added to the A2 Lists of pests recommended for regulation as quarantine pests in 2019.

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Summary of the Pest Risk Analysis for *Agrilus bilineatus* (Coleoptera: Buprestidae)

PRA area: *EPPO region* (Albania, Algeria, Austria, Azerbaijan, Belarus, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Georgia, Germany, Greece, Guernsey, Hungary, Ireland, Israel, Italy, Jersey, Jordan, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Luxembourg, Macedonia, Malta, Moldova, Montenegro, Morocco, Netherlands, Norway, Poland, Portugal, Romania, Russia, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Tunisia, Turkey, Ukraine, United Kingdom, Uzbekistan)

Describe the endangered area:
A. bilineatus could establish in the whole EPPO region wherever *Quercus* and *Castanea* are present.

Main conclusions
Entry: the pest has already been introduced in the EPPO region, and is reported from a small part of Turkey, near Istanbul. The probability of further entry was considered as high with a moderate uncertainty, the highest ratings being for host plants for planting, round wood with bark, wood chips, hogwood and processing residues bigger than 2.5 cm in two dimensions, natural spread from neighbouring countries and wood packaging material (if ISPM 15 is not applied). It should be noted that several EPPO countries (e.g. the EU countries) already have requirements associated with these pathways, which are likely to have reduced the risk of entry of the pest in these countries.

Establishment outdoors: establishment of *A. bilineatus* is very likely to occur in the EPPO region (with a low uncertainty) as the susceptible species *Quercus robur* and *Q. rubra* are widespread and the climate is not considered as a limiting factor. Other *Quercus* species and *Castanea sativa* are likely to also be susceptible to this pest.

The magnitude of spread was rated moderate (mean of 1-10 km per year) with a moderate uncertainty. The pest could spread naturally and by hitchhiking on vehicles from Turkey and is likely to reach Bulgaria and neighbouring countries in the next 10 years (ie. by 2029). In addition, there may be longer 'jumps' with movement of wood, wood products or plants for planting, which would increase the spread.

Impact (economic, environmental and social) is likely to be very high. Larvae can girdle the conductive tissues of host trees, potentially leading to subsequent branch and tree death. Host plants, *Quercus* and *Castanea*, are major forest and ornamental trees in the EPPO region. The uncertainty of the impact is moderate, as impact could be reduced to high if not all *Quercus* and *Castanea* species are hosts and if natural enemies provide some control.

The EWG considered that phytosanitary measures to prevent further introductions should be recommended for all *Quercus* and *Castanea* species.

Phytosanitary Measures to reduce the probability of entry: Risk management options are considered for host plants for planting, wood of hosts and wood chips, hogwood and processing wood material. ISPM 15 is a sufficient measure for wood packaging material. Hitchhiking also presented a risk of introduction, but no measures were defined.

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 Section 17 for a justification of the rating. Individual ratings of uncertainty of entry, establishment, spread and impact are provided in the document)*	High ☐	Moderate ☒	Low ☐

Other recommendations: The EWG made recommendations (detailed in section 18) related to surveys to be performed in Turkey, in neighbouring countries, as well as in countries importing high risk material from infested area; to sentinel trees; as well as to determine the susceptibility of all *Castanea* and *Quercus* species present in infested countries.

Stage 1. Initiation

Reason for performing the PRA: *Agrilus bilineatus* (Coleoptera: Buprestidae) is a North American pest of oak (*Quercus* spp.) and chestnut (*Castanea dentata*), and is commonly associated with oak mortality in the USA, making it among the most notable North American pest in the genus *Agrilus* (Muzika et al., 2000). This pest was identified by Dr. Eduard Jendek as posing a risk because it has been recently introduced in the EPPO region (Turkey). The phytosanitary risk of *A. bilineatus* to European chestnuts was assessed to be "medium" by Peverieri et al. (2017). *A. bilineatus* was also ranked as the third insect species, after *A. anxius* and *A. planipennis*, that can follow the import of deciduous wood chips from eastern North America, and which could present a phytosanitary risk to Norway (VKM, 2013).
In October 2018, the Panel on Phytosanitary Measures decided that this additional PRA could be initiated in 2018 concurrently with the one on *A. fleischeri*, to take advantage of the experts present during that meeting.

PRA area: EPPO region in 2018 (map at https://www.eppo.int/ABOUT_EPPO/eppo_members)

Stage 2.   Pest risk assessment

1. Taxonomy

Taxonomic classification. Domain: Eukaryota; Kingdom: Metazoa; Phylum: Arthropoda; Class: Insecta; Order: Coleoptera; Family: Buprestidae; Genus: *Agrilus*; Species: *bilineatus* (Weber, 1801)

Synonyms. *Buprestis bilineata* Weber 1801; *Agrilus flavolineatus* Mannerheim (1837); *Agrilus bivittatus* Kirby (1837); *Agrilus aurolineatus* Gory (1841)

English and French common names.
Two-lined chestnut borer (English); agrile du châtaignier (French)

2. Pest overview

2.1 Morphology

- Eggs are oval, wrinkled, creamy white when first deposited, and become more golden brown as they mature (Chapman, 1915). Eggs can be laid singly, or in clusters of up to 10 eggs, with most clusters containing 2–4 eggs (Chapman, 1915; Haack & Benjamin, 1982) (ANNEX 2, Fig 1).
- Larvae are elongate, legless, creamy white to yellowish, and dorsoventrally flattened (ANNEX 2, Fig. 2). The head is dark brown and protracted into the enlarged prothorax. *A. bilineatus* has four larval instars which can be determined based on the length of the urogomphi (Cote & Allen, 1980; Haack & Benjamin, 1982). Upon emergence from the egg, first-instar larvae measure 1–1.5 mm long, while fourth instars reach 18–24 mm (Chapman, 1915).
- Pupae (6–10 mm long) are creamy white in color at first, becoming darker as the adult forms (Chapman, 1915).
- Adults (varying from 5–13 mm long depending on the condition of the host in which they developed) are elongate, slender, subcylindrical in cross-section (Haack & Acciavatti, 1992) (ANNEX 2, Fig 3). Horn and Fisher describe the head of *A. bilineatus* as bronzy green in color while the thorax and abdomen are mostly black with a greenish tinge (Fisher, 1928; Horn, 1891). There is a yellow stripe along each side of the thorax and along the center of each elytron. These stripes are very characteristic of this species as no other *Agrilus* species colonizing oaks in Europe have such stripes. However, these stripes may not be distinct on some individuals. The abdomen has a shiny appearance.

Additional pictures can be viewed in the EPPO Global Database (https://gd.eppo.int/taxon/AGRLBL/photos) as well as on Bugwood.org (https://www.insectimages.org/search/action.cfm?q=agrilus+bilineatus).

2.2 Life cycle

Several detailed accounts have been published on the biology and ecology of *A. bilineatus* in the USA, starting with the work of Chittenden in Virginia (Chittenden, 1897a, 1897b), followed by Chapman in Minnesota (Chapman, 1915), Dunbar and Stephens in Connecticut (Dunbar & Stephens, 1976), Cote and Allen in New York and Pennsylvania (Cote & Allen, 1980), and Haack and Benjamin in Wisconsin (Haack & Benjamin, 1982).

<u>General:</u>

- Throughout its range, *A. bilineatus* usually completes its life cycle in a single year, although some individuals can require two years (Cote & Allen, 1980), which may be attributed to slower larval developmental rates in vigorous hosts, populations that occur where summers are cool and short, or individuals that develop from eggs that were laid in late summer (Chamorro et al., 2015). Larvae must experience an extended cold period before they pupate and transform to adults, as is common in many *Agrilus* species that develop in temperate latitudes (Chamorro et al., 2015; Reed et al., 2018).
- Given its broad geographic range in North America, life-history events of *A. bilineatus* will tend to occur several weeks earlier in the southern USA compared to populations in southern Canada. For

example, adults usually initiate emergence from host trees in April in the southern US states, in May in Virginia and Connecticut, late-May to early-June in southern Michigan, and in June in Minnesota, New York, and Wisconsin (Chapman, 1915; Chittenden, 1897a; Cote & Allen, 1980; Dunbar & Stephens, 1976; Haack & Benjamin, 1982; Petrice & Haack, 2014; Solomon, 1995).

Adults and eggs:

- In the USA, adult emergence peaks a few weeks after it begins and continues into July and August, with some adults being active into September (Dunbar & Stephens, 1976; Haack & Benjamin, 1982).
- After emerging, adults fly to the crowns of trees where they feed on foliage (Chapman, 1915; Dunbar & Stephens, 1976), which is required to become sexually mature. This behavior is also common for other *Agrilus* species as well (Chamorro et al., 2015).
- *A. bilineatus* adults are active (e.g. fly, mate, and oviposit) from late morning until late afternoon (Chapman, 1915; Haack & Benjamin, 1982). *A. bilineatus* adults, like many Buprestidae, are most active on sunlit trees along the forest edge (Dunbar & Stephens, 1976; Wellso et al., 1976).
- *A. bilineatus* adults prefer to feed on host foliage but may occasionally feed on foliage of other hardwood trees (Dunbar & Stephens, 1976; Haack & Benjamin, 1982).
- Adults mate on the trunks and branches of host trees, as well as on nearby plants and wood piles (Chapman, 1915). In a field study, *A. bilineatus* males were attracted to females in cages with a fine screen (Dunn & Potter, 1988), suggesting a pheromone was involved but none has yet been discovered. However, in *A. planipennis*, males were found to use visual cues in locating females as well as contact and short-range pheromones (Lelito et al., 2007; Poland et al., 2015).
- Adult females appear to oviposit preferentially on stressed trees, such as girdled trees (Cote & Allen, 1980; Dunbar & Stephens, 1976; Dunn et al., 1986b, 1987; Haack & Benjamin, 1982). Dunn et al. (1987) demonstrated that previously uninfested *Quercus* trees with low root starch reserves were preferentially infested by *A. bilineatus*.
- Females deposit eggs in bark cracks and crevices, often singly or in groups of 2–10 eggs (Chapman, 1915; Haack & Benjamin, 1982). Females secrete a substance over the eggs (Chapman, 1915), which likely aids in cementing the eggs to the host and reducing desiccation (Chamorro et al., 2015). Females oviposit from the base of the tree trunk to branches that measure as little as 2–4 cm in diameter (Chapman, 1915). Lifetime fecundity has not been measured in *A. bilineatus*; however, for several other *Agrilus* species, average lifetime fecundity under laboratory conditions was 23–77 eggs (Chamorro et al., 2015).
- Reports for *A. bilineatus* adult longevity when caged with fresh foliage have varied among studies, with Chapman (1915) stating that adults lived an average of 12 days, Dunbar & Stephens (1976) reporting an average of 20 days for females (with a maximum of 31 days) and 16 days for males, while Haack & Benjamin (1982) reported for both sexes combined that adults lived an average of 28 days at 20°C, 38 days at 24°C, or 8 days at 30°C. Haack & Benjamin (1982) also reported for both sexes combined that un-fed adults lived an average of 11 days at 20°C, 8 days at 24°C and 5 days at 30°C.

Larvae and pupae:

- *A. bilineatus* larvae usually hatch from eggs in 10–14 days (Chapman, 1915; Dunbar & Stephens, 1976) and immediately tunnel into the bark. First-instar larvae enter the bark directly from the side of the egg attached to the bark, and therefore are never exposed on the bark surface (Chapman, 1915).
- Larvae tunnel in the cambial region, scoring both the inner bark (phloem) and outer sapwood (xylem). Larvae typically tunnel into the outer sapwood or the outer bark to molt and then return to the cambial region to feed (Chapman, 1915). Total gallery length for all instars can extend more than 80 centimeters (Chapman, 1915).
- Starting in late summer, mature fourth (last) instar larvae prepare individual pupal cells in either the outer bark, if the bark is sufficiently thick, or in the outer sapwood (Chapman, 1915; Petrice & Haack, 2014).
- Before constructing the pupal cell, larvae extend their gallery close to the outer bark surface, which creates a pathway that the future adult will enlarge with its mandibles and use to exit the tree the following year. The pupal cell is about half the length of the mature larva's body. The larva creates

the cell by tunneling so that its head remains close to the ventral side of its body and continues until the head nears the tip of the abdomen, thus situating itself in a J-shaped position to overwinter. In Wisconsin, some larvae begin to construct pupal cells in August, while by October nearly all fourth-instar larvae have constructed pupal cells (Haack & Benjamin, 1982).

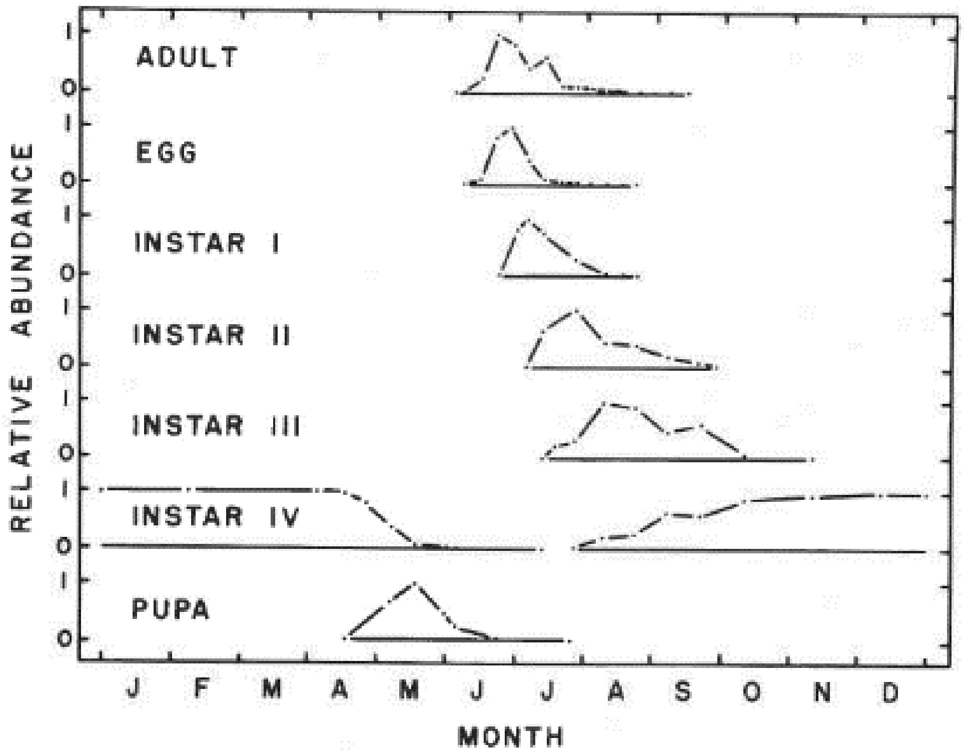
- Larvae that have not reached maturity by late autumn will remain in the cambial region during winter and resume feeding the following year and then construct a pupal cell, thus overwintering twice before emergence. Immature larvae that overwinter in the cambial region suffer higher mortality than those that overwinter in pupal cells (Dunbar & Stephens, 1976).
- Pupal cells of the mature larvae are usually parallel with the wood grain.
- Within individual trees, larvae in the crown tend to construct pupal cells earlier than those in the trunk (Haack & Benjamin, 1982).
- Pupation occurs in spring and early summer. Within the pupal cell, the J-shaped larva becomes a prepupa by contracting its body to about half its former length and straightening out with its head pointing outward towards the bark surface (Chapman, 1915).
- The prepupa then molts to the pupal stage. In Wisconsin, pupation occurs from late April into July, peaking in May (Haack & Benjamin, 1982). Pupation was reported to last an average of 10 days indoors by Chapman (1915), and an average of 12 days at 24°C or 9 days at 30°C in a study by Haack & Benjamin (1982).
- Newly formed adults remain generally motionless within pupal cells for the first two days after adult emegence, allowing time for their cuticle to harden, and then begin to enlarge the exit tunnel that was initiated earlier when they were larvae, and finally emerge from trees in approximately 3 days at 24°C or 2 days at 30°C (Haack & Benjamin, 1982). Adult sex ratio is approximately 1:1 (Cote & Allen, 1980; Dunbar & Stephens, 1976).

Details on morphology and development timing are summarized in Table 1.

Table 1. Details on morphology and development time.

Stage	**Colour/shape**	**Size**	**Duration** (Temperature conditions are indicated in section 2.2)
Eggs	Creamy white to golden brown, oval-shaped (ANNEX 2, Fig. 1).	1 mm long, 0.5 mm wide, 0.3 mm thick (Chapman, 1915).	10-14 days
Mature larvae	Creamy white to yellowish (ANNEX 2, Fig. 2)	18-24 mm long	About 10 months (for the 4 larval instars)
Pupae	Creamy white	6-10 mm long	9-12 days
Adults	Bronzy green head, black, greenish tinge with two stripes on the prothorax and elytra (ANNEX 2, Fig. 3). These stripes are very characteristic as no other *Agrilus* species colonizing oaks in Europe have such stripes.	5-13 mm long	8-38 days

Figure 1. Relative abundance of *Agrilus bilineatus* life stages based on field experiments conducted from June 1979 through May 1980 in Wisconsin (USA) (Haack, 1980)



2.3 Temperature requirements

There is little information about the temperature requirements of *A. bilineatus*. However, the pest is widely distributed in eastern North America (Section 6) and it may adapt its life cycle to local conditions (complete life cycle usually in one year, but sometimes in two years in relation to climatic conditions and host condition). The pest overwinters in the outer bark, the cambial region or outer sapwood of trees which can provide some protection against cold temperatures.

2.4 Dispersal capacity of adults

Newly emerged adults immediately fly in a zigzag pattern toward the tree tops, possibly in response to light (Dunbar & Stephens, 1976). Natural dispersal through adult flight has not been studied for *A. bilineatus*. Studies on the dispersal capacity are available for *A. planipennis* and *A. anxius* which are similar in size to adult *A. bilineatus*. *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 (Taylor et al., 2010; Vannatta et al., 2012 citing Raupp, 2010 and Sargent *et al.*, 2010). *A. anxius* is capable of a natural spread of 16 to 32 km/year (Federal Register, 2003). By analogy with *A. planipennis*, when host plants are available, it can be assumed that the approximately 90 % of the individuals of *A. bilineatus* will disperse less than 100 m during one season (Mercader et al., 2009). At short distances (less than 200 m), in sites with more heterogeneous distribution of hosts, *A. planipennis* spreads more towards areas of relatively abundant ash than towards areas of low ash density (Siegert et al., 2010). In conclusion, *Agrilus* beetles often have the capacity to fly considerable distances; however, they rarely do so because they usually only have to fly short distances to find suitable hosts (Dunbar & Stephens, 1976).

2.5 Nature of the damage

Species of *Castanea* and *Quercus* have ring porous xylem, i.e. water is conducted primarily in the outermost annual ring of xylem, making them highly susceptible to girdling by cambial feeding insects.

Larvae develop mainly in the cambial region and in the outer xylem of infested trees. Feeding activity disrupts the transportation of water and nutrients in the tree.

In addition to tree decline, larval galleries can girdle the trunk and kill the tree. Tree death can occur in a single year, especially during *A. bilineatus* outbreaks, but tree death over a two to four-year period is more common (Haack & Acciavatti, 1992).

2.6 Trees attacked in a stand and location of the pest in the tree

The pest is usually present at low population levels in the North American forests where it breeds in weakened host trees. However, following severe oak defoliation and drought, it has the capabilities of increasing in numbers rapidly and bringing about large-scale oak mortality (Dunbar & Stephens, 1976). *A. bilineatus* has been one of the the major causes of oak mortality in North America (Dunbar & Stephens, 1976).

The pest attacks both the trunk and the branches of its hosts, and during outbreaks it attacks both, apparently healthy and weakened trees. Several stress factors make trees more attractive and more susceptible to attack. Attack usually begins in the crown of the tree and proceeds downward along the bole in each succeeding year of infestation (Haack & Benjamin, 1982).

2.7 Detection and identification

Signs and symptoms of infestation

- Wilted foliage on scattered crown branches in late summer (Haack & Acciavatti, 1992). The wilted foliage turns brown and remains attached for several weeks or even months. Such branches will not produce new foliage in subsequent years.
- D-shaped (i.e., semicircle-shaped) exit holes that are approximately 5-mm wide (Haack & Acciavatti, 1992). On ring-porous trees, wilting pattern generally appears before D-shaped exit holes can be observed.
- Tortuous traces of larval galleries filled with frass (Haack, 1985), which are typical for the genus *Agrilus*. Remark: early instars (first and second) tend to tunnel in any direction, but late instars (third and fourth) tend to tunnel across the wood grain (Chapman, 1915).
- Cracking and/or swelling of the bark: Development of ridges or swelling on the bark surface as a result of callus tissue developing over the larval galleries occasionally occurs on thin-barked trees, especially on branches, but less so on the trunks.
- Dieback and dead trees.
- Signs of adult feeding on the margin of the leaves may be noticeable in large infestations (Jendek, personal communication, 2018).

Additional considerations

All life stages (except adults) remain hidden in bark cracks (i.e. eggs) or within the tree, making their detection more difficult than some other insect pests. In the early stage of infestation, trees attacked by *A. bilineatus* are usually weakened (Haack & Acciavatti, 1992).

D-shaped exit holes produced by emerging adults may be few at first and they may be situated high in the canopy (i.e. not easily visible) on larger trees during the first couple years of infestation.

Sap exudation on the bark surface has never been reported for *A. bilineatus* larvae infesting *Quercus* trees in North America (Haack, personal communication, 2018). However, sap exudation has frequently been observed for *A. biguttatus* on native *Quercus* trees in Europe (Brown et al., 2017).

First emergence, and therefore the appearance of D-shaped exit holes, can only be observed one to two years after the first infestation. Only in subsequent years of infestation will symptoms on infested trees as listed above be more easily observed because infestation proceeds downward along the trunk in each year of attack.

Because other *Agrilus* species are present in the EPPO region with similar body sizes and hosts, D-shaped exit holes on *Quercus* are not characteristic of only *A. bilineatus*. Symptoms on trees are not characteristic either. Eleven species of *Agrilus* can use *Quercus* as larval hosts in Europe (*A. biguttatus*, *A. sulcicollis*, *A. angustulus*, *A. laticornis*, *A. obscuricollis*, *A. hastulifer*, *A. graminis*, *A. grandiceps*, *A. litura*, *A. relegatus alexeevi* and *A. curtulus*) (Coutin, 2005; Jendek & Polarkova, 2014). D-shaped exit holes are also produced by all taxa from the subfamily Agrilinae, in Europe particularly the genera *Agrilus*, *Coraebus* and *Meliboeus* (Jendek, personal communication, 2018)

The following *Agrilus* species are already associated with oak declines in Europe: *A. biguttatus*, *A. sulcicollis* and *A. angustulus*. However, most of these records probably correspond to *A. biguttatus*, which is prominent in oak declines in Europe, with outbreaks of this species being frequently reported after extensive defoliations or severe droughts (Sallé et al., 2014). In addition, the larvae of *A. biguttatus*, *A. graminis*, *A. hastulifer*, *A. laticornis* and *A. angustulus* can develop both on different *Quercus* species and on *Castanea sativa* (Coutin, 2005; Jendek & Polarkova, 2014).
As a consequence, first signs or symptoms following an introduction of *A. bilineatus* in the EPPO region may not be quickly distinguished from those made by native *Agrilus* species.

Detection methods
Except for *A. planipennis*, limited attention has been placed on developing effective traps for *Agrilus* monitoring and surveying programs. *A. bilineatus* adults have been captured on purple, yellow and green sticky traps (Petrice & Haack, 2014), as well as in green funnel traps coated with fluon to increase slipperiness (Petrice & Haack, 2015). The green color is assumed to mimic green foliage, whereas purple is believed to have a similar reflectance as tree bark. Attraction to a specific trap depends on the species concerned, the sex, as well as the place where the trap is placed in the tree (Petrice & Haack, 2015). In a study by Rutledge, (in review) targeting *A. anxius* on birch and *A. planipennis* on ash, many adults of the non-targeted *A. bilineatus* were also captured, with significantly more captured on purple traps than on green traps. However, this may be explained by the difference in trap type (green funnel vs. purple prism) and trap location (green in mid-canopy vs. purple at base of crown), and therefore direct comparisons are difficult. In the study by Petrice & Haack (2014) where all traps were similar in type, more females of *A. bilineatus* were captured on purple, followed by yellow, green, and white, respectively. Males of *A. bilineatus* did not show a significant colour preference and placement. In recent surveys in declining oak forests all species of *Agrilus* developing on oaks in France (i.e., *A. angustulus*, *A. biguttatus*, *A. curtulus*, *A. graminis*, *A. grandiceps*, *A. hastulifer*, *A. laticornis*, *A. obscuricollis*, *A. olivicolor* and *A. sulcicollis*) have been trapped in green funnel traps coated with fluon, which were significantly more attractive than similar purple traps for all species (Sallé, personal communication, 2018).

Several species of male *Agrilus* (*A. angustulus, A. biguttatus, A. cyanescens, A. subcinctus, A. sulcicollis* and *A. planipennis*) are attracted to dead *Agrilus* adults when used as decoys and placed on host plants suggesting a common behavioral template for visual mate-finding among buprestids (Domingue et al., 2011; Lelito et al., 2011, 2007). 3D-printed decoys have also been used for *A. planipennis* (Domingue et al., 2015). Therefore, adding dead adults as decoys or using enlarged silhouettes of an adult *Agrilus* may be used to improve attractiveness of traps.

Applying insect-trapping adhesive to plastic bands wrapped around the lower trunk of girdled host trees has been used to monitor *A. bilineatus* adult flight (Dunn et al., 1986a; Haack & Benjamin, 1982). As for *A. planipennis*, girdling trees may also increase attraction (Mccullough et al., 2011; Siegert et al., 2017), and may be used in specific situations (e.g. at the limit of an infested area to delimit this area) (Gninenko et al., 2012).

As is true for *A. planipennis*, there is no single method that is reliable for detecting low level populations of *A. bilineatus*. General monitoring methods such as trapping, visual examination of trees and tree sampling may be used, but they may not detect low infestations. The EPPO Standard PM 9/14 on *A. planipennis* (EPPO, 2013), recommends the use of traps and biosurveys (with wasps that specialize in hunting buprestids) for situations of eradication and containment.

Identification
Morphological characters of *A. bilineatus* are given in several publications (Blatchley, 1910; Bright, 1987; Crotch, 1873; Downie & Arnett, 1996; Horn, 1891; Huard, 1909; Knull, 1925; MacRae, 1991; Mutchler & Weiss, 1922; Wellso et al., 1976). Characters of *A. bilineatus* urogomphi can be used to distinguish it from *A. sulcicollis* (Petrice & Haack, 2014). In addition, three sequences are recorded in GenBank, which could be used in the future for identification using molecular methods.
Any detection in the EPPO region of *Agrilus* adults on oak or chestnut that possess two stripes on the prothorax and elytra should be followed by confirmation by an expert.

3. Is the pest a vector?

Yes	☐	No	✓

One author suggested that *A. bilineatus* adults vector *Bretziella fagacearum* (=*Ceratocystis fagacearum*) and *Cryphonectria parasitica* spores because they occasionally emerge from diseased trees and also visit fungal fruiting bodies (Craighead, 1912). However, there is little or no support for that *A. bilineatus* is an actual vector of these fungi in nature (Anderson & Babcock, 1913; Lewis, 1987).

4. Is a vector needed for pest entry or spread?

Yes	☐	No	✓

5. Regulatory status of the pest

A. bilineatus is not listed as a quarantine pest by any EPPO country (EPPO, 2018b).
A. bilineatus was not found in the lists of regulated pests for other countries. However, *Agrilus* spp. (except *A. diaguita*, *A. sulcipennis* and *A. thoracicus*) are regulated pests for Chile (SAG, 2018). The information presented in this document is not exhaustive, and *A. bilineatus* may be regulated in more countries.

6. Distribution

Agrilus bilineatus is endemic to eastern North America in regions where chestnut (*Castanea*) and oak (*Quercus*) are native. However, it should be noted that the American chestnut *Castanea dentata* which dominated eastern forests in the USA is now considered as an endangered species (IUCN red list) and was subject to large and rapid declines in the early 1900s due to *Cryphonectria parasitica*. As shown in Figure 2 the range of *A. bilineatus* extends from New Brunswick westward to Manitoba in Canada, southward to Texas and eastward to Florida. Outbreaks are rarely reported from the southern portion (i.e. Florida, Georgia, Alabama, Mississipi, Louisiana) (Millers et al., 1989), and the far western portion of the insects range (North Dakota south to Texas). Far western listings in the USA that were usually not supported by published records and therefore were checked by contacting collection managers of the corresponding State Universities (i.e. for Alabama, Colorado, Kentucky, Nebraska, North Dakota, and South Dakota).

In the EPPO region, so far, in total four specimes of *A. bilineatus* have been found in four separated locations (see map in Figure 3). One *A. bilineatus* adult was first collected in Turkey in 2002 (Jendek, 2016) and then in two separate years (2013, 2016; two specimens) and at two different locations separated by a distance of more than 200 km from the first report (Hızal & Arslangündoğdu, 2018; Jendek, 2016). An additional finding was reported in Turkey in Sile in 2018, Istanbul (Hızal, personal communication, 2018). Adults were collected using insect nets in locations situated several kilometres from the closest shipping harbour (Hızal & Arslangündoğdu, 2018; Hızal, personal communication, 2018; Jendek, personal communication, 2018). Taken together these findings suggests that *A. bilineatus* is established in Turkey.

Table 2 Distribution of *A. bilineatus*.

Region	Distribution	References and comments
America	**Canada**	
	Manitoba	Bright, 1987
	New Brunswick	Webster & DeMerchant, 2012
	Ontario	Bright, 1987; Fisher, 1928; Nelson et al., 2008
	Quebec	Bright, 1987; Fisher, 1928; Nelson et al., 2008
	United States of America	
	Alabama	Haack, 1980; Nelson et al., 2008; Callahan, personal communication, 2018[1]
	Arkansas	Fisher, 1928; Haack, 1980; Nelson et al., 2008

[1] *A. bilineatus* specimen collected in Alabama can be found in the collection of the Auburn University Museum of Natural History. One specimen was collected in 1978 from Randolph County, and one from Walker County in 1980 (Callahan, personal communication, 2018).

Region	Distribution	References and comments
	Colorado	Haack, 1980; Kondratieff, personal communication, 2018[2]
	Connecticut	Fisher, 1928; Haack, 1980; Nelson et al., 2008
	Delaware	Nelson, 1987; Nelson et al., 2008
	Florida	Fisher, 1928; Haack, 1980; Nelson et al., 2008
	Georgia	Fisher, 1928; Haack, 1980; Nelson et al., 2008
	Illinois	Fisher, 1928; Haack, 1980; Nelson et al., 2008
	Indiana	Fisher, 1928; Haack, 1980; Nelson et al., 2008
	Iowa	Fisher, 1928; Haack, 1980; Nelson et al., 2008
	Kansas	Fisher, 1928; Haack, 1980; Nelson et al., 2008
	Kentucky	Dunn et al., 1986a; Chapman, personal communication, 2018[3]
	Louisiana	Carlton et al., 2018; Haack, 1980; Johnson et al., 2015
	Maine	Haack, 1980; Horn, 1891; Nelson et al., 2008
	Maryland	Fisher, 1928; Haack, 1980; Nelson et al., 2008
	Massachusetts	Fisher, 1928; Haack, 1980; Nelson et al., 2008
	Michigan	Fisher, 1928; Haack, 1980; Nelson et al., 2008
	Minnesota	Chapman, 1915; Haack, 1980
	Mississippi	Haack, 1980; Nelson et al., 1981, 2008
	Missouri	Fisher, 1928; Haack, 1980; Nelson et al., 2008
	Nebraska	Haack, 1980; Paulsen, personal communication, 2018[4]
	New Hampshire	Fisher, 1928; Haack, 1980; Nelson et al., 2008
	New Jersey	Fisher, 1928; Haack, 1980; Nelson et al., 2008
	New York	Fisher, 1928; Haack, 1980; Nelson et al., 2008
	North Carolina	Fisher, 1928; Haack, 1980; Nelson et al., 2008
	North Dakota	North Dakota Forest Service, 2011; Fauske, personal communication, 2018[5]
	Ohio	Fisher, 1928; Haack, 1980; Nelson et al., 2008
	Oklahoma	Haack, 1980; Nelson et al., 1981, 2008
	Pennsylvania	Fisher, 1928; Haack, 1980; Nelson et al., 2008
	Rhode Island	Fisher, 1928; Haack, 1980; Nelson et al., 2008
	South Carolina	Haack, 1980; Nelson et al., 2008
	South Dakota	Haack, 1980; Nelson et al., 2008; Johnson, personal communication, 2018[6]
	Tennessee	Haack, 1980; Hansen et al., 2012
	Texas	Fisher, 1928; Haack, 1980; Nelson et al., 2008
	Vermont	VTFPR, 2011
	Virginia	Fisher, 1928; Haack, 1980; Nelson et al., 2008
	West Virginia	Fisher, 1928; Haack, 1980; Nelson et al., 2008
	Wisconsin	Fisher, 1928; Haack, 1980; Hopkins, 1894; Nelson et al., 2008
EPPO region	**Turkey**	Hızal & Arslangündoğdu, 2018; Jendek, 2016; Hızal, personal communication, 2018

[2] *A. bilineatus* specimens collected in Colorado can be found in the collection of the C. P. Gillette Museum of Arthropod Diversity, Colorado State University. One specimen was collected in Pinewood Springs, Larimer Co., CO (N40.269476, W105.360503) during 30 July to 7 September 2014. A second record is related to two adults that emerged in Colorado from firewood that originated from Missouri. These insects were identified by Dr. G. H. Nelson and Dr. R. L. Westcott, experts on this insect family. The insect collection at Colorado State University has also many other specimens from the states of Missouri, Virginia, Michigan, Wisconsin, Oklohama, Ohio, and Kentucky (Kondratieff, personal communication, 2018).

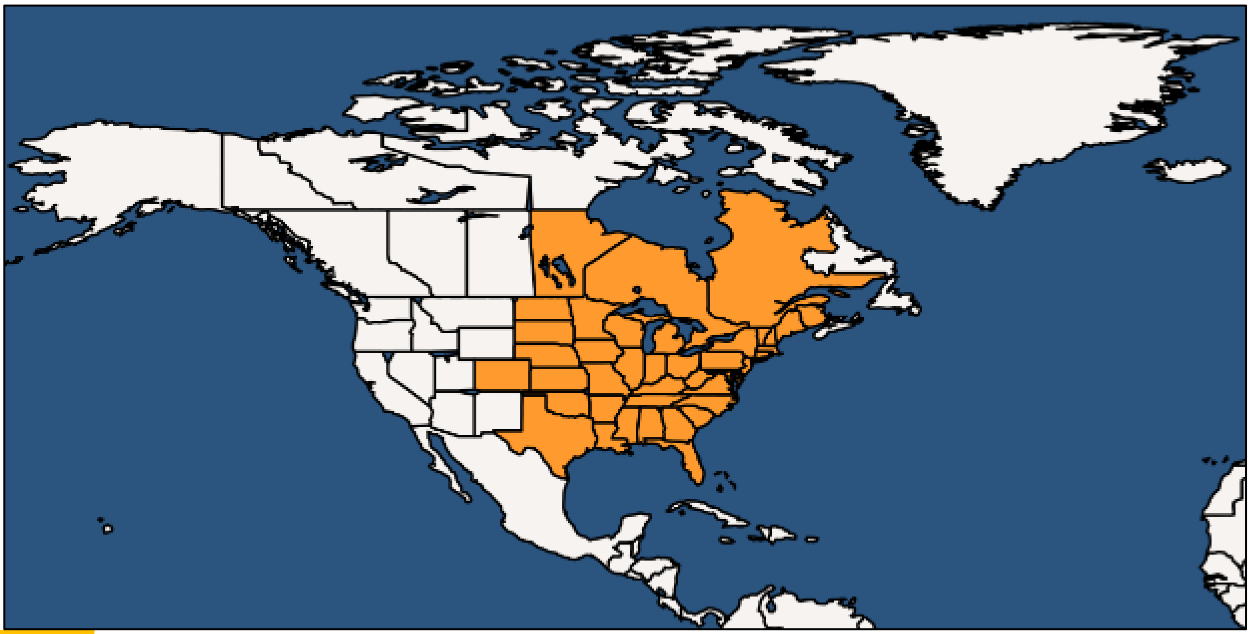
[3] *A. bilineatus* specimens collected in Kentucky can be found in the the personal collection of Dr. Eric G Chapman (in Lexington), collection manager of the Department of Entomology at the University of Kentucky. A total of 24 specimens are from Madison Co. (KY) Berea College Exp. Forest, End of Horse Cove Road (37.5716°N, 84.2180°W) with dates indicating May 13 to July 15, 2013. Two specimens are from Madison Co. (KY), Berea College Exp. Forest, Cowbell Creek Area (37.5397°N, 84.2277°W) with dates indicating June 3 & 10, 2013. One specimen is from Madison Co. (KY), Berea College Exp. Forest, Pinnacle Peaks Area (37°33.26'N, 84°14.47'W), with date indicating June 6, 2009. One specimen is from Powell Co. (KY), Red River Gorge, Gray's Arch SE of Nada tunnel Rd. (SR 77) (37°49.17'N, 83°39.39'W) with date indicating July 3, 2009. Three additional specimens from Pennsylvania and Arkansas are also available.

[4] *A. bilineatus* specimens collected in Nebraska can be found in the entomology collection of the University of Nebraska State Museum. A total of 11 specimens are available. Those with dates indicate June 30 to July 2, 1915, and they were determined by Frost. They are all from Rulo, NE, which is in Richardson County (the extreme southeast corner of the State) (Paulsen, personal communication, 2018).

[5] *A. bilineatus* specimens collected in North Dakota can be found in the North Dakota State Insect Reference Collection (NDSIRC). These specimens had been collected in Burleigh Co., Bismarck, ND; Ramsey Co., Sully's Hill, CMA [National Game Preserve), ND; Richland Co., Hankinson Hills Campground, Sheyenne National Grasslands, ND (Fauske, personal communication, 2018).

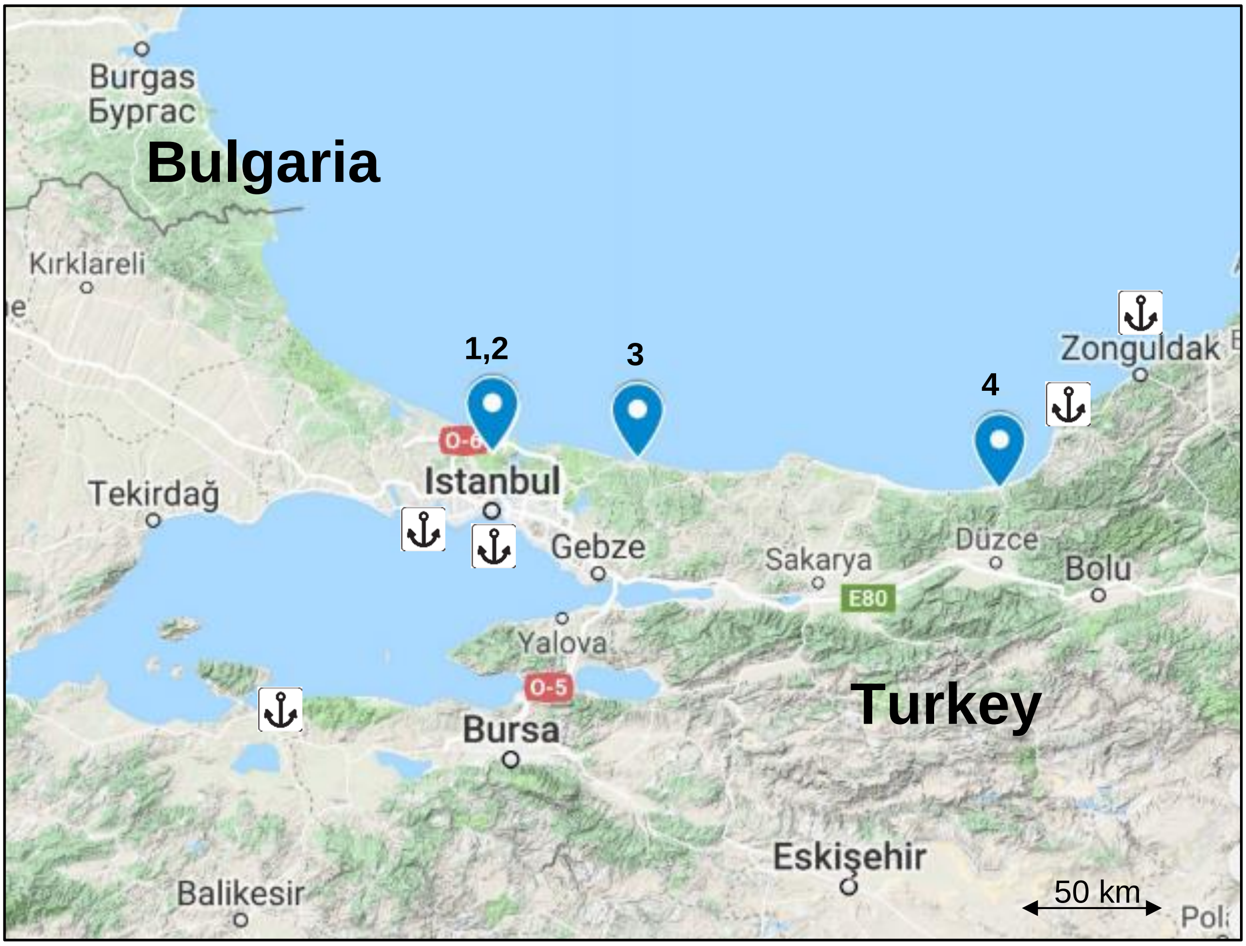
[6] Two specimens of *A. bilineatus* specimens collected in South Dakota can be found in the collection of the South Dakota State University. They were collected in 1935. Three additional specimens from Pennsylvannia, and one from Connecticut are also available in this collection (Johnson, personal communication, 2018).

Figure 2. Distribution of *A. bilineatus* in the North-America (prepared by the EPPO Secretariat based on information in Table 2, using https://gd.eppo.int/)



In orange: States where *A. bilineatus* occurs.

Figure 3. Reports of *Agrilus bilineatus* in Turkey. **Legend:** The four locations where *A. bilineatus* has been reported are indicated with a number. Location of the main turkish shipping ports are indicated with an anchor. **Sources:** Location 1 and 2 (in 2013 and 2016, approximately 1 km between the two trap locations; Hızal & Arslangündoğdu, 2018), Location 3 (in 2018, Hızal, personal communication, 2018), and Location 4 (in 2002, Jendek, 2016). (source: Map data © 2018 Google).



7. Host plants and their distribution in the PRA area

Host plants

Despite its common name, the two-lined chestnut borer is principally a pest of oak. In North America, *A. bilineatus* attacks *Castanea dentata* (Fagaceae) and numerous species of *Quercus* (Fagaceae). It will probably attack any of the oaks (Fisher, 1928). Complete development of *A. bilineatus* in *Q. robur* (pedunculate oak) has been documented multiple times in Michigan (Haack, 1986; Petrice & Haack, 2014) (Table 3). There is no information on the host status of *C. sativa* in North America as this species is not widely planted there (because of its susceptibility to *Cryphonectria parasitica).*

Table 3. Hosts genera and species of *Agrilus bilineatus* on which larvae can develop.

Host	Presence in PRA area (Yes/No/Not known)	References for host status
Fagaceae		
Quercus spp.	Yes	Chapman, 1915; Chittenden, 1900
Q. alba	Yes. As ornamental*.	Fisher, 1928; Haack & Acciavatti, 1992; Nelson & Hespenheide, 1998; Solomon, 1995
Q. coccinea	Yes. As ornamental* because of its red colour.	Chapman, 1915; Fisher, 1928; Haack & Acciavatti, 1992; Nelson & Hespenheide, 1998; Solomon, 1995
Q. ellipsoidalis	Yes. As ornamental*.	Haack & Acciavatti, 1992
Q. fusiformis	Not known	Lewis, 1987
Q. lyrata	Yes. As ornamental. Introduced in Europe in 1786. This oak is quite tolerant to flooding and can be cultivated in non-drained soils.	Nelson et al., 2008
Q. macrocarpa	Yes. As ornamental*.	Chapman, 1915; Fisher, 1928; Haack & Acciavatti, 1992; Nelson & Hespenheide, 1998; Solomon, 1995
Q. marilandica	Yes. As ornamental*.	Lewis, 1987
Q. michauxii	Yes. As ornamental*.	Carlton et al., 2018
Q. muehlenbergii	Yes. As ornamental*.	Nelson et al., 2008
Q. nigra	Yes. As ornamental*.	Nelson & Hespenheide, 1998; Solomon, 1995
Q. palustris	Yes. As ornamental*.	Nelson & Hespenheide, 1998; Solomon, 1995
Q. prinus (=Q. montana)	Yes. As ornamental*.	Haack & Acciavatti, 1992; Jendek & Poláková, 2014; Solomon, 1995
Q. robur	**Yes. The pedunculate oak is widely distributed in the EPPO region.** One of the most economically and ecologically important deciduous forest tree species in Europe (EUFORGEN, 2018). Only species of this list considered as a European and Mediterranean oak species (Bussotti & Grossoni, 1997). Ornamental trees or trees for wood.	Haack, 1986; Petrice & Haack, 2014
Q. rubra	**Yes. The northern red oak is now naturally found throughout western and central Europe.** The tree is valued as an ornamental (EUFORGEN, 2018) and for timber plantations (Sallé, personal communication, 2018), but is sometimes considered as being invasive (e.g. listed as a non-native plant species identified as medium risk on Ireland's Biodiversity List).	Chapman, 1915; Fisher, 1928; Haack & Acciavatti, 1992; Nelson & Hespenheide, 1998; Solomon, 1995
Q. stellata	Yes. As ornamental*.	Haack & Acciavatti, 1992; Nelson & Hespenheide, 1998

Host	Presence in PRA area (Yes/No/Not known)	References for host status
Q. texana (=Q. shumardii var. *texana; Q. nuttallii)*	Yes. As ornamental*.	Cited as *Q. shumardii* var. *texana by* Lewis, 1987. Cited as *Q. nuttallii* in Nelson & Hespenheide, 1998
Q. velutina	Yes. As ornamental*.	Fisher, 1928; Haack & Acciavatti, 1992; Nelson & Hespenheide, 1998; Solomon, 1995
Q. virginiana	Yes. As ornamental*.	Jendek & Poláková, 2014
Castanea spp.	Yes	Jendek & Poláková, 2014
C. dentata	Not known, except in arboreta. This species native to North-America formerly dominated eastern forests in the USA. However, it is now considered as an endangered species in the USA (IUCN red list) due to the large and rapid declines (90-99%) in population size during the early 1900s due to *Cryphonectria parasitica* (http://www.iucnredlist.org/details/62004455/0). *C. parasitica* is largely present in Europe. This reduces a lot the potential use of this species in most of the EPPO region.	Chittenden, 1900; Fisher, 1928; Haack & Acciavatti, 1992; Solomon, 1995

** These species are sold on internet sites of commercial nurseries in Europe.*

Doubtful hosts

- *Q. prinoides* is cited as a host plant (Nelson & Hespenheide, 1998). However, it seems to be an error. Indeed, this publication is referring to Solomon(1995) and should have stated *Q. prinus* (for chestnut oak) rather than *Q. prinoides,* which is sometimes called 'dwarf chestnut oak'.
- Early reports of *A. bilineatus* infesting *Betula* (Moffat, 1900) and *Gleditsia* (Blatchley, 1910) are considered erroneous (Haack, personal communication, 2018).
- In addition, a taxon considered for a long time as a subspecies or a variety of *A. bilineatus* previously recognized under the name *azureus* or *carpini* (Knull 1922, 1923), was elevated to the species status in the 1990s under the name *Agrilus carpini* Knull (Nelson & Hespenheide, 1998). This led to some confusion in the literature on the hosts of *A. bilineatus*. The documented hosts of *A. carpini* are *Carpinus caroliniana* (Betulaceae), *Fagus grandifolia* (Fagaceae), and *Ostrya virginiana* (Betulaceae) (Champlain & Knull, 1922; Fisher, 1928), none of which are now considered as certain hosts for *A. bilineatus* (Jendek & Poláková, 2014; Nelson & Hespenheide, 1998). In addition to host plants differences, *A. bilineatus* and *A. carpini* only differ in color and extent of pubescence.
- Adults are also reported to feed on the foliage of other trees such as *Abies* sp., and on chestnut blight fungal spores (*Cryphonectria parasitica*) (Nelson et al., 2008). However, it is considered that the observation on *Abies* is likely incorrect. Concerning the feeding on fungal spores on the trunk of trees, it is considered that it may have occurred but is likely rare. Usually, when adults are on the trunks of trees, they are mating and laying eggs, not feeding (Haack, personal communication, 2018).

Remarks

- In Turkey, the pest was recently reported on *Q. robur* as well as on one other non-specified *Quercus* sp. (Hızal, personal communication, 2018). One adult was also found feeding on *C. sativa* leaves in Turkey. Exit holes were observed on *C. sativa* in the surrounding; however, these may have been caused by other *Agrilus* species. Therefore, the host status of *C. sativa* in Turkey needs to be further investigated (Hızal, personal communication, 2018).
- Some *Castanea dentata* trees that are resistant against *C. parasitica* are being planted now in the USA, as well as European x Japanese cultivars in commercial orchards; however, no infestation have been reported so far on these new varieties in the USA (Haack, personal communication, 2018).

Considering that many *Agrilus* species can use both tree taxa, *Quercus* spp. and *Castanea sativa* as larval hosts, *C. sativa* is considered as a potential host. For this PRA, all *Quercus* spp. and *Castanea* spp. are considered as potential hosts.

8. Pathways for entry

Bark- and wood-infesting insects, including most *Agrilus* species, can be transported in live plants as well as wood products such as logs, firewood, solid wood packaging, lumber, bark, and wood chips (Meurisse et al., 2018).

For live plants, such as nursery stock, there are not always external signs of infestations during the first year of infestation (e.g., no exit holes).

For wood products, *Agrilus* individuals would be most likely to complete development in items with some bark (e.g., logs and dunnage), given that *Agrilus* larvae feed in the cambial region and immature larvae need bark to complete their development. Also, bark would be required for those individuals that pupate in the outer bark. However, it is possible for some individuals that would have constructed pupal cells in the outer sapwood, that bark is not required.

Between 1984–2008, there were 49 distinct interceptions of *Agrilus* individuals at US ports-of-entry, of which 5 interceptions were in live plants, 30 in dunnage, 13 in crating and pallets, and 1 at large (i.e. not associated with wood or live plants) (Haack, unpublished data used for Haack et al., 2014). In the EPPO region, 9 interceptions of Buprestidae (but not necessarily *Agrilus*) were reported between 2005-2017 in dunnage, pallets, wood packaging material and wood & bark (Table 4).

Table 4. Interceptions of *Buprestidae* reported to EPPO and/or to the EU during the period 2005-2017 (source: Europhyt & EPPO reporting service). Legend: n.a = not available.

Year	2009	2013	2014	2016	2017
Number of interceptions	1	2	1	1	4
Commodity (plant species)	Dunnage (n.a)	Wood pallets (n.a)	Wood packaging material (n.a)	Wood pallets (n.a)	A. Wood pallets (n.a) B. Wood & bark (*Eperua*) C. Wood & bark (*Juglans*) D. Wood & bark (*Ulmus*)
Origin	India	China	India	China	A. China B. Surinam C. USA D. USA

Remark: for all the wood pathways, by analogy with *A. planipennis*, it is considered that the pest is never associated with the heartwood, infesting only the bark and the outer sapwood.

In cut firewood stored outdoors, Petrice & Haack (2007) recorded successful adult emergence of *A. planipennis* one year after infested trees were cut, which was two years after they were infested.

Dunbar & Stephens (1974) found that adult emergence of *A. bilineatus* from slabs of processed logs was high, but that when the slabs in this experiment were converted to woodchips the emergence was reduced to nothing. However, live *Agrilus* life stages can be transported in bark or wood chips (McCullough et al., 2007; Økland et al., 2012; VKM, 2013). The risk of individuals completing development would be greatest for those transported as J-larvae, prepupae, pupae, and pharate adults because they no longer need to feed before transforming to adults and emerging.

The *EPPO Study on wood commodities* ((EPPO, 2015b) or 'EPPO Study' below) distinguishes many commodities (definitions in ANNEX 4). In this PRA, they were grouped into several pathways. This is because the existence of a trade into the EPPO region is an important factor for assessing the risk, but there is no trade data for many of the commodities as described in the EPPO Study. The PRA relies on existing data (from Eurostat, using existing CN customs codes) that cover together several EPPO wood commodities, hence the groupings proposed below. Finally, the EPPO Study provides a preliminary assessment of pest risk for different types of pest groups depending on the initial material used to produce the commodity (e.g. different risk for wood chips produced from treated (heat treated or fumigated) or untreated wood). Such distinctions are not used here as there is no indication of the type of material entering the EPPO region.

The following pathways for entry of *A. bilineatus* are discussed in this PRA. Pathways in bold are described and evaluated in section 8.1; other pathways were considered very unlikely for reasons stated in section 8.2.

- **Host plants for planting**
- **Round wood (with or without bark) and sawn wood of hosts**
- **Deciduous wood chips, hogwood, processing wood residues (except sawdust and shavings)**
- **Wood packaging material (including dunnage)**
- **Natural spread**
- **Hitchhiking on other commodities or vehicles**
- **Bark of hosts**
- **Cut branches**
- Furniture and other objects made of wood of host plants
- Wood sawdust and shavings, processed wood material, post-consumer scrap wood
- Seeds, fruits, bulbs and tubers, grain, pollen, stored plant products, soil and growing medium
- Movement of individuals, shipping of live insects, e.g. traded by collector

8.1 Pathways investigated in detail

All the pathways are considered for all *Quercus* spp. and *Castanea* spp. from areas where the pest is present (including Turkey) to the EPPO region. Host plants for planting are studied in Table 5, wood commodities in Table 6 and Table 7. Bark of hosts, hitchhiking and cut branches are discussed after these tables.

Examples of prohibition and inspection are given for some EPPO countries (in this express PRA the regulations of all EPPO countries were not analysed). Similarly, the current phytosanitary requirements of EPPO countries in place on the different pathways are not detailed in this PRA (although some were taken into account when looking at management options). EPPO countries would have to check whether their current requirements are appropriate to help preventing the introduction of the pest.

Table 5. Host plants for planting.

Pathway	**Host plants for planting (except seeds, tissue culture, pollen)**
Coverage	• Plants for planting in pots or similar (including bonsais), plants with bare roots, cuttings, scions. • Seeds, tissue culture, pollen are excluded because the pest is not associated with these pathways
Pathway prohibited in the PRA area?	Partly. In the EU, *Castanea* and *Quercus* plants for planting are only prohibited, from 'Non-European countries' and from 'third countries' respectively, when they are imported with leaves). Both genera have been listed on the provisional list of '*high risk plants*' in the EU. Therefore, in the EU, import of plants for planting of these genera will be prohibited from 14 December 2019, pending a risk assessment (EU, 2018). In addition, *Quercus* plants for planting imported from *Xylella fastidiosa*-infected countries (e.g. USA) must come from pest free areas, or pest free production sites with production in protected condition. In Turkey, *Quercus* plants for planting (excluding seeds) are prohibited when imported from an area where *Xylella fastidiosa* is reported (Ministry of Agriculture and Forestry of Turkey, 2011).
Pathway subject to a plant health inspection at import?	Yes, in some EPPO countries. For example, in the EU, phytosanitary certificate and general inspection requirement for *Castanea* spp. and *Quercus* spp. with specific requirements (e.g. related to *Cronartium* spp. (non-European) and *Cryphonectria parasitica* on *Castanea*; and *Ceratocystis fagacearum* on *Quercus*). As *Quercus* plants should come from areas known to be free from *Ceratocystis fagacearum*, and as *C. fagacearum* occurs in most of the States where *A. bilineatus* is present in the USA, this would reduce the current risk of introduction of *A. bilineatus* from the USA. After December 2019 in the context of application of EU regulation 2016/2031 (EU, 2016), all plants for planting (excluding seeds) will need to be accompanied by a phytosanitary certificate at import and an EU plant passport for movement within the EU.
Pest already intercepted?	No interceptions reported for the EU on plants for planting, not known for others. Five *Agrilus* interceptions have been reported on plants for planting in the USA.
Plants concerned	*Castanea* and *Quercus* are the only known hosts.
Most likely stages that may be associated	*Quercus* are not propagated by cuttings. All life stages can be present in trees. *A. bilineatus* has successfully developed in branches as small as 2.3 cm in trees that were heavily infested (Petrice & Haack, 2014). However, no reports were found referring to the presence of *A. bilineatus* in small trees in nurseries.
Important factors for association with the pathway	Cuttings are less likely to be infested because they are generally small. *A. bilineatus* usually attacks stressed trees in North America and nursery plants for planting are usually well maintained. Infestations are easier to detect if there are D-shaped exit holes from which adults emerged (this is only likely to occur in plants transported in non-cool conditions). In the context of import inspections, careful visual examination of the plants for presence of exit holes may enable an inspector to detect the presence of larvae. However, if only larvae are present, trees are lightly infested, and no adults have emerged, it will be very difficult to detect the presence of the pest. The presence of holes may be the result of attack by other insects, and they may not be conspicuous at low levels of infestation in a consignment.
Survival during transport and storage	Eggs, larvae, pupae and callow adults can survive within the host plant during transport.
Trade	Between 2000 and 2010, 6810 *Quercus* plants (including *Q. alba*, *Q. bicolor*, *Q. coccinea*, *Q. dentata*, *Q. ellipsoidalis*, *Q. macrocarpa*, *Q. palustris* and *Q. robur*) were imported from USA to Belgium, Germany and the Netherlands mainly for 'decorative' purposes. Import of *Quercus* plants from Canada during this period was negligeable (10 plants of *Q. muehlenbergii*). No imports of *Quercus* plants were reported from Turkey. There is no report of import of *Castanea* species from the USA, Canada or Turkey, to EPPO countries, during this period, in ISEFOR data (database used for Eschen et al., 2017).
Transfer to a host	Eggs, larvae, pupae would continue their development once at destination. Emerging adults are already on a suitable host and may therefore establish easier.

Pathway	Host plants for planting (except seeds, tissue culture, pollen)
Likelihood of entry and uncertainty	**Host plants for planting with a maximum diameter below 2 cm:** low with a low uncertainty. **Host plants for planting with a maximum diameter wider than 2 cm:** moderate with a moderate uncertainty (data on trade, area in the USA from which plants for planting are imported). Biological considerations support a high-level rating, but because of the low level of trade this rating was reduced.

Table 6. Round wood (with or without bark) and sawn wood of hosts.

Pathway	Round wood and sawn wood of hosts	Deciduous wood chips, hogwood, processing wood residues (except sawdust and shavings)
Coverage	This pathway intends to cover all types of round wood and sawn wood, including with or without bark. The understanding of sawn wood is as per definition in ISPM 5, i.e. wood sawn longitudinally, with or without its natural rounded surface with or without bark (FAO, 2018). Round wood includes logs, but also other types of material. Whole trees including branches, twigs, possibly stumps, may be harvested (e.g. as fuel wood). In addition, part of the commodity described in the EPPO Study as 'harvesting residues' is a type of round wood (when in the form of tops of trees, branches, twigs etc.). - *composition*: Consignments of round wood (as logs) and sawnwood would generally be of one species. Harvesting residues (in the form of round wood) arise from the harvest of logs and may initially be from one tree species, but it is not known if they would be grouped with others from other origins when traded (e.g. as fuel wood). Round wood intended for other purposes (e.g. fuel wood, production of chips) may contain a mixture of species. - *presence of bark*: round wood (as logs) and sawn wood may be traded with or without bark. Other types of round wood may also have bark attached. - *size*: Logs would normally be of a large size. For harvesting residues (in the form of round wood) and any material sold as fuel wood, the material may be of variable size (including branches, top of trees, branches, twigs etc.). **Sawn wood of less than 6 mm of thickness is considered to pose a minimal risk because larvae and pupae will be damaged during the processing.** - *intended use*. Such commodities may be used for construction, furniture, long poles, energy purposes, or processed (such as chips, pulp, fibreboard etc.).	*Note '(except sawdust and shavings)' is not repeated below to simplify text but is intended throughout this pathway.* Where harvesting residues are in another form than round wood (e.g. residues from squaring), the EPPO study considers that they would either be left on-site or be transformed on-site, in which case they become another commodity (e.g. wood chips, hogwood). All these commodities may be used for different purposes, such as pulp, fibreboard production, energy purposes, mulch and bark tanning. - *composition:* depending on the intended use, wood chips are produced from one or a mixture of species. This is not known for the other commodities but would presumably be the same. - *presence of bark:* wood chips or hogwood may be produced from different types of initial material (e.g. wood with or without bark, post-consumer scrap wood etc.). Processing wood residues are residues from round and sawn wood, e.g. off-cuts, and may have bark attached. As a consequence, at least part of these commodities may include some bark. - *size:* wood chips are produced through a shredder using a round-hole sieve that defines the dimension of chips (e.g. <2.5 cm) on two sides (not the third). The European Standard on solid fuel (Alakangas, 2010; CEN, 2010) identifies four classes of wood chips according to size; in the the class with the largest wood chips, 75% of wood chips should be comprised in the range 16-100 mm, and 6% can measure 200-350 mm. Hogwood or processing wood residues have no size requirement. As a consequence, both wood chips and hogwood can be quite large. - *intended use*: use of the wood commodities as mulch is presenting the highest risk (as it facilitates transfer of pests to nearby trees).

Pathway	Round wood and sawn wood of hosts	Deciduous wood chips, hogwood, processing wood residues (except sawdust and shavings)
Pathway prohibited in the PRA area?	No	No
Pathway subject to a plant health inspection at import?	Partly Wood of *Quercus* spp. from the USA should be imported in the EU and in Turkey with an import certificate stating that the wood (Annex IV.A.I point 3 of Council Directive 2000/29/EC & Ministry of Agriculture and Forestry of Turkey, 2011): (a) is squared so as to remove entirely the rounded surface, or (b) is bark-free and the water content is less than 20 % expressed as a percentage of the dry matter, or (c) is bark-free and has been disinfected by an appropriate hot-air or hot water treatment, or (d) if sawn, with or without residual bark attached, has undergone kiln-drying to below 20 % moisture content, expressed as a percentage of dry matter, achieved through an appropriate time/temperature schedule. There shall be evidence thereof by a mark 'Kiln-dried' or 'KD' or another internationally recognised mark, put on the wood or on any wrapping in accordance with current usage. This would decrease the risk of presence of *A. bilineatus*, but this is not considered enough as the pest may be present in the debarked wood, and because reaching 20% of moisture content when undergoing kiln-drying may be achieved using low temperatures compatible with the survival of *A. bilineatus* (EUPHRESCO, 2010). No requirements are given in the EU for import of *Quercus* wood from Canada or Turkey. There are only requirements for import of *Castanea* wood into the EU for the Member states which have a protected zone for *C. paracitica* and no requirements for the import of *Castanea* wood into Turkey.	Partly Wood in the form of chips, particles, sawdust, wood waste or scrap of *Quercus* spp.) from the USA should be imported in the EU and in Turkey with an import certificate, stating that it has either undergone kiln-drying to below 20 % moisture content, or has undergone an appropriate fumigation, or has undergone an appropriate heat treatment to achieve a minimum temperature of 56 °C for a minimum duration of 30 continuous minutes throughout the entire profile of the wood (including at its core) (Annex IV.A.I point 7.2 of Council Directive 2000/29/EC & Ministry of Agriculture and Forestry of Turkey, 2011). The heat treatment is assumed to efficiently eliminate the pest. However, no requirement is given for import of deciduous wood chips from Canada to the EU or to Turkey.
Pest already intercepted?	No interception reported for the EU on this pathway, not known for others. However, interceptions of Buprestidae in the EPPO region originating from the USA have already been reported on wood and bark of non-host plants (Section 8). *Agrilus* larvae are sometimes intercepted in wood packaging and dunnage.	No interception reported for the EU on this pathway, not known for other regions.
Plants concerned	*Castanea* and *Quercus* are the known hosts.	As for wood.
Most likely stages that may be associated	Eggs, larvae and pupae may be associated with wood with bark. Only the fourth instar larvae in pupal cells and pupae would be associated with wood without bark and possibly survive. Adults would be associated with consignments of wood only if they form into adults and are still in their pupal cells or emerge during transport or storage.	Given the size of larvae, and pupae, both are likely to be associated. Adults are less likely to be associated because teneral adults emerge from trees in 2 to 3 days. Live mature larvae, or pupae or teneral adults are likely to be killed during processing if wood pieces are smaller than 2.5 x 2.5 cm in two dimensions (see below).

Pathway	Round wood and sawn wood of hosts	Deciduous wood chips, hogwood, processing wood residues (except sawdust and shavings)
Important factors for association with the pathway	There may be many larvae (up to 931 per tree) or pupae in one trunk (Dunbar & Stephens, 1975). Debarking will destroy or remove eggs and feeding larvae. The presence of bark on the wood would favour survival of larvae. Low levels of infestation may not be detected. The pest would probably be more easily detected in sawn wood as galleries may be seen after sawing (in relation to short galleries when the insect enters to molt and pupate), or in round wood without bark because larval galleries can be seen directly on the sapwood surface. Date of cutting may greatly affect the number of viable larvae present in the wood. A lower proportion of the pest may survive in trees that were cut early during the summer when most larvae are early instars (Haack & Benjamin, 1980a). Kiln-drying process is expected to reduce survival of larvae in the wood. The concentration is expected to be higher in wood for bio-energy use, as wood of poor quality is usually used for this purpose and no treatment is applied afterwards.	The pest is known as a forest pest causing regular outbreaks. As heavily infested trees cannot be used as round wood or sawn wood, they may be processed (e.g. into wood chips). McCullough et al. (2007) did find some surviving *A. planipennis* in chips that had been produced from infested wood processed with a grinder with a 5 cm screen. The higher risk of introduction would arise from the presence of mature larvae, or pupae (see other considerations below).
Survival during transport and storage	Larvae would survive during transport (transit), and during subsequent storage if the wood and bark remains suitable for feeding/boring galleries. Pupae would survive. If adults emerge during transport, their survival would be more limited (range 5-11 days) (Haack & Benjamin, 1982) because there will be no foliage to feed on. *A. bilineatus* adults need maturation feeding prior to oviposition (Chamorro et al., 2015) so will not be able to lay eggs again in the consignment.	Chipping of infested wood greatly reduces survivorship of *A. bilineatus* (Dunbar & Stephens, 1974) and similarly for other agrilids such as *A. auroguttatus* (Jones et al., 2013) and *A. planipennis* (McCullough et al., 2007). Because young larvae are mostly feeding on the inner bark (phloem), and cambial tissue, any of this tissue that is present on wood chips would soon dry and not support larval growth. Survival rates of late instars may be higher than for early instars. Chipping would cause high larval mortality because of the chipping process. This was demonstrated for *A. planipennis* prepupae using a horizontal grinder with a 2.5 cm x 2.5 cm screen: no evidence of survival was observed (McCullough et al., 2007). Chipping below 2.5 cm x 2.5 cm is considered effective against *A. planipennis* [and therefore against *A. bilineatus* which has a similar size]. However, it cannot be excluded that surviving J-larvae or prepupae could have been found if a larger volume of wood chips would have been used in the experiment (Økland et al., 2012). Further, mortality of any insects that would survive chipping is presumed to be high since the chips are usually dry and because of possible other treatments (Dunbar & Stephens, 1974; McCullough et al., 2007). In addition, young larvae would not be able to survive and complete their development since the amount of wood would not be enough. Mature larvae and pupae can survive in the piece of wood in which they have survived processing.

Pathway	Round wood and sawn wood of hosts	Deciduous wood chips, hogwood, processing wood residues (except sawdust and shavings)
		Such commodities may be stored in big piles. The temperature in the core of the bulk for wood chips may become high (e.g. 55° C or greater) due to composting effect, which will affect the pest (McCullough et al., 2007). Temperatures in the periphery of the pile are expected to be much lower and seldom lethal. Thus, only part of the consignment/pile is likely to present conditions that would allow survival of larvae and pupae. If adults at the periphery of consignments emerge during transport, they would not find foliage to feed if the consignemnt is enclosed in a way which would prevent escapes in transits. They are less likely to survive, feed and reproduce (see assessment for "Round wood and sawn wood of hosts").
Trade	*Quercus* spp. and *Castanea* spp. are listed in the Working List of Commercial Timber Tree Species (Mark et al., 2014). FAO Stat (which includes data for most EPPO countries) provides data for '*non-coniferous non-tropical wood*', but the tree species and commodities concerned are not known. High volumes of industrial non-coniferous non-tropical round wood (0.7M to more than 1M m^3) and non-coniferous sawnwood (0.4M to 0.5M m^3) are imported from the USA. Significant imports also occur from Canada. Limited imports are reported from Turkey (ANNEX 7, Table 1a and Table 2a). Trade data are available in Eurostat (i.e. into the EU) for '*fuel wood as logs, billets, twigs, faggots or similar forms*' (EU CN code 44011000) as well as for logs and sawn wood of certain tree species (ANNEX 7, Table 1b and 2b). <u>- Round wood</u> Trade data is available in Eurostat (i.e. into the EU) for '*Oak '*Quercus *spp.' in the rough, whether or not stripped of bark or sapwood or roughly squared*' (EU CN code 44039100) and for '*Chestnut wood in the rough, whether or not stripped of bark or sapwood or roughly squared*' (EU CN code 440399200) Data was extracted for years 2012 to 2017 (ANNEX 7, Table 1b and below). In 2017, there were major imports of oak from the USA (10 175 tonnes) mainly to Germany, Spain and Portugal (ANNEX 7, Table 1). No import of chestnut wood is reported from known infested countries. <u>- Sawn wood</u> Trade data is available in Eurostat (i.e. into the EU) for '*oak '*Quercus *spp.*' *sawn or cut lengthwise, sliced or barked, with a thickness of > 6 mm, sanded or end jointed,*	FAOStat (which includes data for most EPPO countries) groups coniferous and non-coniferous wood chips which confirms that Canada and the USA are major exporter of woodchips (ANNEX 7, Table 3a). Turkey is the largest importer of wood chips with 2-2.5 million m^3 in 2012-2016 from USA and Canada. Other EPPO non-EU countries only have incidental imports. Trade data is available in Eurostat (i.e. into the EU) for deciduous wood chips ('*Wood in chips or particles (excl. those of a kind used principally for dying or tanning purposes, and coniferous wood)*' (EU CN code 44012200), and for '*wood waste and scrap (whether or not agglomerated in logs, briquettes or similar forms (excl. sawdust and pellets)'* (EU CN 44013980). These data overlap several commodities as described in the EPPO Study; 'wood chips' likely covers hogwood; 'wood waste and scrap (whether or not agglomerated in logs, briquettes or similar forms (excl. sawdust and pellets)' would cover part of processing residues, possibly of harvesting residues, as well as other commodities that do not present a risk; it would cover both deciduous and coniferous wood. Data was extracted for 2012 to 2017 (ANNEX 7, table 3b and 3c). The volume of such imports is expected to rapidly increase to satisfy future demands for renewable energy production in Europe (Flø et al., 2015; VKM, 2013). For example, the Norwegian Government intends to double the bioenergy production in the period 2008-2020 (VKM, 2013). <u>- wood chips</u> *Significant imports from the USA (744 - 20,790 t) in 2012-2017, mostly to Germany, Spain, France and Sweden (highest value in 2014 because of the import of 15,468 t in Germany).

Pathway	Round wood and sawn wood of hosts	Deciduous wood chips, hogwood, processing wood residues (except sawdust and shavings)
	whether or not planed or sanded (EU CN code 44079115). Data was extracted for years 2012 to 2017. There were some imports from the USA (870 – 8839 tonnes per year), from Canada (7 – 185 tonnes per year), and from Turkey (3.2 – 164) into EU countries in 2012-2017 (ANNEX 7, Table 2b).	Minor and irregular imports from other countries: *Canada: 15 t to 30 t in 2012-2017 *Turkey: 0 t to 2 t per year in 2012-2017 - wood waste and scrap *Significant imports from the USA (2,220-8,505 t) in 2013-2016, mostly to Belgium, Germany and France. No data available for 2017. Minor and irregular imports from other countries: *Canada: 18 t to 1,776 t in 2013-2016 (highest value for 2013). No data available for 2017. *Turkey: 19 to 195 t per year in 2013-2016. No data available for 2017.
Transfer to a host	Wood is often stored outdoors. If mature larvae or pupae are present in the wood, adults could later emerge. Wood is often stored close to forests or trees, so transfer is considered possible. Emerging adults would need to find a suitable host. The survival of young larvae would depend on their stage and the availability of suitable quantity of host material in a suitable state. However, the conditions in drying wood are unlikely to allow their full development for more than 1 year (see introduction of Section 8). This also supposes that the wood is not used/processed before it becomes unsuitable to support the developments of the pest.	Transfer would be similar as for '*Round wood and sawn wood of hosts*'. Transfer would be facilitated if the commodities are used outdoors (e.g. ground cover, mulch) or stored outdoors for enough time prior to processing, allowing emergence (e.g. chips for energy). However, products for ground cover (mulch) likely constitute to a small part of imports. Adults would need to find a suitable host.
Likelihood of entry and uncertainty	**Round wood with bark.** High (pathway highly favourable to entry of the pest from biological considerations. Major trade to the EU) with moderate uncertainty (volume of trade, requirements for non-EU countries, end-use of wood, size of the logs that are traded) **Round wood without bark.** Low with moderate uncertainty (real impact of the debarking process on the pupae, size of the logs that are traded) **Sawn wood of more than 6 mm with bark.** Moderate with moderate uncertainty (amount of bark, thickness of the sawn wood that are traded, proportion of sawn wood that was dried or not) **Sawn wood of more than 6 mm without bark.** Low with low uncertainty (thickness of the sawn wood that are traded, proportion of sawn wood that was dried or not)	**Wood chips >2.5 x 2.5 cm in two dimensions, hogwood, processing wood residues.** High (Survival is lower than for round wood with bark, but volumes are higher, possible lower quality than for sawn wood) with moderate uncertainty (proportion of oak within the consignment, types of processing wood residues that are traded). **Wood chips <2.5 x 2.5 cm in two dimensions.** Low with a moderate uncertainty (impact of the process in real conditions on the survival of the pest).

Table 7. Wood packaging material.

Pathway	**Wood packaging material**
Coverage	Pallets, dunnage etc. moving in trade
Pathway prohibited in the PRA area?	In international trade, WPM must be debarked and treated according to ISPM 15 (FAO, 2017a). However, unintentional noncompliance or fraud may occur (Haack et al., 2014).
Pathway subject to a plant health inspection at import?	In the EU, consignments are inspected randomly to check compliance with ISPM 15. It is expected that other EPPO countries also inspect randomly.
Pest already intercepted?	No interception of *Agrilus bilineatus* from North America reported for the EU on this pathway, not known for other countries.
Plants concerned	Oak and chestnut are wood usually accepted for contact with all food types, including solid foods. Wood packaging material is built from wood of many species. It is comprised of wood-based products such as sawn wood, plywood, particle board, oriented strand board, veneer, wood wool, etc., which has been created using glue, heat, and pressure or a combination thereof used in supporting, protecting, or carrying a commodity (includes dunnage). The current trend by many pallet producers is not to separate out pallet material by species, but rather by hardwood vs. softwood (see internet sites of pallet producers).
Most likely stages that may be associated	Larvae, pupae and newly formed adults may be present in pieces of wood used for wood packaging material if they consist of wood pieces larger than 2.5 x 2.5 cm in two dimensions.
Important factors for association with the pathway	For mature larvae or pupae to still be alive in the wood packaging material, it would suppose that: 1) Wood packaging material is made with wood from recently harvested trees. The risk would be higher if wood packaging material is made from trees harvested at the time of the year when the mature larvae are entering the sapwood to overwinter, or later to pupate; 2) Requirements in ISPM 15 *Regulation of wood packaging material in international trade* (FAO, 2017a) were not applied. These treatments should generally be effective in destroying eggs, larvae, pupae and teneral adults (see paragraph below). ISPM 15 requires that all wood packaging material moved in international trade is debarked and heat treated (either 56°C for 30 min at the core if using a conventional steam or dry kiln heat chamber; or 60 °C for 1 minute throughout the entire profile of the wood if using dielectric heating) or fumigated with methyl bromide or sulphuryl fluoride (and stamped or branded with a mark of compliance). These treatments are internationally considered adequate to destroy most insects and nematodes present in wood packaging material at the time of treatment. However, there are evidence that fraudulent marks are sometimes used (Eyre et al., 2018) 3) *Agrilus bilineatus* is not considered to be capable of re-infesting wood that is treated according to ISPM 15, as the wood would not be suitable enough for the development of the larvae. Some research on round wood shows that if the temperature in the heating chamber is below 70°C when applying ISPM 15, there might be 1% survival of *A. bilineatus* (ANNEX 1).
Survival during transport and storage	If ISPM 15 treatments were not applied, mature larvae and pupae would survive, allowing adults to emerge. If large amount of bark were not removed, this would be evidence that ISPM 15 Standard was not fully applied, and younger larvae may also survive.
Trade	Pallets are either produced from new or recycled wood. The US wood pallet and container industry is the largest consumer of all solid hardwood production in the US. Overall, the industry used 64% (by volume) hardwood and 36% softwood material in 2006. Within the hardwood category, 61% (by volume) of the lumber, cants, and parts used for pallets were of mixed species. The most commonly utilized single species was oak (27% of total hardwood use by volume).

Pathway	Wood packaging material
	A total of 441 million pallets were produced in 2006 in the US, representing 7.26 billion board feet (approximately 17.1 million m^3). When comparing 1992 to 2006, the use of oak as a single species decreased from approximately 40 to 27% of the total volume of hardwood lumber, cants, and parts used. During the same time, mixed hardwood (no species separation) increased from 33% in 1992 to 61% in 2006 (Bush et al., 1994, 2011). No trade data was sought, but there are very large quantities of wood packaging material moving in trade (although only a small proportion would contain infested host wood material).
Transfer to a host	If mature larvae or pupae are still present at destination, adults may emerge and find hosts. Transfer would require certain circumstances, i.e. that the wood packaging material is kept outdoors at destination, in an area where the host plants are present and during a time period when host foliage is available. In places where used wood packaging material is collected in large quantities (e.g. for recycling), the probability of having several infested items increases. Because of the expected higher level of adults emerging, the probability of adults finding suitable hosts and mating increases (EPPO, 2015a).
Likelihood of entry and uncertainty	**Proportion of Wood packaging material** - **on which ISPM 15 is appropriately applied.** Very low with low uncertainty. - **which is not appropriately treated according to ISPM 15.** Moderate with high uncertainty (amount of bark, thickness of the wood that is used).

- *Natural spread from countries where* A. bilineatus *occurs to EPPO countries where it does not occur*.
  Agrilus beetles may have the capacity to fly considerable distances; however, they rarely do so because they usually only have to fly short distances to find suitable hosts. *A bilineatus* is present in Turkey near Istanbul which is relatively close to Bulgaria and could spread from this area to other EPPO countries situated in the north and west of this area, using the continuum of *Quercus* species and *Castanea sativa* available (ANNEX 5, Fig. 1a – e). There is very limited information on the distribution and on the abundance of the pest in Turkey. No official measures have been taken on this pest in Turkey, to date (Üstün, personal communication, 2018).

  Likelihood of entry from Turkey by natural spread over the next 10 years in absence of eradication/control measures: High (near the border of Bulgaria); *Uncertainty*: Moderate (level of population, low climate suitability).

- *Hitchhiking on other commodities or in vehicles.*
  Hitchhiking on the outside or inside vehicles has been shown to be a pathway for *A. planipennis* (Buck & Marshall, 2008; PRA on *A. planipennis*, EPPO, 2013a) for spread of adults at relatively short distances (i.e. between neighbouring countries). In particular, in the USA and Canada, many new infestations of *A. planipennis* were found along major highways at "rest areas" where ash trees were common (Haack, personal communication, 2018). There is a significant amount of vehicle movement (including cars and boats) and large human populations in the area of Istanbul. Hitchhiking is not considered to be a significant pathway from USA or Canada.

  Likelihood of entry from Turkey to neighbouring countries including Bulgaria and other countries around the Black sea by hitchhiking: Moderate (assumed low level of pest population); *Uncertainty:* Moderate (level of population)

- *Bark of hosts*.
  This covers bark traded on its own, with the understanding that in bark consignments, pieces of cambium or wood may be attached to the bark (EPPO, 2015b). Eggs could be present on the bark before harvest, and larvae can be associated with thick bark. J-larvae, prepupae, pupae and teneral adults are mostly found in the thick outer bark or in the outer sapwood (Petrice & Haack, 2014) and could therefore be associated with bark consignments. Some eggs or larvae would be destroyed during removal of the bark and further processing. Early life stages would not complete their development in the absence of enough quantity of phloem and wood, and because the material would degrade. Even if there was enough phloem and wood material, the further development of small larvae to adults would take at least 1 year, during which the bark and wood attached would have desiccated and probably become unsuitable for larvae.

  Import of isolated bark of *Castanea* from non-European countries as well as isolated bark of *Quercus* (other than *Quercus suber*) from North American countries are prohibited in the EU. Isolated bark of *Quercus* spp. from Turkey can only be imported into the EU with an import certificate.

  Likelihood of entry: Low (low volumes/prohibition in the EU, but high percentage of pupal cells in the bark); *Uncertainty:* High (use of this material, trade to non-EU countries)

- *Cut branches of hosts.*
  It is not known whether cut branches of any of the host tree species are used (e.g. for decoration), nor if they are traded as such at international level. *A. bilineatus* is known to be less frequently associated with branches than in the main trunk (Dunbar & Stephens, 1976; Petrice & Haack, 2014). Life stages could survive and continue development, but emerging adults are unlikely to survive/find food in transport (leaves would probably be lacking or be unsuitably dry on such material). This may be a pathway (if the trade exists) for mature larvae and pupae if adults emerge at destination and find a host.

  Likelihood of entry: Moderate*; Uncertainty:* High (volume of trade, use of this material)

For all pathways and at the scale of the PRA area, it is considered that the current phytosanitary requirements in place are not enough to prevent further introductions of *A. bilineatus* into the EPPO region by import or further spread within the EPPO regions by natural spread. There are prohibitions on the import of *Castanea* spp. and *Quercus* spp. plants for planting with leaves, as well as for bark and wood (e.g. into the EU), but this is not considered enough.

Overall rating of the likelihood of entry combining the assessments from the individual pathways considered:

Rating of the likelihood of entry	*Very low* ☐	*Low* ☐	*Moderate* ☐	*High* ☒	*Very high* ☐
Rating of uncertainty			*Low* ☐	*Moderate* ☒	*High* ☐

8.2 Unlikely pathways: very low likelihood of entry

- *Furniture and other objects made of wood of host plants.*
  Oak wood is used for furniture making and flooring, timber frame buildings, veneer production, barrels of wine and spirits. For most of these objects, any exit hole would be seen as a defect. Further, *A. bilineatus* is likely to be killed during the manufacturing process. As the wood dries, the wood may become less suitable for larvae and, if pupae are present in the wood, it is not known if adults would be able to emerge from very dry wood. Some traded wood objects are known to allow the movement of insects: the longhorn beetles *Monochamus alternatus* (vectoring *Bursephalenchus xylophilus*) and *Trichoferus holosericeus* have been found in dining chairs, *Trichoferus campestris* in a wooden cutlery tray, and *Leptura quadrifasciata*, in a railway sleeper (Hodgetts et al., 2016; Ostojá-Starzewski, 2014). However, the size of some objects made of wood may not be sufficient to allow the presence or the complete development of the insect.
  Uncertainty: low.

- *Sawdust and shavings, processed wood material, post-consumer scrap wood* (see definitions in ANNEX 4). EPPO Study (EPPO, 2015b) assesses the risk as being low for all pests. Such wood material is processed to a level that would not allow survival of the pest. Any eggs, larvae, pupae or teneral adults present in the initial material would die or not be able to pursue development.
  Uncertainty: low.

- *Seeds, fruits, bulbs and tubers, grain, pollen, stored plant products, soil and growing medium*.
  No life stages are associated with these.
  Uncertainty: low.

- *Movement of individuals, shipping of live Buprestidae, e.g. traded by collectors.*
  The insect will most likely be sent dead. This pathway is also difficult to regulate as such.
  Uncertainty: low.

9. Likelihood of establishment outdoors in the PRA area

9.1 Climatic suitability

The pest is widely distributed in North America (Section 6) and has recently established in Turkey.

Regarding comparisons of climatic conditions between areas where *A. bilineatus* occurs in North America and the EPPO region:

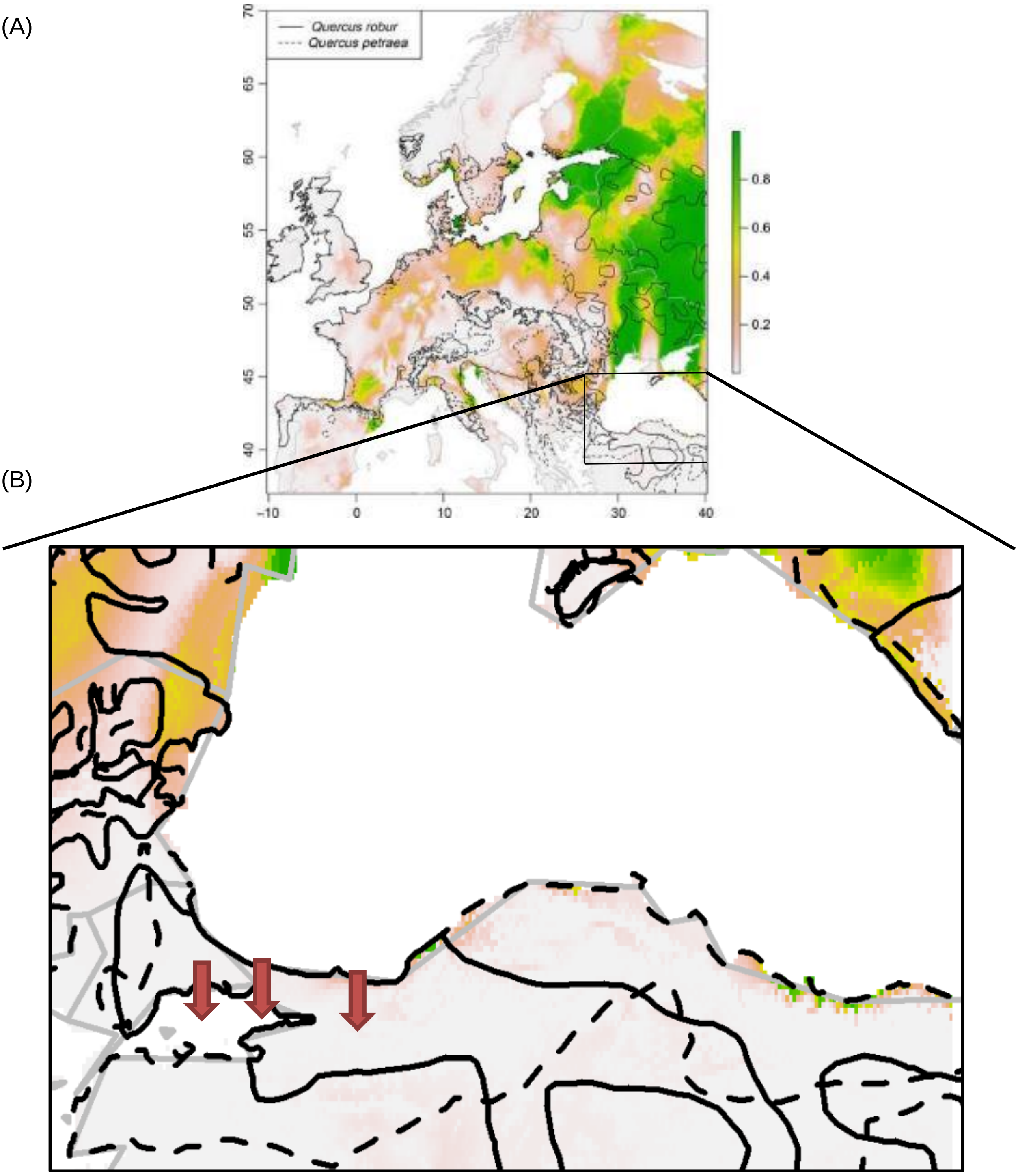
- The maps of degree-day accumulation for Europe/the Mediterranean area and North America in ANNEX 3 (Figure 1) shows similarities between a large part of the PRA area and areas where *A. bilineatus* occurs.
- In relation to plant hardiness, the distribution of *A. bilineatus* includes hardiness zones (at least) 3-9 (ANNEX 3, Figure 2), which also corresponds to a large part of the EPPO region.
- According to the classification of climates of Köppen-Geiger (maps in ANNEX 3, Figure 3), *A. bilineatus* is present in the climatic zones Cfb and Dfb. These climate types occur in the EPPO region especially in the center and eastern part of the European continent, representing respectively 42% and 8% of Europe (MacLeod & Korycinska, 2019).

Flø et al. (2015) predicted the potential distribution of the two-lined chestnut borer *Agrilus bilineatus* in Europe by Maximum entropy modelling (MaxEnt) of climatic suitability.

Figure 4A shows that *A. bilineatus* has a wide potential distribution and the environmental suitability was predicted to be particularly high in the eastern parts of Europe.

Figure 4B shows the positions of the findings of *A. bilineatus*. They are not located on the map in an area predicted as highly suitable for establishment but there is a narrow region along the Turkish coast zone towards the Black Sea in which there are areas predicted to be suitable for establishment of *A. bilineatus*. This map could corroborate the fact that the pest is established in Turkey in an area where the climate is suitable only in restricted areas and has not allowed the buildup of sufficiently high populations causing evident high impacts.

Figure 4. (A) Potential distribution of the two-lined chestnut borer *Agrilus bilineatus* in Europe predicted by Maximum entropy modelling (MaxEnt) (Flø et al., 2015). **(B)** Excerpt from the originally published map, kindly provided by D. Flø, showing the environmental suitability in the region where *A. bilineatus* has been found in Türkey. ***Legend:*** *Colours indicate probability of occurrence of* A. bilineatus *(green = high, white = low). The solid and dashed lines show the distribution of two potential host trees (pedunculate oak* (Q. robur*) and sessile oak* (Q. petraea*)) respectively. The red arrows indicate the approximate positions where* A. bilineatus *has been found (see section 6).*



Considering the above, it is suggested that the pest is pre-adapted to a wide range of climatic conditions. The pest is widely distributed in eastern North America, it may adapt its life cycle (complete life cycle usually in one year, but sometimes in two years in relation to climatic conditions and host affinity) and is situated under bark or in sapwood in winter and is therefore protected somewhat from extreme cold.

Climatic conditions would therefore probably not limit establishment of *A. bilineatus* and it is considered that the pest could establish whereever suitable host trees are present in the EPPO region.

9.2 Host plants

The *Quercus* spp. listed in Table 3 and *Castanea dentata* are known to be host plants. There is currently no data on the susceptibility of European *Quercus* species except for *Q. robur*, nor on the susceptibility of *C. sativa*. *Castanea sativa* and the many European *Quercus* species that are widespread in the EPPO region are important as timber and ornamentals trees, as well as for food for humans and wildlife (Conedera et al. 2016, Eaton et al. 2016).

Oaks

All oak species should be considered as being potential hosts for *A. bilineatus*.

A. bilineatus could adapt similarly on European *Quercus* species, as the European *A. biguttatus* and *A. sulcicollis* were shown to adapt onto North American *Quercus* species in Europe (Moraal & Hilszczanski, 2000).

In Europe there are 22 native species belonging to the genus *Quercus*, with some present as far north as southern Norway, Sweden and Finland (*Q. robur* and *Q. petraea*), while others are present in northern Africa (*Q. afares*, *Q. ilex*, and *Q. suber*) (Quercus Portal, 2017).

Pedunculate oak (*Q. robur*) and sessile oak (*Q. petraea*) are the two species most widely distributed in Europe (see maps in ANNEX 5) and belong to the most economically and ecologically important deciduous forest tree species in Europe, covering approximately 49,000 and 38,000 km2, respectively (Ducousso & Bordacs, 2004; Eaton et al., 2016). Pedunculate oak is very tolerant to soil conditions and the continental climate. It can be found in periodic wet areas by streams and rivers but prefers fertile and well-watered soils. Pedunculate oak is a pioneer species in plains and hills, while it is a late successional species in valleys and floodplains (Ducousso & Bordacs, 2004). Another oak species (*Q. pubescens*), covers 25,000 km2 in Europe (Hemery, 2008).

Northern red oak (*Q. rubra*) is native to the eastern USA, where it has a wide distribution range. It is a fast-growing and valuable broadleaved tree due to its ecological characteristics, good wood properties and high economic value. The tree was introduced to Europe near the end of the 17th century to improve timber yields and is now naturally found throughout Europe, except in the coldest part of Scandinavia. The tree is also valued as an ornamental (e.g. in parks, public gardens and as a common street tree), given its symmetrical shape and significant red autumn foliage, and remains an important timber species in many countries today. However, the tree has generated controversy given its invasive nature and the current focus on promoting the declining European oak species instead. *Q. rubra* is often found in pure stands, where it grows on a wide variety of soils. However, the tree prefers deep, well-drained loamy soils (EUFORGEN, 2018; Nicolescu et al., 2018). *Q. rubra* covers over 350 000 ha in Europe with the most important forest areas in Ukraine (192 868 ha), France (52 000 ha) and Germany (44 550 ha (Nicolescu et al., 2018).

Turkey oak (*Q. cerris*) is grown in southern Europe and Asia Minor in mixed forest stands and is used for reforestation or as ornamental (EUFORGEN, 2018).

Cork oak (*Q. suber*) is grown in the coastals region of the western Mediterranean basin as a source of cork, for wine stoppers, panels, floor, wall tiles and sound-proofing materials in the car industry (EUFORGEN, 2018).

The bark of *Quercus alba* is used in medical preparations, by tanners for tanning leather, or for mulching.

Other species such as *Q. frainetto*, *Q. ilex*, *Q. palustris*, *Q. pedunculiflora*, *Q. trojana*, *Q. virgiliana* and *Q. vulcanica* are also found in the EPPO region (EUFORGEN, 2018). A list of native Quercus (applying at least for Europe and Turkey, probably wider) is provided in ANNEX 6.

Chestnut

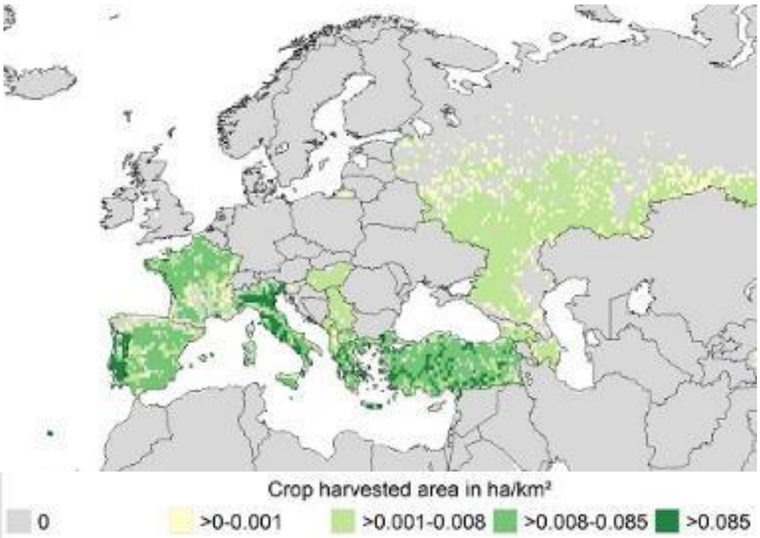
All chestnut species should be considered as being potential hosts for *A. bilineatus*.

Castanea dentata is not considered to be present in the EPPO region except in a few arboreta.

Castanea sativa, the only native and widespread species of *Castanea* in the EPPO region (Figure 5 and ANNEX 5), occurs from England and Belgium in northern Europe, southward to Morocco in North Africa, and eastward through southern Europe to Azerbaijan (Conedera et al., 2016; Monfreda et al., 2008). It is cultivated for fruit and as a forest or ornamental tree, and is also growing in the wild. In forests, it is often present as a secondary species in mixed forests of several tree species, but there are also pure chestnut forests;

these are very widespread covering ca two millions ha (from Turkey to the Iberian peninsula, through southern Switzerland and France, incl on the Mediterranean islands). Such forests may be used for wood production, fruit or they may be unmanaged (EPPO, 2018a). This species is not known to be a host plant for *A. bilineatus* larvae.

Figure 5. Chestnut crop distribution (Monfreda et al., 2008). Remark: data for some countries may be missing.



9.3 Biological considerations

When introduced, an important factor for the establishment is that the development rate of the pest can be influenced by the host plant and climate conditions (section 9.1).

For the establishment of a population, there should be simultaneous entry of several individuals. Adults have a limited lifespan (about 8-38 days), which may limit the chances of finding a mate (if individuals are isolated), and of finding a host for feeding and oviposition. Where mating occurred during transport, mated females may escape the consignment at destination, find a host and lay eggs. As eggs may be laid sometimes together (in groups of 2–10 eggs) and in relatively high numbers (average 23-77 eggs throughout the adult's lifespan under laboratory conditions), it may result in the establishment of a population.

A. bilineatus shares the same host genera (*Quercus* and *Castanea*) with many other existing *Agrilus* spp. in the EPPO region. There is no information indicating that establishment could be prevented by competition from existing *Agrilus* species in the PRA area, such as *Agrilus biguttatus.*

Rating of the likelihood of establishment outdoors	*Very low* ☐	*Low* ☐	*Moderate* ☐	*High* ☐	*Very high* ☒
Rating of uncertainty			*Low* ☒	*Moderate* ☐	*High* ☐

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

A. bilineatus is a pest of woody plants, which are normally not grown under protected conditions in the PRA area. However, bonsais and ornamental plants may be grown in protected conditions, e.g. in nurseries or botanical gardens. Establishment would require that *A. bilineatus* is able to complete its life cycle on plants that are small in size. However, the pest would be easier to detect and eliminate in protected conditions.
Quercus plants for planting are usually grown during a limited period in protected conditions and are often planted outdoors afterwards. Therefore, the risk of establishment is related to open field conditions rather than to protected conditions.

11. Spread in the PRA area

A. bilineatus is considered to be a good flyer. However, it is assumed that the dispersal of *A. bilineatus* will generally be low (less than 1 km per year), if suitable hosts are available. Speed of spread will likely be affected by how easily it can locate suitable hosts, and whether it will be capable of infesting *Quercus* spp. and *Castanea sativa* that are currently not known as hosts and are widespread in the EPPO region (Section 2.4).

At longer distances, the pest could be transported in wood and wood products, including wood packaging material (if not treated according to ISPM 15, e.g. when circulating within the EU or within countries) or in plants for planting. Hitchhiking can play a role at least locally (Section 8).

In North America, the spread of *Agrilus planipennis* was higher than predicted (more than 50 km per year). In about 25 years it has moved southwards from Michigan to Texas, and westwards to South Dakota (USDA, 2018). It is most likely a combination between natural and human assisted spread, even though quarantine measures were applied. In Russia, the spread was estimated to be 10-12 km per year (Musolin et al., 2017).

In conclusion, if *A. bilineatus* behaves like *A. planipennis*, speed of natural spread (e.g. from Turkey) will depend on the situation (host plant availability and distribution in a given landscape) and spread can be increased by hitchhiking. There may also be '*jumps*' with wood packaging material, wood and plants for planting, that would lead to multiple outbreaks and decrease the time to spread to its maximum extent within the EPPO region.

Rating of the magnitude of spread	*Very low* ☐	*Low* ☐	*Moderate* ☒	*High* ☐	*Very high* ☐
Rating of uncertainty			*Low* ☐	*Moderate* ☒	*High* ☐

Uncertainty: host range, no direct data on spread capacity for this pest

12. Impact in the current area of distribution

Nature of the damage: See details in section 2.5.
Damage is mainly caused by larvae when constructing tunnels in the cambial region, which can result in girdling the conductive tissues of the tree which leads to subsequent branch and tree death.

<u>In North America:</u>
Impact
The larvae construct galleries in the phloem and outermost xylem tissues leading to a decrease of transport capacity by the phloem sieve tubes and xylem vessels, which can lead to crown dieback and eventually tree death. Eventhough *A. bilineatus* has been reported infesting (Dunbar & Stephens, 1975; Dunn et al., 1987) and sometimes killing healthy trees (Haack, 1986; Kotinsky, 1921), this beetle is usually a secondary pest (Dunn et al., 1990), infesting and killing *Castanea dentata* and *Quercus* trees weakened by various other stress events (Dunn et al., 1987).
For example, widespread *A. bilineatus* outbreaks have frequently followed periods of severe drought (Haack & Benjamin, 1982; Haack & Mattson, 1989; Hursh & Haasis, 1931; Millers et al., 1989) and defoliation (Baker, 1941; Cote & Allen, 1980; Dunbar & Stephens, 1975; Haack, 1985; Kegg, 1971; Knull, 1932; Millers et al., 1989; Muzika et al., 2000; Nichols, 1968; Staley, 1965; Stringer et al., 1989; Wargo, 1977). Other outbreaks of *A. bilineatus* have followed ice storms, hail damage, and late spring frost events (Haack, 1985). Individual trees or small groups of trees have also been killed by *A. bilineatus* in areas where soil compaction has occurred or soil levels have dramatically changed, which can occur during construction in wooded sites (Felt & Bromley, 1932; Haack & Acciavatti, 1992; Koval & Heimann, 1997). In such situations, the pest has the ability to rapidly increase in number and bring about large-scale host mortality (Bright, 1987).
A. bilineatus-related mortality of *Quercus* trees tended to increase along an acidic-deposition gradient in the central USA (Haack, 1996; Haack & Blank, 1991). It is therefore plausible that pollutants could stress oaks sufficiently to increase their susceptibility to *A. bilineatus* attacks.
Stress events may sometimes have been caused by other pests, such as defoliation by the gypsy moth, *Lymantria dispar* after having extended its range in the eastern USA (Muzika et al., 2000). A chronological summary of oak mortality in the eastern USA (from 15% to 90% of the oak trees affected in a stand) cites *Agrilus* spp. as a regular cause of tree mortality in association with other pests (Millers et al., 1989). *A. bilineatus* has been reported to infest host trees that were already infected with various disease organisms, such as armillaria root rot (*Armillaria* spp.) (Wargo, 1977; Wargo et al., 1983), oak wilt [*Bretziella fagacearum* (=*Ceratocystis fagacearum*)] (Lewis, 1987; Stambaugh et al., 1955), and chestnut blight (*Cryphonectria parasitica*) (Dunn et al., 1990; Metcalf & Collins, 1911). These diseases (e.g. *Armillaria mellea*) appeared

sometimes to be the primary cause of the death of the tree (Chapman, 1915). Therefore, impact of the pest is sometimes difficult to evaluate.
However, the pest is qualified as being one of the principal factors contributing to the mortality of weakened oaks in eastern North America (Haack, 1980).

Individual outbreaks usually persist for a few years, often subsiding once normal rainfall resumes or defoliator populations fall to endemic levels. Tree death usually takes 1-3 years, depending upon the number of insects attacking the tree (Koval & Heimann, 1997) and other stress factors (e.g. highest mortality 2 years after heavy insect defoliation (Wargo et al., 1983)). When an entire tree is killed, the borers will often infest and kill surroundings trees (Koval & Heimann, 1997).

Historically in North America, high levels of tree mortality attributed to this pest have been reported, representing, for example, up to 75% of chestnut trees in Fairfax County (Virginia) in 1893, these trees being presumably stressed by various factors (Chittenden, 1897a). No recent reports of mortality on *Castanea dentata* are available, likely because this species was subject to large and rapid declines in the early 1900s in North America because of *C. parasitica* (IUCN red list). *A. bilineatus* is reported as causing the death of isolated oak trees as well as groups of oaks of different ages (Hopkins, 1894). Annual forest pest reports produced by each state's Department of Natural Resources of the three "Lake States" (Michigan, Minnesota and Wisconsin) between years 1950 to 2017 mention *A. bilineatus* at least as a pest in 90 reports of the 197 reports available, and as causing moderate to severe damage in 50 of these 197 reports (Haack & Petrice, 2019).

Although this pest is never found in the heartwood, if the tree is killed, it will be infested by other secondary pests which can seriously affect the usage of wood, causing losses to forestry production during outbreaks.

In addition, infestations significantly reduce the aesthetic value of the ornamental trees (including the European *Q. robur*) (Haack, 1986).

Existing control measures
Under forested conditions, control is usually impractical except where strict management practices are employed (Dunbar & Stephens, 1976). Use of insecticides against this pest can have environmental impacts.

Sanitation, silvicultural and physical methods:
Sanitation cutting of infested branches or trees prior to adult emergence, followed by burning or chipping, has been recommended for a long time in North America (Dunbar & Stephens, 1976; Haack, 1985; Haack & Acciavatti, 1992; Hopkins, 1904; Koval & Heimann, 1997). Alternatively, cutting infested trees early in summer when most larvae are early instars, and cutting the trunks in short sections and allowing the logs to remain in the forest, can greatly reduce subsequent adult emergence because the host tissues dry out too quickly to support complete larval development (Haack & Benjamin, 1980a; Petrice & Haack, 2006a). As *A. bilineatus* is attracted to stressed trees, removal of overstory trees of low vigour and low starch reserves (Dunn et al., 1990) can help maintain low populations of this pest (Muzika et al., 2000).

Cultural practices:
As for some other *Agrilus* species, anything that stimulates growth and promotes tree vigor should help prevent attack. In a small woodland or for valuable shade trees where expense is not often a limiting factor, watering, fertilization and spraying to prevent defoliation are useful in maintaining tree growth and vigor (Dunbar & Stephens, 1976). Such practices are best suited for urban areas or for valuable shade trees. However, at a forest stand level, thinning in advance of gypsy moth (*Lymantria dispar*) defoliation appeared to lessen subsequent *Quercus* mortality caused by *A. bilineatus* (Muzika et al., 1997).

Chemical control:
As for *A. planipennis*, no practical treatment is available to control the pest in forest on large scale situations. Treatments are currently costly and are only used for high value trees (e.g. urban trees, ornamentals). Several insecticides have been used over the past century to protect or treat host trees from *A. bilineatus* infestation, many of which are now prohibited. Insecticides can also be used to control defoliating insects, which should help maintain host vigor and thus reduce susceptibility to *A. bilineatus* (Felt & Bromley, 1931; Haack & Acciavatti, 1992). Insecticides used to target *A. bilineatus* have been applied as trunk and foliar sprays for leaf-feeding and egg-laying adults, as well as sprays to the bark surface of trees and logs to target the overwintering stages and adults as they chew through the bark (Dunbar & Stephens, 1974, 1976; Felt, 1935; Haack &

Benjamin, 1980b; Herms et al., 2014). Since the early 2000s, several new insecticides (e.g., azadirachtin, emamectin benzoate, clothianidin, dinotefuran & imidacloprid) have been tested in the USA for control of *A. auroguttatus* (Jones et al., 2013) and *A. planipennis* (Herms et al., 2014; McCullough et al., 2011; Petrice & Haack, 2006b; Smitley et al., 2015). The above new classes of insecticides are registered in the USA for other buprestid borers, including *A. bilineatus*. These newer products are applied as soil drenches or soil injections, trunk injections, or cover sprays on the trunk, branches, and foliage (Herms et al., 2014).

Repellents:
Repellent sprays such as lime sulphur, white wash, iron sulphate and Bordeaux mixture can be used in preventing adult females from oviposing on treated trees. However, it would be difficult to obtain a suitable bark coverage and rain would wash the material which make the interest of repellent sprays questionable (Dunbar & Stephens, 1976). Therefore, repellents are considered as being an experimental rather than a practical control measure.

Biological control:
Several natural enemies of *A. bilineatus* have been reported in the literature, including both parasitoids and predators. Some of the larval parasitoids include species in the genera *Atanycolus* (Braconidae), *Leluthia* (Braconidae), *Phasgonophora* (Chalcididae), *Spathius* (Braconidae), and *Wroughtonia* (Braconidae) (Chapman, 1915; Chittenden, 1897a; Cote & Allen, 1980; Haack et al., 1981; Hopkins, 1892; Petrice & Haack, 2014). It is also reported that a species of *Trichogramma* has been reared from an *A. bilineatus* egg (Chapman, 1915). Similarly, some of the larval and pupal predators were species of *Adelocera* (Elateridae), *Cymatodera* (Cleridae), *Phyllobaenus* (Cleridae), and *Tenebrioides* (Trogossitidae) (Cote & Allen, 1980; Dunbar & Stephens, 1976; Haack et al., 1981). Various bird species also feed on *A. bilineatus* adults and within-tree life stages (Cote & Allen, 1980; Dunbar & Stephens, 1976).

<u>In Turkey</u>

Impact

No impacts have been observed to date at the different sites where the pest has been reported in Turkey (Hızal, personal communication, 2018). Host and/or climatic conditions may not be suitable to build up high populations of *A. bilineatus* at this time (Section 9.1).
It should be noted that for *A. planipennis*, 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). No widespread damage was reported for the first 10 years after initial introduction, during which time populations built up. A similar scenario may occur in Turkey.

Existing control measures

No control measures have been taken so far against this pest (Üstün, personal communication, 2018).

Rating of the magnitude of impact in the current area of distribution	*Very low* ☐	*Low* ☐	*Moderate* ☒	*High* ☐	*Very high* ☐
Rating of uncertainty			*Low* ☒	*Moderate* ☐	*High* ☐

This rating is for North America (Turkey is excluded).

13. Potential impact in the PRA area

Will impacts be largely the same as in the current area of distribution? Yes /No, not like in North America

All oak and chestnut species are considered as being potential hosts for *A. bilineatus* in the EPPO region (Section 7 and 9.2). The impact in the EPPO region is expected to be different from the impact observed in North America because of the difference of susceptibility of European native *Quercus* species and of *C. sativa* compared to North American host species.

Pedunculate oak (*Q. robur*) is one of the the two oak species most widely distributed in Europe and belongs to the most economically and ecologically important deciduous forest tree species in Europe (Section 7). In France, the three main forest species used as standing wood are *Q. robur*, *Q. petrea* and *C. sativa* and represent 11%, 11% and 5% of the volume respectively (IGN, 2017). For the moment, *Q. robur* is the only native European tree species for which there is data on susceptibility to *A. bilineatus*, and it was found to be highly susceptible. The pest infested and killed healthy ornamental *Q. robur* planted on the Michigan State University

(MSU) campus (Haack RA, unpublished data), and at two MSU Experimental Forest genetic test sites where it was inter-planted with native *Q. alba* and *Q. rubra* trees (Haack, 1986) (Table 8). *A. bilineatus* also readily attacked *Q. robur* trees in Michigan that were artificially girdled to induce stress, and among these trees, *A. bilineatus* attacked trees showing less evidence of stress compared to *A. sulcicollis* (Petrice & Haack, 2014). It should be noted that *Q. robur* are alive in other sites where *A. bilineatus* is present in the USA.

Table 8. Monitored *A. bilineatus*-associated yearly mortality of *Quercus alba* and *Q. robur* during 1984-88, Michigan State University Kellogg Forest in South-West Michigan. Trees (88 *Q. alba* and 90 *Q. robur*) were mixed and planted in 1962 (Haack RA, unpublished data)

	Cumulative percent of dead trees	
Year	***Quercus alba***	***Quercus robur***
1984	3%	25%
1985	3%	31%
1986	3%	43%
1987	3%	58%
1988	4%	67%

The potential impact of *A. bilineatus* depends on susceptibility of *Castanea sativa* and European *Quercus* host species. An *Agrilus* species may infest only weaken trees (of host species that have co-evolved with it) in its area of origin but can infest and kill apparently healthy trees of other species in the same host genus in new areas where they are introduced. This has been shown for North American *A. bilineatus* on European *Q. robur* species, as well as for the North American *A. anxius* on Eurasian *Betula* species (Miller et al., 1991; Nielsen et al., 2011); for the Asian *A. planipennis* on European and North American *Fraxinus* species (Haack et al., 2015); for the Mexican *Agrilus prionurus* on *Sapindus* in Texas (Billings et al., 2014); and even the Arizona species *Agrilus auroguttatus* on *Quercus* in California (Coleman & Seybold, 2011). However, this does not seem to be the case for *A. sulcicollis* following its introduction in North America (Petrice & Haack, 2014).

The potential impact would also depend on other stress factors. For example, declines are reported to frequently affect *Quercus robur* and, to a lesser extent, *Quercus petraea* and other oak species in Europe (Sallé et al., 2014). The introduction of *A. bilineatus* in new European regions may play a prominent role, preventing weakened trees from recovering and pushing the impacted ecosystem beyond a reversibility threshold. Moreover, considering that, together with temperature, the frequency and duration of severe droughts are expected to increase in the future years because of climate change, the impact of wood boring insects (such as *A. bilineatus*) is likely to be more important in the future (Sallé et al., 2014).

A. bilineatus could therefore kill isolated trees as well as large groups of trees. This would have an impact on wood production yields. Moreover, damage would decrease timber quality because of the larval gallery systems and because of subsequent colonization by secondary pests. The aesthetic value of ornamental oaks in parks, public gardens and as street trees would also be impacted. More generally, this pest could have an impact on the landscape if trees are already stressed on a large scale by other factors.

As for other wood borers, early detection and control would be rendered difficult because adults are only present for a short window of time, and the hidden life habits of larvae and pupae. Adults would be detected at best one year after egg-laying. Control would imply costly measures (see existing measures in the USA) and an environmental impact if phytosanitary treatments are applied.

Several parasitoids have been reported for *A. biguttatus* and other native *Agrilus* spp., including species in the genera *Deuteroxorides* (Ichneumonidae), *Atanycolus* (Braconidae), *Spathius* (Braconidae), *Baryscapus* (Eulophidae), *Eusandalum* (Eupelmidae) and *Agrilocida* (Pteromalidae) (reviewed in Kenis & Hilszczanski, 2004). Few predators have been reported and include woodpeckers and clerid beetles (e.g. *Thanasimus formicarius*) (Brown et al., 2014; Kenis & Hilszczanski, 2004). However, these natural enemies might not be sufficient to control *A. bilineatus* if introduced.
The sweet chestnut *C. sativa* has a remarkable multipurpose character, and may be managed for timber production (coppice and high forest) as well as for fruit production (traditional orchards), including a broad range of secondary products. Chestnust trees have cultural significance for people in some areas of Europe (e.g. in Spain) when these forests are used for tourism and as Natural Reserves.

Oak is one of the most valuable hardwood species in Europe (Attocchi, 2015). The wood from oaks is hard and durable and valued for several purposes including for construction, furniture, veneer, fencing and firewood. It has a high tannin content, which makes it resistant, to some extent, to insect and fungal attacks and is particularly useful for wine and spirit barrels. Oak trees have cultural significance for people throughout Europe and the trees or leaves are frequently used in national or regional symbols. *A. bilineatus* could therefore have a social impact in the EPPO region.

In 2018 for the EPPO region, the IUCN Red list (https://www.iucnredlist.org/) does not describe oak species being threatened (ie. vulnerable, endangered or critically endangered). However, some are considered as being near threatened such as *Q. aucheri* in Greece and Turkey. Nevertheless, other species were listed as endangered in 2007 such as *Q. alpestris* in Spain (Oldfield & Eastwood, 2007) and their current status is unclear. Introduction of *A. bilineatus* in such areas could contribute to the population decrease of these threatened or near-threatened *Quercus* species.

Oak species also have an important ecological role. Their acorns provide a valuable food source for many wildlife species. The canopy of oaks allows a fair amount of light to pass through, permitting a diverse and enriched understory (EUFORGEN, 2018). Oaks also provide additional ecosystem services such as soil protection/stabilization and improvement, carbon sequestration, habitat for wildlife (including birds, mammals and insects), as shelterbelt, windbreak (plain areas, continental sand dunes) and fire belt (pine regions) (Nicolescu et al., 2018). Decline of oak species therefore also affect other species in the environment. Chestnut trees provide similar ecosystem services, and traditional orchards also form an ecological foundation for many other species (EUFORGEN, 2018).

Rating of the magnitude of potential impact	*Very low* ☐	*Low* ☐	*Moderate* ☐	*High* ☐	*Very high* ☒
Rating of uncertainty			*Low* ☐	*Moderate* ☒	*High* ☐

Uncertainty: situation in Turkey, limited data about Q. robur *in North America, higher susceptibility of European native species, potential control by natural enemies*

14. Identification of the endangered area

A. bilineatus could establish in the whole EPPO region wherever *Quercus* and *Castanea* trees are present.

15. Overall assessment of risk

Summary of ratings:

	likelihood	**Uncertainty**
Entry (overall)	**High**	**Moderate**
Host plants for planting with a diameter < 2 cms	Low	Low
Host plants for planting with a diameter > 2 cms	Moderate	Moderate
Round wood with bark	High	Moderate
Round wood without bark	Low	Moderate
Sawn wood of more than 6 mm with bark	Moderate	Moderate
Sawn wood of more than 6 mm without bark	Low	Low
Wood chips >2.5 x 2.5 cm in two dimensions, hogwood, processing wood residues	High	Moderate
Wood chips <2.5 x 2.5 cm in two dimensions	Low	Moderate
Wood packaging material (including dunnage) on which ISPM 15 is appropriately applied.	Very low	Low
Wood packaging material (including dunnage which is not appropriately treated according to ISPM 15.	Moderate	High
Natural spread in 10 years	High	Moderate
Hitchhiking on other commodities or vehicles	Moderate	Moderate
Bark of hosts	Low	High
Cut branches	Moderate	High

Establishment outdoors	**Very high**	**Low**
Spread	**Moderate**	**Moderate**
Magnitude of impact in the current area of distribution	**Moderate**	**Low**
Magnitude of potential impact	**Very high**	**Moderate**

Entry: the pest has already been introduced in the EPPO region, and is reported from a small part of Turkey, near Istanbul. The probability of further entry was considered as high with a moderate uncertainty, the highest ratings being for host plants for planting, round wood with bark, wood chips, hogwood and processing residues bigger than 2.5 cm in two dimensions, natural spread from neighbouring countries and wood packaging material (if ISPM 15 is not applied). It should be noted that several EPPO countries (e.g. the EU countries) already have requirements associated with these pathways, which are likely to have reduced the risk of entry of the pest in these countries.

Establishment outdoors: establishment of *A. bilineatus* is very likely to occur in the EPPO region (with a low uncertainty) as the susceptible species *Quercus robur* and *Q. rubra* are widespread and the climate is not considered as a limiting factor. Other *Quercus* species and *Castanea sativa* are likely to also be susceptible to this pest.

The magnitude of spread was rated moderate (mean of 1-10 km per year) with a moderate uncertainty. The pest could spread naturally and by hitchhiking on vehicles from Turkey and is likely to reach Bulgaria and neighbouring countries in the next 10 years (ie. by 2029). In addition, there may be longer 'jumps' with movement of wood, wood products or plants for planting, which would increase the spread.

Impact (economic, environmental and social) is likely to be very high. Larvae can girdle the conductive tissues of host trees, potentially leading to subsequent branch and tree death. Host plants, *Quercus* and *Castanea*, are major forest and ornamental trees in the EPPO region. The uncertainty of the impact is moderate, as impact could be reduced to high if not all *Quercus* and *Castanea* species are hosts and if natural enemies provide some control.

The EWG considered that phytosanitary measures to prevent further introductions should be recommended for all *Quercus* and *Castanea* species.

Phytosanitary Measures to reduce the probability of entry: Risk management options are considered for host plants for planting, wood of hosts and wood chips, hogwood and processing wood material. ISPM 15 is a sufficient measure for wood packaging material. Hitchhiking also presented a risk of introduction, but no measures were defined.

Stage 3. Pest risk management

16. Phytosanitary measures

16.1 Measures on individual pathways

Measures were studied (ANNEX 1) for host plants for planting, round wood and sawn wood of hosts, and wood chips, hogwood and processing wood residues. ISPM 15 should be applied for wood packaging material. Measures for bark are suggested in the table below. Hitchhiking also presented a risk of introduction, but no measures were defined.

The EWG recommended that measures should apply to the entire host genera *Castanea* and *Quercus* and not only to known host species, i.e. it is considered that the host range of *A. bilineatus* is wider than what is known from where it occurs (section 7).

Possible pathways *(in order of importance))*	**Measures identified (see Annex 1 for details)**
Plants for planting of *Castanea* spp., *Quercus* spp. (except seeds, tissue cultures and pollen)	PFA (see requirements below) and plants packed in conditions preventing infestation during transport. Or Pest-free site of production under complete physical isolation (PM 5/8 *Guidelines on the phytosanitary measure* 'Plants grown under complete physical isolation') + Plants packed in conditions preventing infestation during transport (or moved outside the period where adults are present).
Round wood and sawn wood (> 6mm) of *Castanea* spp. and *Quercus* spp.	PFA (see requirements below) Or Debarking followed by heat treatment (minimum temperature of 56 °C for a minimum duration of 30 continuous minutes throughout the entire profile of the wood (including its core)). Or Irradiation (EPPO Standard PM 10/8(1) *Disinfestation of wood with ionizing radiation*) Or Fumigation with sulfuryl fluoride (only for debarked wood below 20 cm in cross-section) (ISPM 28 PT 22 or PT 23 (FAO, 2017b, 2017c)) Or Removal of bark and 2.5 cm of outer xylem in authorized facilities
Wood chips, hogwood, processing wood residues obtained in whole or part from *Castanea* spp. and *Quercus* spp.	PFA (see requirements below) and storage and transport to prevent contamination by adults under control of the NPPO.
Wood packaging material obtained in whole or part from *Castanea* spp. and *Quercus* spp.	ISPM 15
Bark of *Castanea* spp. and *Quercus* spp.	PFA (see requirements below)
Cut branches of *Castanea* spp. and *Quercus* spp.	PFA (see requirements below)

Measures considered by the EWG but not retained:

Plants for planting of *Castanea* spp., *Quercus* spp. (except seeds, tissue cultures and pollen)

- Pre- or Post-entry quarantine (2 years);
- Visual inspection at the place of production;
- Visual inspection of the consignment;
- Plants with diameter below 2 cm;
- Plants packed;

Round wood and sawn wood (>6mm) of *Castanea* spp. and *Quercus* spp.:

- Visual inspection at the place of production;

- Harvesting in summer;
- Inspection;

Wood chips, hogwood, processing wood residues obtained in whole or part from *Castanea* spp. and *Quercus* spp.:

- For wood chips: chipped into pieces of less than 2.5 cm in two dimensions;
- Packed to avoid escape of the pest and processing or burning immediately after import;
- Visual inspection at the place of production;
- Specific packing;
- Harvesting in summer;

Bark of *Castanea* spp. and *Quercus* spp.:

- Treatment (heat treatment, irradiation, fumigation);
- Chipped into pieces of less than 2.5 cm in two dimensions;

Cut branches of *Castanea* spp. and *Quercus* spp.:

- Treatment (heat treatment, irradiation, fumigation).

Requirements for establishing a PFA:

PFA is not considered applicable in Eastern North America.

Measures proposed to establish a PFA are similar to the requirements proposed for *A. planipennis* (EPPO, 2013):

- 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 (using trapping and other methods) should be conducted in the area in the three 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/introduced.
- There should be restrictions on the movement of host 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.

16.2 Eradication and containment

This pest may fly long distances and early detection of an infestation and control are difficult. Therefore, it would be extremely difficult to eradicate (see section 11. Spread). 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 host resources available to the pest but may increase local spread.
Monitoring to determine pest distribution and densities, as well as inventories and surveys for host abundance and distribution, prior to developing strategies to slow the natural dispersal. The strategy should involve:
- activities to suppress populations by removing infested trees (before adult emergence), insecticide treatments, host utilisation or removal (harvesting for timber or firewood),
- regulatory measures such as restrictions on the movement of host material originating from areas where the pest is present.

Public information and outreach campaigns (support of residents and landowners) may help an earlier reporting of findings and a better implementation of measures.
This could be completed later by biological control when more knowledge would be available on this.

Remark: Emamectin benzoate, a systemic insecticide administered by trunk injection, has demonstrated three years of control against both *Agrilus* larvae and leaf-feeding *Agrilus* adults (Herms et al., 2014; Mccullough et al., 2011; Smitley et al., 2010). Using emamectin benzoate, it is reported that girdling *Fraxinus* trees 2–3 weeks after insecticide injection, created lethal trap trees that were attractive to *A. planipennis* adults (McCullough et al., 2016). There have been anecdotal reports from tree care professionals in the USA, claiming that emamectin benzoate is very effective for controlling *A. bilineatus* for three years, however, no actual test results have been published to date for *A. bilineatus*. This active substance is authorized on other uses in Europe under the name emamectin (e.g. in the EU by injection of palm trees for *Rynchophorus ferrugineus* (ANSES, 2018)).

17. Uncertainty

Main sources of uncertainty within the risk assessment are linked to the host range, to the higher susceptibility of European native host species, to the potential impact on *Castanea sativa* as well as on other European *Quercus* species, to the spread capacity for this pest, to the very limited information available on the distribution and impact of the pest in Turkey and to the potential control by natural enemies in Europe.

18. Remarks

- A survey should be conducted in Turkey using girdled trees and/or traps to check the extent of the distribution.
- Survey should be conducted in neighbouring countries.
- Countries importing high risk material from infested area in North America and Turkey should conduct surveys.
- Planting sentinel trees (of *Quercus* and *Castanaea* species present in the EPPO region) in infested areas would be useful to gather data on the susceptibility of European tree species to the pest.
- A survey targeting *A. bilineatus* on all *Castanea* and *Quercus* species present in infested countries would be useful to determine their susceptibility.

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ANNEX 1. Consideration of pest risk management options

The table below summarizes the consideration of possible measures for the pathways '*plants for planting*','*round wood and sawn wood*', and '*wood chips, hogwood, processing wood residues (except sawdust and shavings)*' (based on EPPO Standard PM 5/3). Measures for isolated bark and cut branches may be extrapolated from the ones described for round wood and sawn wood.
For measures, all *Castanea* and *Quercus* species are considered as potential host plants.
When a measure is considered appropriate, it is noted "yes", or "yes, in combination" if it should be combined with other measures in a systems approach. "No" indicates that a measure is not considered appropriate. A short justification is included. Elements that are common to several pathways are in bold.

Option	Host plants for planting	Round wood and sawn wood (> 6 mm) of hosts	Wood chips, hogwood, processing wood residues (except sawdust and shavings)
Existing measures in EPPO countries	No, see section 8.	Partly, see section 8.	No, see section 8.
Options at the place of production			
Visual inspection at place of production	Yes, in combination* (for measures marked with *, see after the table). **Detection by visual inspection is unlikely to be completely effective and needs to be used within a systems approach. Infestation is difficult to detect without destructive sampling (signs and symptoms may be restricted to exit holes and galleries under the bark. Larvae may not produce signs externally visible).** Plants should be free from signs and symptoms of infestation.	Yes, in combination*. As for plants for planting, but detection by visual inspection in a forest would be more difficult due to the size and location (e.g. small exit holes relatively high in the trees) and number of trees.	Yes, in combination*. As for wood.
Testing at place of production	No. **Not possible without destroying the trees.**	No. As for plants for planting	No. As for wood
Treatment of crop	No. For *A. planipennis*, 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 for *A. planipennis* in nurseries in the USA and Canada (EPPO, 2013). Injection is quite expensive and would be available only for high value plants.	Not relevant in forest.	Not relevant in forest.
Resistant cultivars	Not available	Not available	Not available
Growing the crop in	Yes, for bonsais.	Not relevant	Not relevant

Option	Host plants for planting	Round wood and sawn wood (> 6 mm) of hosts	Wood chips, hogwood, processing wood residues (except sawdust and shavings)
glasshouses/ screenhouses	Yes (theoretically) for others. Plants for planting could be grown under protected conditions with sufficient measures to exclude the pest (following EPPO Standard PM5/8(1) Guidelines on the phytosanitary measure 'Plants grown under complete physical isolation' - (EPPO, 2016)). However, this is not common practice for nurseries of forest or ornamental trees and would be realistic only for small scale production of high value material.		
Specified age/size of plant, growth stage or time of year of harvest	Size of plant: Yes, in combination*. Limiting the commodity to plants with diameter below 2 cm are unlikely to be infested (Section 8, Table 5). Growth stage/time of the year: No. **Larvae may be present in trunks or branches throughout the year**. In particular, dormant plants may contain overwintering larvae	Age/size of plant: No, trees need to be large enough before being cut for wood. Growth stage/time of the year: Yes, in combination*, by harvesting in summer (Section 8, Table 6). This would greatly reduce the survival of young larvae present in the wood. However, some remaining late-instars larvae may be present in wood throughout the year.	Age/size of plant: No. As for wood. Growth stage/time of the year: Yes, in combination*, by harvesting in summer (Section 8**,** Table 6**).** This would greatly reduce the survival of young larvae present in the wood. However, some remaining late-instars larvae may be present in wood throughout the year.
Produced in a certification scheme	Not relevant	Not relevant	Not relevant
Pest free production site	Yes, grown under complete physical isolation (see Growing the crop in glasshouses/screehouses). It is not possible to have a buffer zone for a strong flyer.	Not relevant	Not relevant
Pest free place of production	Yes, grown under complete physical isolation. It is not possible to have a buffer zone for a strong flyer.	Not relevant	Not relevant
Pest free area	This measure is not considered applicable in Eastern North America. Yes. Measures similar to the requirements proposed for *A. planipennis* (EPPO, 2013): • 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 (using trapping and other methods) should be conducted in the area in the three years prior to establishment of the PFA and continued every year.	As for plants for planting.	As for plants for planting. In addition, as recommended in the past for *A. planipennis*, the Panel on Phytosanitary Measures considered that 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

Option	Host plants for planting	Round wood and sawn wood (> 6 mm) of hosts	Wood chips, hogwood, processing wood residues (except sawdust and shavings)
	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 host 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.		
Options after harvest, at pre-clearance or during transport			
Visual inspection of consignment	Yes, in combination*. Visual inspection may detect some infested trees. However, the pest would be difficult to detect in large consignments. Plants are generally traded during the dormant season, when the larvae would be overwintering inside the tree. A subsample of the trees could be destructively sampled to determine if shipment is pest free.	Yes, in combination*. Inspection will not guarantee detection. Visual inspection of wood consignments is generally difficult, but even more with consignments mixing several tree species (such as firewood). An infestation on wood without bark may be easier to detect. Low levels of infestation may not be detected.	No Inspection of consignments of wood chips and other such commodities is difficult. It is unlikely to detect *A. bilineatus* as consignments may contain several tree species, and signs of presence of the pest would not be easy to observe. In a study on *A. anxius*, when simulating the process from logging in North America to sampling the wood chips upon arrival in Europe, the probability of pest detection for current sampling protocols used by port inspectors was very low (<0.00005), while a 90% chance of detection may require sampling 27 million litres of wood chips per shipload (Økland et al., 2012). However, there is still a value in inspecting wood chip consignments at the point of entry in that it will contribute to a better understanding of the risks (e.g. categories of material that are traded, size of the chips, tree species).
Testing of commodity	No There is no practical information about the practical	Not relevant. There is no practical information about the practical use of a	Not relevant

Option	Host plants for planting	Round wood and sawn wood (> 6 mm) of hosts	Wood chips, hogwood, processing wood residues (except sawdust and shavings)
	use of a scanner or sniffing dogs for this pest.	scanner or sniffing dogs for this pest.	
Treatment of the consignment	No	Yes. *Heat treatment of debarked wood.* According to EPPO Standard PM 10/6(1) *Heat treatment of wood to control insects and wood-borne nematodes* (EPPO, 2009), Buprestidae are killed in round wood and sawn wood which have been debarked and heat-treated until the core temperature reaches at least 56 °C for at least 30 min. Haack & Petrice (unpublished data) recorded *A. bilineatus* survival in oak logs subjected to various core temperatures (50, 56 & 60°C) for 30 minutes, as well as conducting these tests in heat chambers that were held at different constant temperatures (60, 65, 70 & 75°C). Overall, there was 100% *A. bilineatus* mortality at a core temperature of 60°C no matter the chamber temperature. However, at a core temperature of 56°C, there was 100% mortality at chamber temperatures of 70° and 75°C, but slightly lower (99%) mortality at 60° and 65°C. Given that the air temperatures inside commercial heat chambers commonly exceed 70°C, complete mortality of *A. bilineatus* life stages would be expected for wood heat treated to current ISPM 15 standards (Haack, personal communication, 2018). These data show that if a temperature below 70°C in the room chamber is used, it might not be sufficient to kill 100% of the *A. bilineatus* present in the wood. For wood with bark, the chamber temperature should be at least 70°C (section 8). Yes. *Irradiation*. According to EPPO Standard PM 10/8(1) Disinfestation of wood with ionizing radiation (EPPO, 2009), Buprestidae infesting wood are killed after an irradiation of 1kGy. Such treatments might be applied to quality logs but will be too expensive for low-value products such as firewood. Yes. *Fumigation with sulfuryl fluoride* could be applied. ISPM 28 PT 22 and PT 23 (FAO, 2017b, 2017c) only applies to debarked wood below 20 cm in cross-section. Note: methyl bromide has been phased-out and MBr fumigation	No. The chipping down to a certain size (2.5cm x 2.5 cm) (Section 8) was suggested by the EWG as a standalone measure. However, in the past, when this measure was discussed for *A. planipennis* and *A. anxius*, the Panel on Phytosanitary Measures considered that further research should be performed to determine the safe size for wood chips and how such size can be consistently obtained in commercial production of chips. This measure, when combined with debarking, was not considered realistic due to the cost of debarking compared to the value of the chips. The Panel on Quarantine Pests for Forestry also commented that the chipping process was applied repetitively by McCullough et al. (2007) on the same material, which is not representative of a classical industrial process. In coherence with the measures recommended for *A. planipennis* and *A. anxius*, this measure was not proposed by the Panel on Phytosanitary Measures for *A. bilineatus*. Treatments (heat treatment, fumigation, irradiation) were suggested by the EWG (see Round wood and sawn wood). However, the Panel decided that the treatment of woodchips and bark should not be proposed as a measure before analysing specifically whether the measures detailed in PM 10/6(1) *Heat treatment of wood to control insects and wood-borne nematodes*, in PM 10/8(1) *Disinfestation of wood with ionizing radiation* as well as in ISPM 28 PT 22 or PT 23 on fumigation could be applicable for other wood commodities including woodchips and bark.

Option	Host plants for planting	Round wood and sawn wood (> 6 mm) of hosts	Wood chips, hogwood, processing wood residues (except sawdust and shavings)
		is not considered here. Yes. *Processing*. Conversion of the wood into sawn timber of less than 6 mm.	
Pest only on certain parts of plant/plant product, which can be removed	No. **Life stages are on or in the trunk or branches.**	Yes. Debarking, including the removal of 2.5 cm on the outer-xylem. However, experience with *Agrilus* planipennis in the EU shows that it is difficult to apply in practice.	Yes. As for wood.
Prevention of infestation by packing/handling method	Yes, in combination*. Trees should be packed in conditions preventing infestation during transport and storage.	No. Not an appropriate option for imported round and sawn wood. *A. bilineatus* will not lay eggs and complete its cycle of development.	No. The EWG suggested that a specific packing should be required if wood chips were imported to be directly burned/transformed. However, the Panel on Phytosanitary Measures suggested that this measure should only be accepted by derogation, in a bilateral agreement between the exporting and the importing country.
Options that can be implemented after entry of consignments			
Pre or Post-entry quarantine	No, except in the framework of a bilateral agreement. The EWG suggested that plants may be kept in pre or post-entry quarantine for enough time to detect the symptoms of larval activity or adult emergence (24 months to provide that the pest is detected if there were only eggs on the plants). This measure is likely to be applicable only for small scale import of high value plants, and it may pose practical difficulties for large trees. The Panel on Phytosanitary Measures considered that this measure should only be proposed in the framework of a bilateral agreement.	Not relevant for wood	Not relevant for wood
Limited distribution of consignments in time and/or space or limited use	No. Plants for planting are destined to be planted, and if adults emerged, they could fly and may find hosts in the vicinity. Limiting the distribution to areas where the pest is not likely to establish is not feasible (and this area cannot be precisely defined).	No. **Not possible/practical to restrict import to periods of the year outside of the emergence and flight period of *A. bilineatus* (these are also not clearly known), and to process the material before the next such period (with appropriate conditions in storage).**	No. As for wood.

Option	Host plants for planting	Round wood and sawn wood (> 6 mm) of hosts	Wood chips, hogwood, processing wood residues (except sawdust and shavings)
Only surveillance and eradication in the importing country	**No.** **Detection is difficult, and the pest may be detected only once established.**	As for plants for planting.	As for plants for planting.

*The EWG considered whether the measures identified above as ‘Yes in combination’ (listed below) could be combined. This was not possible for all these commodities.

Host plants for planting	Round wood and sawn wood	Wood chips, hogwood etc.
Visual inspection at the place of production	Visual inspection at the place of production	Visual inspection at the place of production
Visual inspection of the consignment	Harvesting in summer	Specific packing
Plants with diameter below 2 cm	Inspection	Harvesting in summer
Plants packed		

ANNEX 2. Different life stages of **A. bilineatus**

Figure 1 - Group of eggs laid in the lab on an oak twig wrapped with ribbon to simulate bark cracks. Courtesy: Deborah L. Miller, USDA Forest Service.

Figure 2 - 4th instar larva and galleries in cambial region of Northern pin oak, Quercus ellipsoidalis (Pine County - St. Croix State Park in Minnesota, USA). Courtesy: Steve A. Katovich, USDA Forest Service.

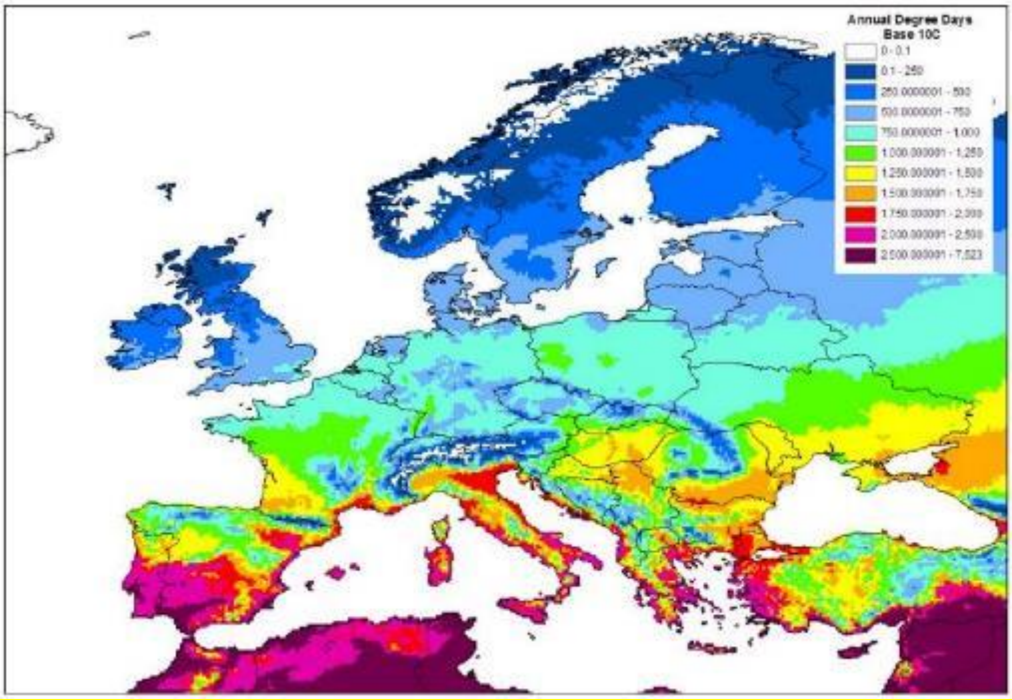
Figure 3 - Adult of *Agrilus bilineatus.* Courtesy: A Robert A. Haack, USDA Forest Service, Bugwood.org

More photographs available at https://www.insectimages.org/search/action.cfm?q=agrilus+bilineatus and at https://gd.eppo.int/taxon/AGRLBL/photos.

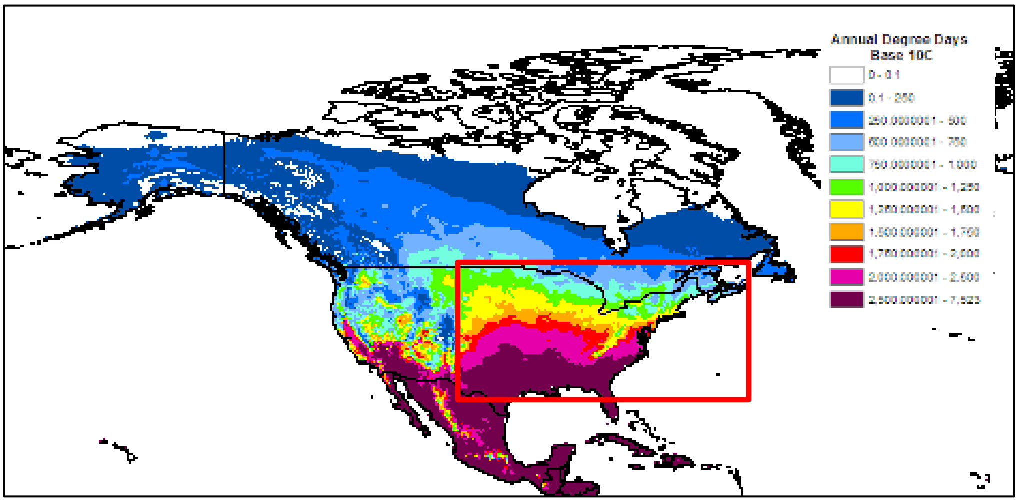
ANNEX 3. Climate in Eastern of America and comparison with climate of the EPPO region

Fig 1. Maps of temperature accumulation (Degree Days) based on a threshold of 10°C using 1961-90 monthly average maximum and minimum temperatures taken from the 10-minute latitude and longitude Climatic Research Unit database (New *et al*., 2002).

- **For Europe and Mediterranean area**

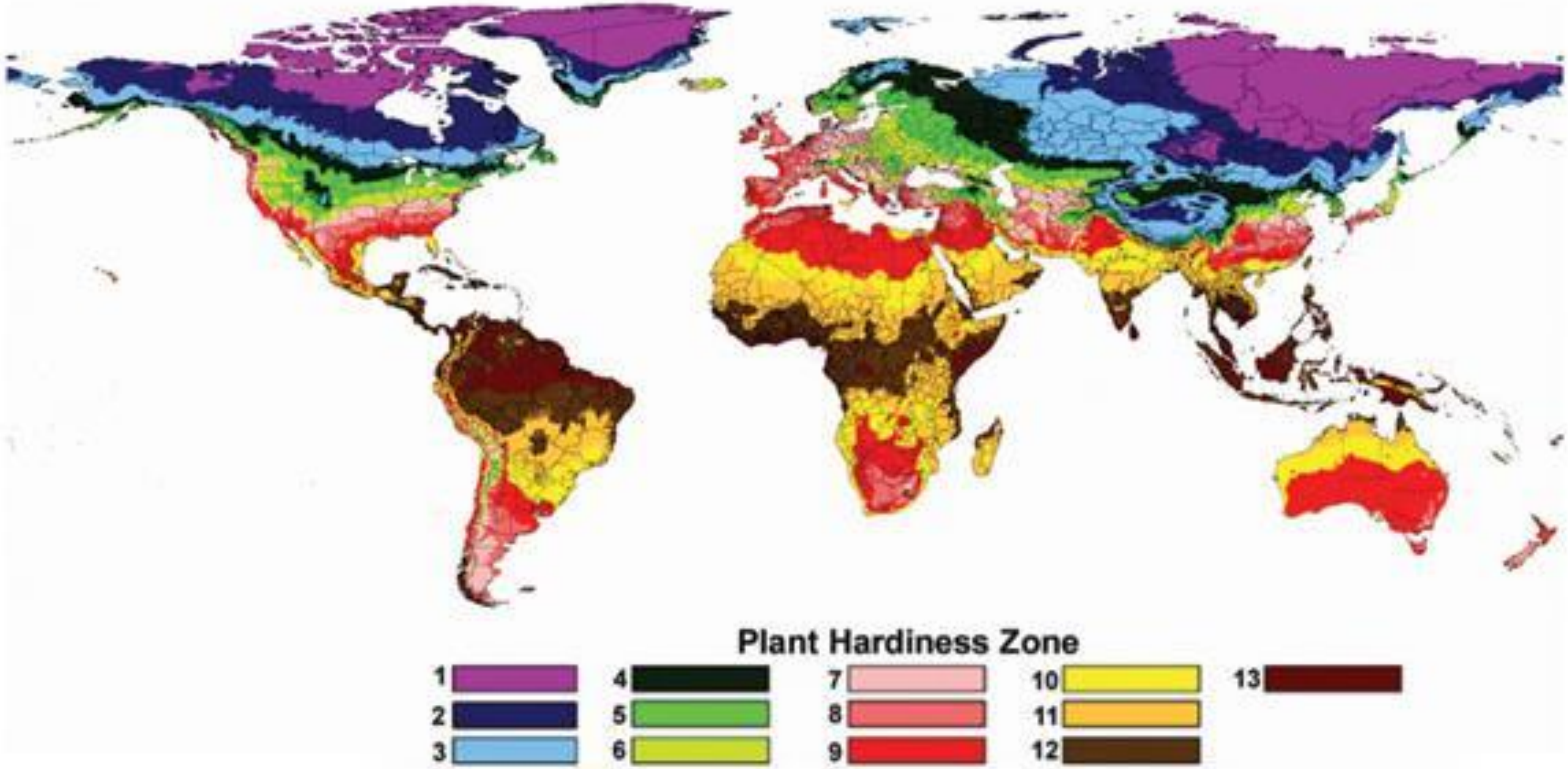


- **For North-America**



Red square: *A. bilineatus* present here.

Fig 2. Comparison of plant hardiness zones: Thirty-year global plant hardiness zone map for the period 1978-2007
European and American Hardiness Zones updated by Magarey et al. (2008) (map extract)



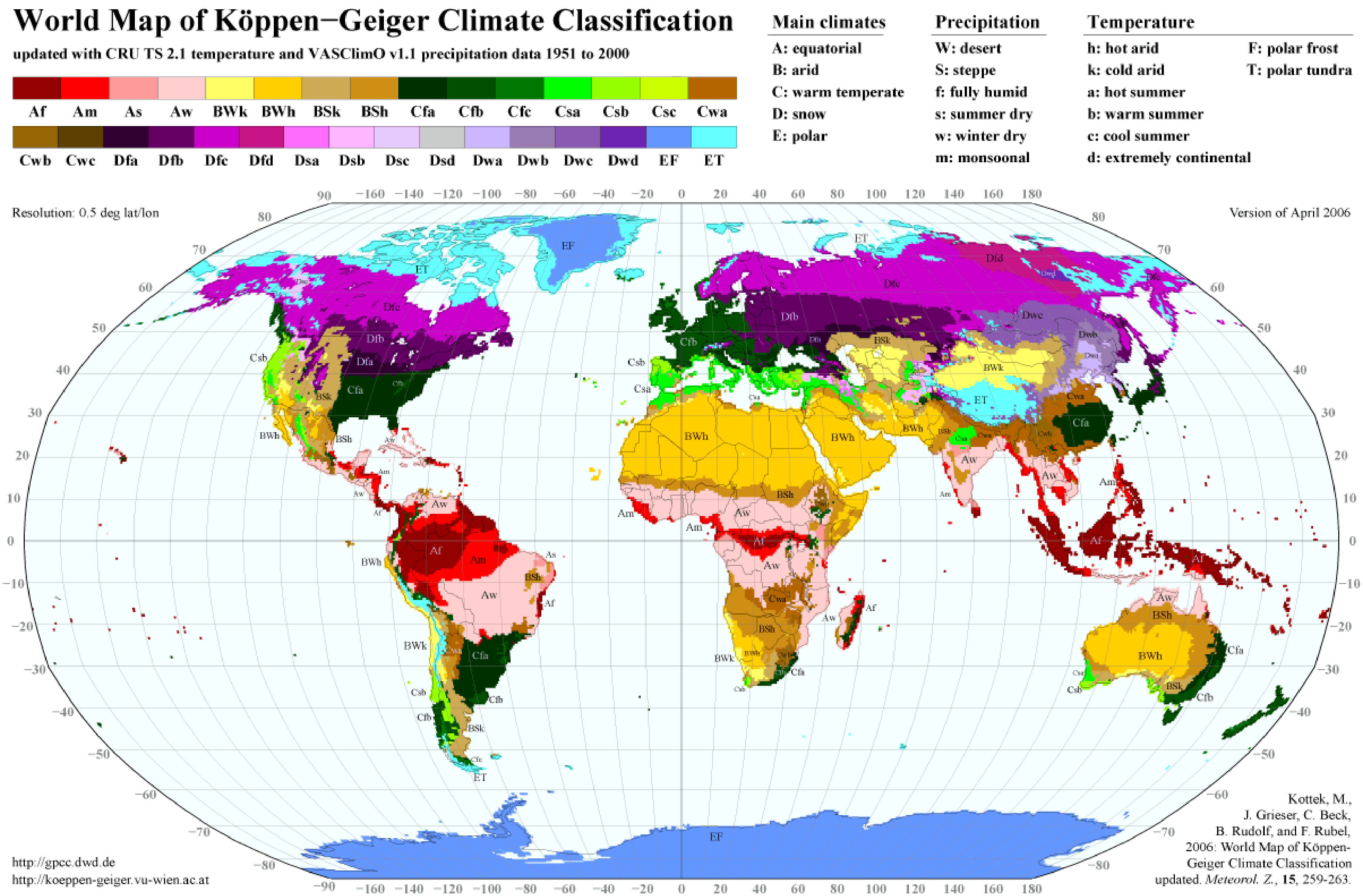
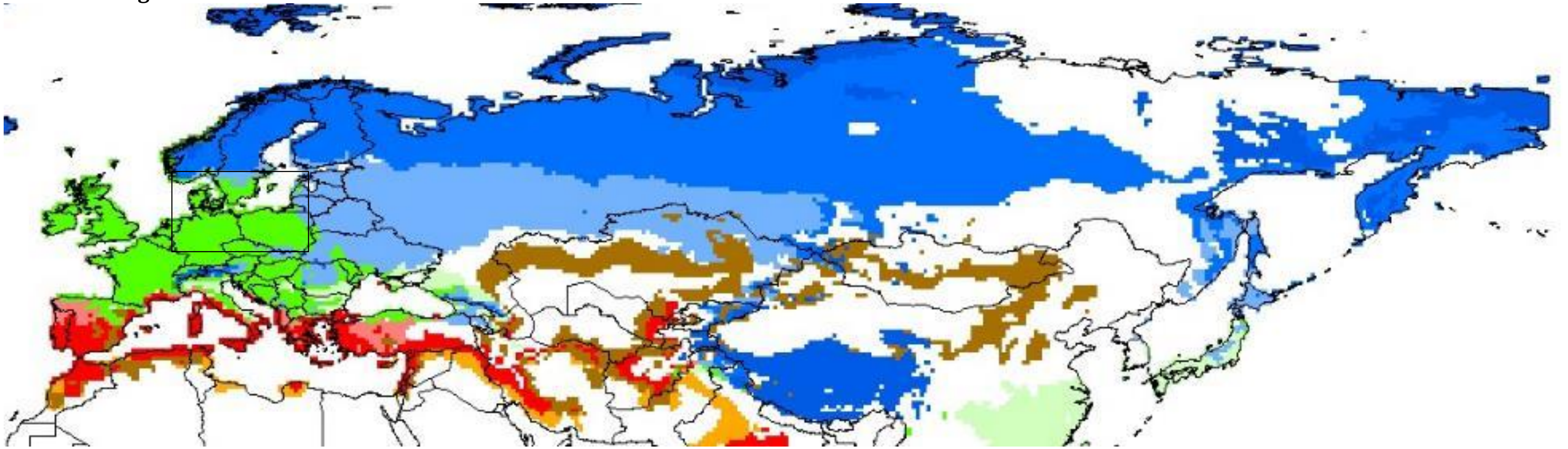

World Map of Köppen−Geiger Climate Classification
updated with CRU TS 2.1 temperature and VASClimO v1.1 precipitation data 1951 to 2000
Af Am As Aw BWk BWh BSk BSh Cfa Cfb Cfc Csa Csb Csc Cwa
Cwb Cwc Dfa Dfb Dfc Dfd Dsa Dsb Dsc Dsd Dwa Dwb Dwc Dwd EF ET
Main climates
A: equatorial
B: arid
C: warm temperate
D: snow
E: polar
Precipitation
W: desert
S: steppe
f: fully humid
s: summer dry
w: winter dry
m: monsoonal
Temperature
h: hot arid
k: cold arid
a: hot summer
b: warm summer
c: cool summer
d: extremely continental
F: polar frost
T: polar tundra
Resolution: 0.5 deg lat/lon
Version of April 2006
http://gpcc.dwd.de
http://koeppen-geiger.vu-wien.ac.at
Kottek, M.,
J. Grieser, C. Beck,
B. Rudolf, and F. Rubel,
2006: World Map of Köppen-
Geiger Climate Classification
updated. Meteorol. Z., 15, 259-263.

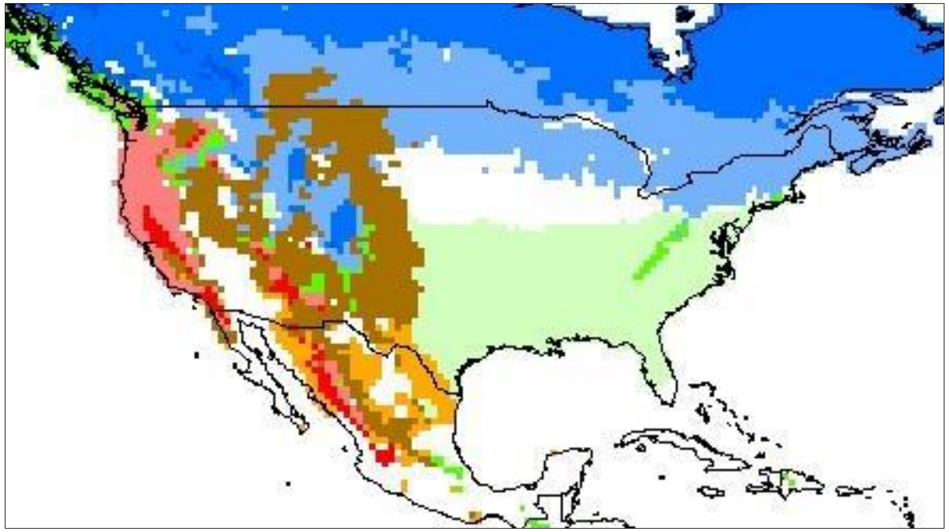
Fig 3.

Fig 4. Updated Köppen-Geiger Climate Classification (Kottek et al., 2006) showing only the distribution of climates that occur in the EU

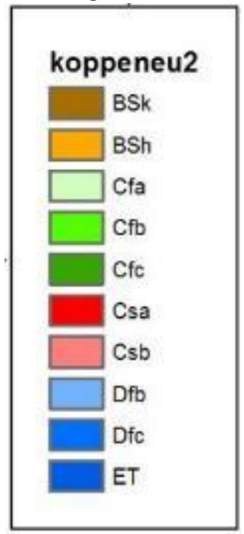
a – EPPO Region



b – North America



Legend:



ANNEX 4. Definitions used in the EPPO Study on wood commodities (EPPO, 2015b)

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

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

ANNEX 5. Maps of distribution of host species/genus and some related species in the PRA area

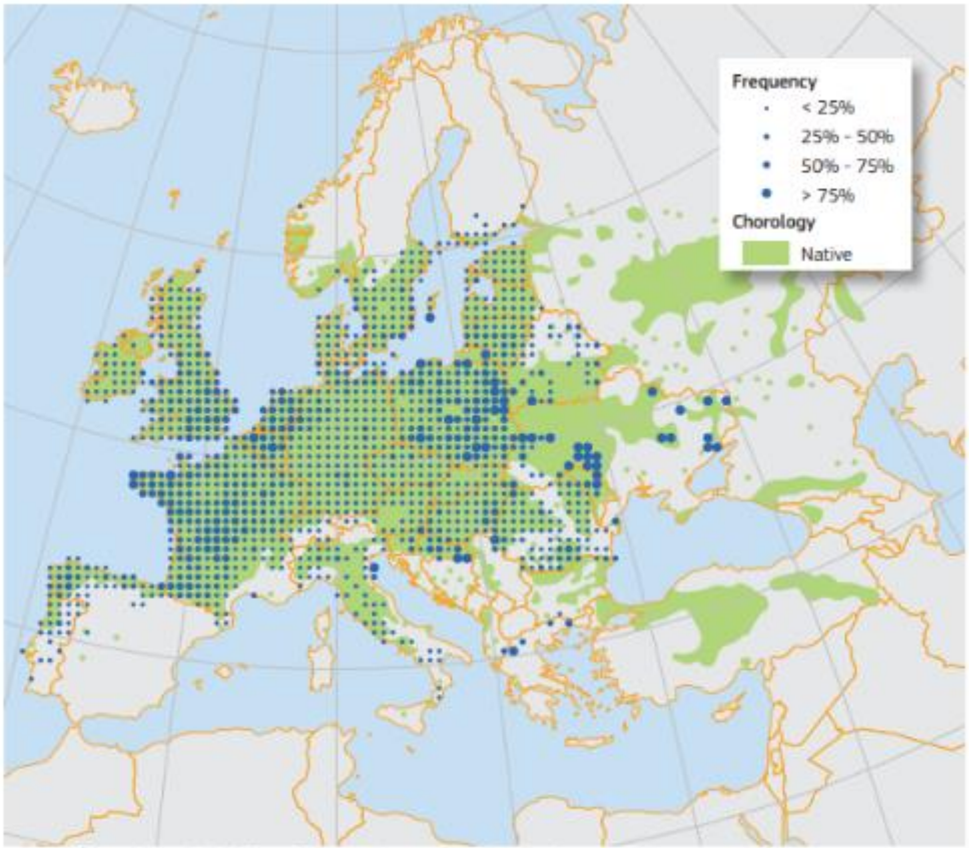
Maps were extracted from the following site:

JRC. © European Union, 2016 http://forest.jrc.ec.europa.eu/european-atlas-of-forest-tree-species/atlas-download-page/

(other maps available for *Q. frainetto*, *Q. ilex*, *Q. palustris* and *Q. pyrenaica* at the same adress)

Maps 1 – Quercus

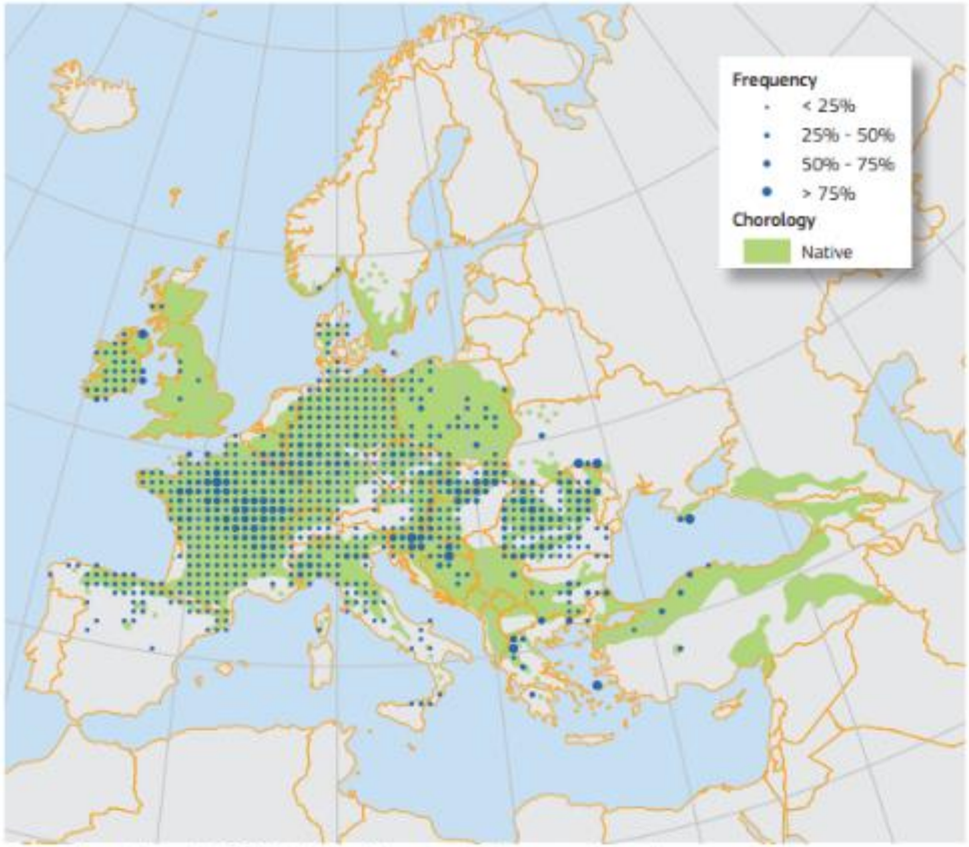
1a. *Quercus robur*



Map 1-A: Plot distribution map (*Q. robur*).

Frequency of *Quercus robur* occurrences within the field observations as reported by the National Forest Inventories. The chorology of the native spatial range for *Q. robur* is derived after EUFORGEN[45].

1b. *Quercus petraea*

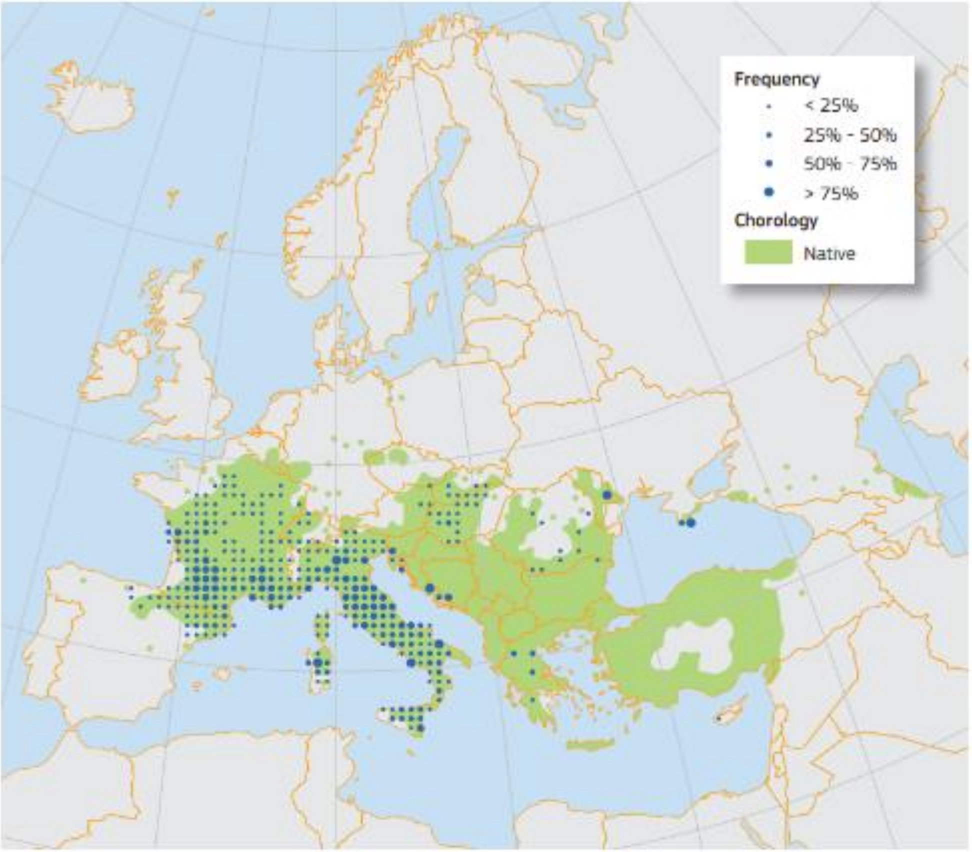


Map 1-B: Plot distribution map (*Quercus petraea*).

Frequency of *Quercus petraea* occurrences within the field observations as reported by the National Forest Inventories. The chorology of the native spatial range for *Q. petraea* is derived after EUFORGEN[46].

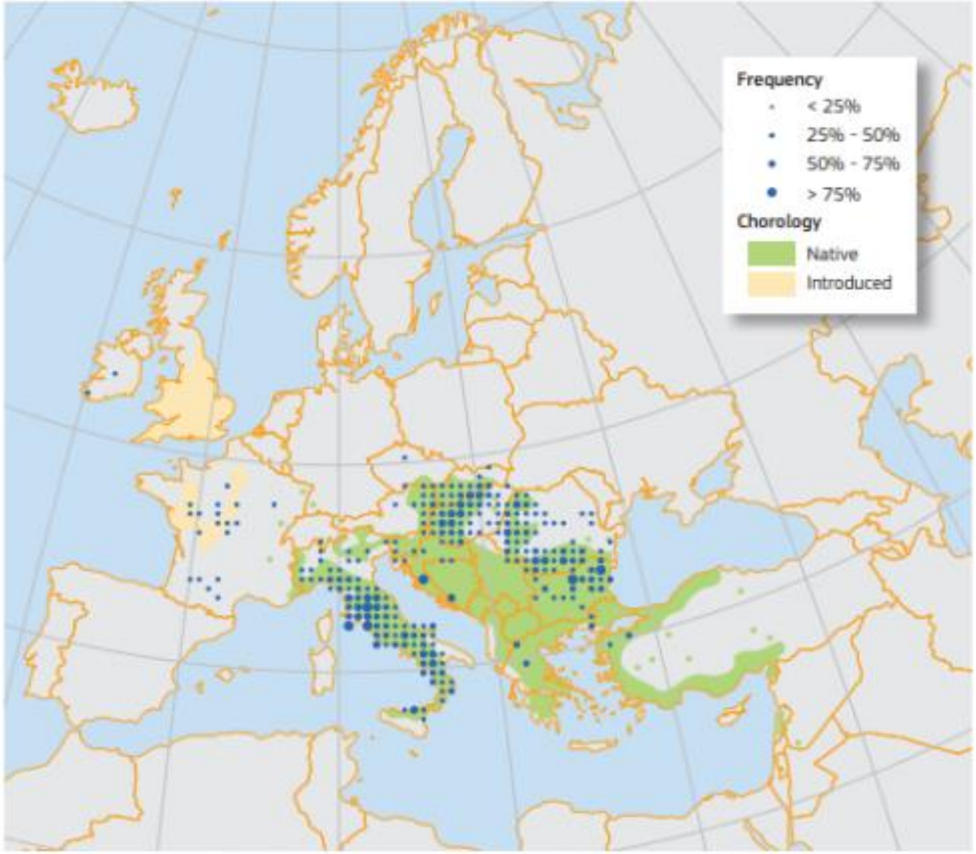
Maps 1 – Quercus

1c. *Quercus pubescens*



Map 1: Plot distribution and simplified chorology map for *Quercus pubescens*. Frequency of *Quercus pubescens* occurrences within the field observations as reported by the National Forest Inventories. The chorology of the native spatial range for *Q. pubescens* is derived after Wellstein and Spada[58].

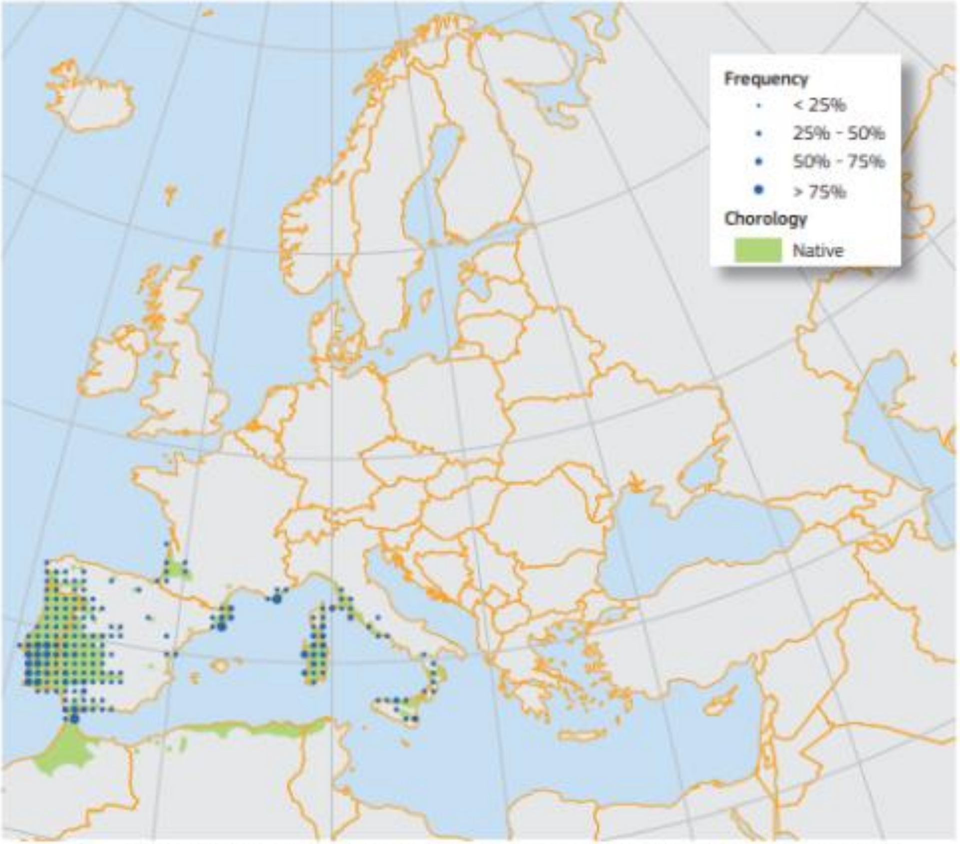
1d. *Quercus cerris*



Map 1: Plot distribution and simplified chorology map for *Quercus cerris*. Frequency of *Quercus cerris* occurrences within the field observations as reported by the National Forest Inventories. The chorology of the native spatial range for *Q. cerris* is derived after Meusel and Jager, and Jalas and Suominen[25, 26].

Maps 1 – Quercus

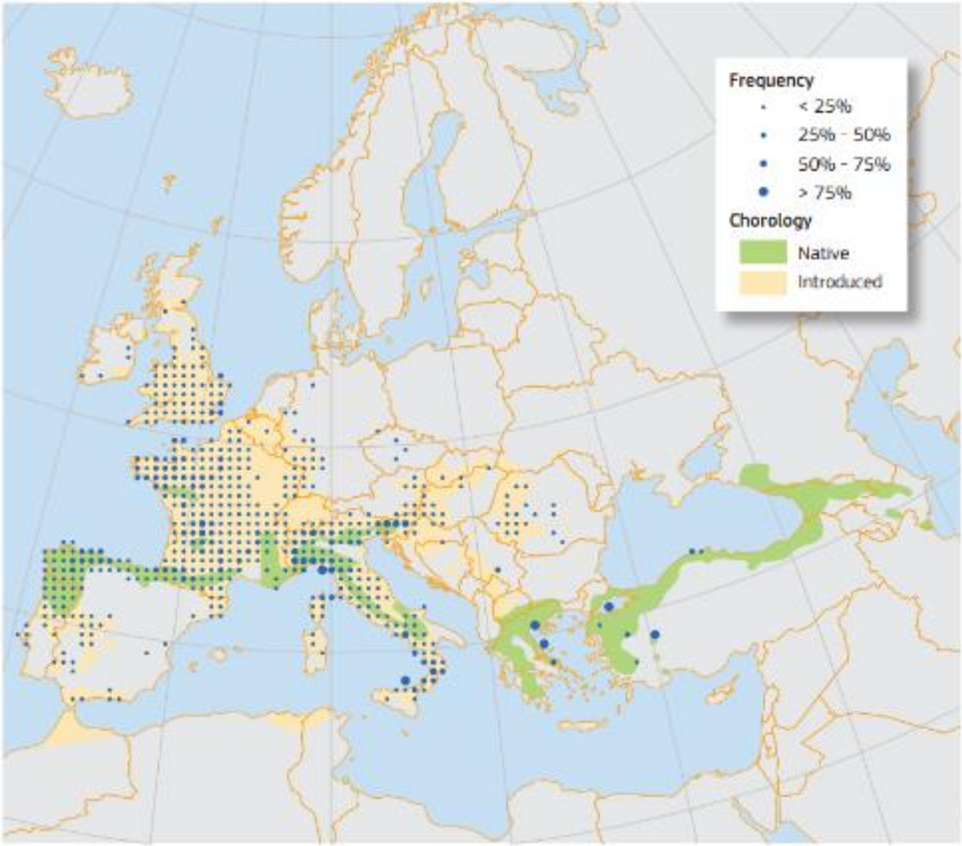
1e. *Quercus suber*



Map 1: Plot distribution and simplified chorology map for *Quercus suber*. Frequency of *Quercus suber* occurrences within the field observations as reported by the National Forest Inventories. The chorology of the native spatial range for *Q. suber* is derived after EUFORGEN[18].

Maps 2 – Castanea

2a. *Castanea sativa*



Map 1: Plot distribution and simplified chorology map for *Castanea sativa*. Frequency of *Castanea sativa* occurrences within the field observations as reported by the National Forest Inventories. The chorology of the native and introduced spatial range for *C. sativa* is derived after several sources[4, 7, 21-23].

ANNEX 6. List of native European* Quercus *species (from the International Plant Sentinel Network, EEA, 2006; IPSN, 2017).

Note: This list of species is from the International Plant Sentinel Network, IPSN, 2017 and EEA, 2006) and it illustrates the diversity of oaks in Europe. Some species are considered as subspecies of others in different sources, but this has not been fully analyzed here.

Name	Distribution in Europe	Source
Quercus alnifolia	Cyprus, Mediterranean	IPSN, 2017; EEA, 2006
Quercus aucheri	Greece+	IPSN, 2017
Quercus boissieri	Mediterranean	EEA, 2006
Quercus canariensis	Madeira, Spain	IPSN, 2017; EEA, 2006
Quercus cerris	Widespread	IPSN, 2017; EEA, 2006
Quercus coccifera	Widespread, Mediterranean	IPSN, 2017; EEA, 2006
Quercus congesta	Sardinia/Sicily	IPSN, 2017
Quercus crenata	Italy	IPSN, 2017
Quercus dalechampii	Italy, Sicily	IPSN, 2017
Quercus faginea	Spain, Portugal	IPSN, 2017; EEA, 2006
Quercus frainetto	Greece, Mediterranean	IPSN, 2017, EEA, 2006
Quercus hartwissiana	Bulgaria & Turkey	IPSN, 2017
Quercus ichnusae	Sardinia	IPSN, 2017
Quercus ilex	Widespread	IPSN, 2017; EEA, 2006
Quercus infectoria	Greece, Turkey	IPSN, 2017; EEA, 2006
Quercus ithaburensis	Albania, Balkan, Bulgaria, Greece, Italy, Turkey	IPSN, 2017; EEA, 2006
Quercus lusitanica	Spain, Portugal	IPSN, 2017
Q. macranthera ssp. *syspirensis*	Turkey	EEA, 2016
Quercus macrolepis	Greece	EEA, 2006
Quercus pauciradiata	Spain (mainland)	IPSN, 2017
Quercus pedunculiflora	Balkan, Greece, Turkey	EEA, 2006
Quercus petraea	Widespread	IPSN, 2017, EEA, 2006
Quercus pseudocerris	Mediterranean	EEA, 2006
Quercus pubescens (Q. brachyphylla, Q. virgiliana)	Widespread	IPSN, 2017; EEA, 2006
Quercus pyrenaica	Spain, Portugal	IPSN, 2017; EEA, 2006
Quercus robur	Widespread	IPSN, 2017, EEA, 2006
Quercus rotundifolia	Mediterranean	EEA, 2006
Quercus suber	Spain, Portugal, Italy	IPSN, 2017, EEA, 2006
Quercus trojana	Albania, Balkan, Bulgaria, Greece, Italy	IPSN, 2017; EEA, 2006

ANNEX 7. Import of wood from countries where the pest occurs

1. Round wood

Table 1a. FAO STAT - Import quantities (in m^3), from Canada, Turkey and USA, of non-coniferous non-tropical wood from 2012 to 2016. (Countries without imports from these countries were deleted)

	Canada					Turkey					United States of America				
	2012	2013	2014	2015	2016	2012	2013	2014	2015	2016	2012	2013	2014	2015	2016
Albania							1	3	6	4		111			67
Algeria									1			198	882	501	354
Austria				1000	2000		33		3		20000	514	4000	8000	2000
Azerbaijan							1		60			64			
Belarus											3076	563			
Belgium			106	1000								48000	127000	37000	29000
Bosnia and Herzegovina															43
Bulgaria						770	69			21		820			
Croatia															289
Cyprus						7					22	48	20		238
Czechia			179	4000	130	61	38	19		17	191	1000	459	15000	1000
Denmark										18	2000	26000	57000	23000	19000
Estonia		316									19000		6720	13275	12912
Finland											12	9000	28000	6000	6000
France		1000		6	22		28					31000	31000	17000	22000
Georgia						23	607	78				199			
Germany	13	4000	2015	7000	10000		4		24		270000	151000	143000	128000	119000
Greece									25	4		1259	1727	1299	117
Ireland		4	18	34							225	378	159	173	10
Israel											2	13	8	5759	16
Italy	164	8			43				5	19	245000	261000	231000	189000	175000
Jordan											45				
Latvia											37				
Lithuania											1000	1000	101	7000	2000
Luxembourg													15		
Malta												2681	1628	2448	1406
Morocco								3			4000	1000	2060	1758	2877
Netherlands				3	3				18	24		4156	33	1572	46
Norway				1100							47000	6772	9497	6374	1351
Poland		58									22000	5000	2000	9000	3000
Portugal											91000	90000	189000	143000	112000
Romania								20	962					1000	2000
Russian Federation													2	366	
Slovenia			20	43			6				1159	41000	1000	888	233
Spain											98000	44000	145000	95000	121000
Sweden	34	1000	7	4000	11						59000	23000	51000	30000	24000
Switzerland			2	16							171	34		25	23
Turkey		1000									56000	39000	9864	10168	8519
Ukraine			68						791			23	61		720
United Kingdom	1793	1066	1130	708	79	83			1		3006	1427	412	327	404

Table 1b. Eurostat - Import from USA* of round wood of 'Oak '*Quercus* spp.' in the rough, whether or not stripped of bark or sapwood or roughly squared' (EU CN code 44039100) into EU members in 2017** (quantity in 100 kg). Note: EU countries for which there was no import were deleted from the table below.

Partner	**USA**
Reporter/Period	**2017**
AUSTRIA	847
GERMANY	27 862
DENMARK	11
SPAIN	32 192
FRANCE	363
UNITED KINGDOM	490
IRELAND	408
ITALY	262
MALTA	438
PORTUGAL	38 168
ROMANIA	706

**Canada, Turkey: no data available*

***No data available for the period 2012 - 2016*

2. Sawnwood

Table 2a. FAO STAT - Import quantities (in m^3), from Canada, Turkey, and USA, of non-coniferous sawnwood from 2012 to 2016. (Countries without imports were deleted)

	Canada					Turkey					United States of America				
	2012	2013	2014	2015	2016	2012	2013	2014	2015	2016	2012	2013	2014	2015	2016
Albania	10					3	5	1			216	136	131	159	474
Algeria	23	48	47	290	427	12	14	9	62	4	465	101	87	345	337
Austria	992	358	390	316	300		18	3			2000	1000	1000	1000	1000
Azerbaijan						2049	1444	141	82	115		41			
Belarus	43	63									281	339	18	246	171
Belgium		1000	1000	1000	1000	56	8	45	15	26		11000	10000	11000	12000
Bosnia and Herzegovina				9	2							54	3	25	56
Bulgaria	19	212	85		24	61		179	20	124	162	232	256	120	104
Croatia	2	10	72	52	5	9	3	3	9		106	30	34	20	9
Cyprus	73	95	38	23	53	120	101				606	463	473	516	673
Czechia	47	19	78		2			4			471	642	826	136	406
Denmark	815	485	415	433	1060	11		38	78	56	33000	3895	3656	2702	3747
Estonia	1504	1163	1628	318	408						6522	6588	8967	5637	4882
Finland	126	161	171	123	68		3	11			416	2525	2449	1643	1951
France		1000	1000	1000	1000	2			28	54		6000	4000	5000	7000
Georgia						59	7	15	49	342	50	188	113	266	131
Germany	8088	12000	11000	10000	10000	117	54	23	38	88	44000	44000	50000	45000	53000
Greece	123	336	82	52	317	8	52	20	44	71	2893	2943	3137	2076	2857
Hungary											42			79	17
Ireland	737	936	773	834	545		54	72	19		7204	6404	7477	7078	7536
Israel		1000	2000	919	610	68	25	173	31	134		12000	11000	8501	8032
Italy	1315	3000	2000	2000	2000	139	51	10	10	2	159000	147000	73000	59000	57000
Jordan	15712	11213	8676	3000	4420	72	206	256	10	7	6116	3753	5112	2518	2085
Kazakhstan						74	19	7		3			29		17
Kyrgyzstan	2						10	8						16	
Latvia					9						89	159	271	143	44
Lithuania	770	345	628	279	1000						1849	2190	2287	3000	3000
Luxembourg											5	57			
Malta		53		76							1769	1822	1766	1316	2141
Morocco	2388	2140	2420	1594	355					22	1481	1836	2364	3988	4145
Netherlands	1098	1000	1000	1000	2000	369	580	845	366	469	4000	8000	7000	7000	6000
Norway	670	1348	1670	3825	2429		168	20	1	776	20331	16269	20391	21037	23445
Poland	331	1000	1000	192	132	47	178				2000	2000	3000	3000	4000
Portugal	317	495	338	181	162	175	137	169	134	155	16313	20125	16374	13087	12936
Republic of Moldova									6						11
Romania						176	5		2	154		148	117	150	73
Russian Federation	198	207	100	14	28	51	11	15	2		1597	1826	1427	548	598
Slovakia	5	5	11	23	26						41	43	63	6	23
Slovenia		5	55	42						24	61	46	21	90	52
Spain	644	359	2000	1000	1000						20253	19155	36000	45000	47000
Sweden	869	369	535	246	639			29		6	7647	6295	8464	8123	8800
Switzerland	52	103	126	162	67	7		2	14	2	771	1067	966	1114	859
Tunisia		41	65	3								108	28		
Turkey	587	1272	1915	1782	1598						11237	10835	10184	10542	8417
Ukraine	18	21	6			3	2		63	7	13	48	26	4	
United Kingdom	6890	16000	16000	15000	13000	46	30	149	46	4	127000	120000	106000	95000	113000
Uzbekistan									15	14					

Table 2b. Eurostat – Import, from Canada, Turkey and USA, of 'oak '*Quercus* spp.' sawn or cut lengthwise, sliced or barked, with a thickness of > 6 mm, sanded or end jointed, whether or not planed or sanded (EU CN code 44079115) into EU members in 2012-2017 (quantity in 100 kg) Note: EU countries for which there was no import where deleted from the table below.

Partner	**United States**						**Canada**						**Turkey**				
Reporter/Period	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2012**	**2013**	**2014**	**2015**	**2016**
BELGIUM	5 100	:	:	:	:	:	:	:	:	19	84	43	294	:	:	:	:
BULGARIA	:	:	:	:	:	:	:	:	:	:	:	:	1	2	1	:	:
CYPRUS	:	:	:	:	:	184	:	:	:	:	:	:	:	:	:	:	:
CZECH REPUBLIC	:	244	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
DENMARK	441	:	83	:	154	200	:	:	:	:	:	:	82	:	248	:	:
FINLAND	:	:	1 403	1 872	2 625	3 793	:	:	585	648	:	:	:	:	:	:	:
FRANCE	472	692	224	195	:	:	:	257	:	:	:	:	:	:	:	:	:
GERMANY	:	:	12	:	:	:	:	:	:	:	:	:	:	:	:	:	:
GREECE	:	200	200	:	:	59	:	262	:	:	:	:	:	:	:	:	:
IRELAND	236	110	5	:	272	:	:	127	248	39	16	:	0	:	:	0	:
ITALY	1 731	2 901	2 521	4 017	3 160	2 683	67	452	:	:	:	254	361	167	:	:	:
LITHUANIA	2 665	1 115	983	1 313	615	630	:	:	:	:	:	:	:	:	:	:	:
MALTA	497	2 033	1 215	1 834	1 045	1 321	:	:	:	:	:	:	:	:	:	:	:
NETHERLANDS	:	:	:	38	46	:	:	:	:	:	:	:	225	:	:	:	:
POLAND	:	:	:	:	:	:	:	:	:	:	:	:	235	889	:	:	:
PORTUGAL	:	:	200	:	:	:	:	:	:	:	:	:	:	:	:	:	:
ROMANIA	:	:	:	:	:	:	:	:	:	:	:	:	440	:	:	:	:
SPAIN	1 015	110	911	11 087	6 762	336	:	:	:	245	:	:	:	:	:	:	:
SWEDEN	635	:	15 440	23 742	13 749	22 581	:	:	:	:	36	1 338	:	:	250	:	32
UNITED KINGDOM	2 163	1 313	2 077	2 254	4 103	56 601	:	23	:	907	:	216	:	132	91	365	:

No data available for Turkey in 2017.

3. Woodchips and wood waste

Table 3a. FAO STAT - Import quantities (in m^3), from Canada, Turkey and USA, of woodchips and particles from 2012 to 2016. (Countries without imports were deleted)

	Canada					Turkey	United States of America				
	2012	2013	2014	2015	2016	2012	2012	2013	2014	2015	2016
Austria	17			1			5000	89	18	86	
Azerbaijan							16	1	3		
Belarus							20				
Belgium	1	1	91	20			1000	1164	34	59	131
Bulgaria							2596	30			
Czechia	1		7		15		5	5	5	15	1
Denmark					18		2000	8000	4000	11000	22
Finland			27	24				1000	13	23	7
France	1						21000	56000	37000	38000	28000
Georgia									22	19	10
Germany	26		1000	1000	2	1	38000	48000	55000	18000	27000
Greece	1		4		9						
Hungary	2		1		1					13	16
Ireland										16	40
Israel	2		1				267	289	345	409	145
Italy	133	6	27000	11	31		20000	89000	95000	15000	37000
Malta					9						
Netherlands		7	24	1000	5		42	23000	27	9000	13
Norway			31		6		11000	158	2369	415	41
Poland	2	21	6		2		20	11	10	1000	91
Portugal											11
Republic of Moldova							50				1
Russian Federation							21	18	8	10	3
Slovenia	9000							1		18	
Spain	119	1		84			5000	5000	14000	390	180
Sweden	2	101	77	206	51		1000	3000	4553	173	100
Switzerland			2		2		24	1000	5	27	4
Turkey	873000	512000	528000	460000	352000		2096000	2063000	1826000	1703000	2246000
Ukraine	1		1								
United Kingdom	4	6	86	140	15		105	174	133	164	116

Table 3b. Eurostat - Import, from Canada, Turkey and USA, of 'Wood in chips or particles (excl. those of a kind used principally for dying or tanning purposes, and coniferous wood)' (EU CN code 44012200) into EU members in 2012-2017 (quantity in 100 kg). Note: EU countries for which there was no import where deleted from the table below, as well as individual years when there was no import with positive data.

Partner	United States						Canada						Turkey		
Reporter/Period	2012	2013	2014	2015	2016	2017	2012	2013	2014	2015	2016	2017	2014	2016	2017
AUSTRIA	0	186	0	180	:	:	:	2	:	6	:	:	1	:	:
BELGIUM	175	:	340	293	1 310	128	:	:	:	:	1	2	:	:	:
BULGARIA	:	302	2	:	:	:	:	:	:	:	:	:	:	:	:
CROATIA	2	0	:	:	:	:	:	:	:	:	:	:	:	:	:
CYPRUS	:	:	:	:	1	:	:	:	:	:	:	:	:	:	:
CZECH REPUBLIC	0	0	5	37	7	7	20	16	15	:	3	:	:	:	:
DENMARK	645	1 599	1 664	1 151	152	33	:	:	:	0	:	:	:	:	:
ESTONIA	:	:	:	1	0	:	:	:	:	:	:	:	:	:	:
FINLAND	:	113	40	16	3	74	:	:	:	:	:	:	:	:	:
FRANCE	2 361	3 012	2 932	3 727	5 659	2 501	:	3	:	:	:	:	:	:	:
GERMANY	1 565	2 581	154 676	2 736	364	449	:	:	0	:	16	:	:	:	:
HUNGARY	3	7	15	62	174	:	2	:	8	0	:	32	:	:	:
IRELAND	:	6	0	:	:	:	:	:	:	:	:	:	:	:	:
ITALY	194	143	285	338	828	1 116	:	:	:	:	:	:	:	:	:
LITHUANIA	:	:	:	0	:	1	:	:	:	:	:	:	:	:	:
MALTA	:	:	:	:	:	70	:	:	:	:	:	258	:	:	:
NETHERLANDS	424	176	428	361	107	609	5	68	241	123	50	3	:	1	2
POLAND	2	7	0	169	905	377	:	:	:	2	:	:	:	:	:
PORTUGAL	:	0	:	:	109	55	:	:	:	:	:	:	:	:	:
SPAIN	1 062	1 230	1 488	1 949	1 797	4 543	:	:	:	:	:	:	:	:	:
SWEDEN	251	465	44 747	23	3	10	:	:	:	1	104	1	:	:	:
UNITED KINGDOM	757	1 687	1 279	820	1 164	2 018	40	62	37	:	:	1	:	:	:

Table 3c. Eurostat - Import, from Canada, Turkey and USA, of 'Wood waste and scrap, not agglomerated (excl. sawdust)' (EU CN code 44013980) into EU members in 2012-2017 (quantity in 100 kg) Note: EU countries for which there was no import where deleted from the table below, as well as years whithout positive data.

Partner	United States				Canada				Turkey			
Reporter/Period	2013	2014	2015	2016	2013	2014	2015	2016	2013	2014	2015	2016
BELGIUM	48 270	38 688	3 437	3 237	13 145	69	172	0	:	:	:	:
BULGARIA	7	6	1	1	:	:	:	:	:	:	:	:
CROATIA	:	1	:	:	:	:	:	:	:	:	:	:
CZECH REPUBLIC	49	144	129	172	0	:	0	:	:	:	:	:
DENMARK	1	106	0	0	0	1	:	:	64	16	223	154
FINLAND	:	4	:	74	:	:	:	:	:	:	:	:
FRANCE	11 497	26 567	2 913	64	211	250	:	234	:	:	:	:
GERMANY	19 948	26 629	12 273	11 951	:	:	:	:	8	163	5	6
GREECE	43	:	:	:	:	:	:	:	1 879	:	256	240
ITALY	200	367	57	218	4 390	:	:	260	:	:	:	0
MALTA	:	:	:	:	:	:	:	:	:	:	:	160
NETHERLANDS	3 269	488	509	7 998	:	:	:	:	:	:	:	:
POLAND	:	0	0	1	:	:	5	:	:	:	:	:
PORTUGAL	:	:	183	266	:	:	:	:	:	10	:	:
ROMANIA	:	:	1	0	5	:	:	:	:	:	:	:
SLOVAKIA	:	:	9	:	:	:	:	:	2	:	:	:
SPAIN	:	2	0	:	:	:	:	:	:	:	:	185
SWEDEN	25	1	5	18	:	:	:	0	:	:	:	:
UNITED KINGDOM	1 739	4 367	2 692	1 509	7	:	:	:	:	:	:	: