EUROPEAN AND MEDITERRANEAN PLANT PROTECTION ORGANIZATION
ORGANISATION EUROPEENNE ET MEDITERRANEENNE POUR LA PROTECTION DES PLANTES

20-25970

This PRA document was modified in 2021 to clarify the phytosanitary measures recommended

Pest Risk Analysis for

Massicus raddei (Coleoptera: Cerambycidae), oak longhorn beetle

September 2018

EPPO
21 Boulevard Richard Lenoir
75011 Paris
www.eppo.int
hq@eppo.int

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

Cite this document as:
EPPO (2018) Pest risk analysis for *Massicus raddei*. EPPO, Paris.
Available at https://gd.eppo.int/taxon/MALLRA/documents

Photo: Cross-section of galleries in the xylem (left), Adult female (right). Courtesy: Wang Xioa-Yi (Chinese Academy of Forestry)

Based on this PRA, *Massicus raddei* was added to the EPPO A1 Lists of pests recommended for regulation as quarantine pests in 2018.

Pest Risk Analysis for *Massicus raddei* (Coleoptera: Cerambycidae)

PRA area: EPPO region
Prepared by: EWG on *Massicus raddei*.
Date: 5-8 December 2017. Further reviewed and amended by core members and Panel on Phytosanitary Measures (see below).

Composition of the Expert Working Group (EWG)

BJÖRKLUND Niklas (Mr)	Swedish University of Agricultural Sciences, Uppsala, Sweden
BONIFÁCIO Luís Filipe (Mr)	Instituto Nacional de Investigação Agrária e Veterinária, Oeiras, Portugal
HÖLLING Doris (Ms)	Swiss Federal Research Institute WSL, Birmensdorf, Switzerland
HOPPE Björn (Mr)	Julius Kühn-Institute, Federal Research Centre for Cultivated Plants, Institute for National and International Plant Health, Braunschweig, Germany
MONTECCHIO Lucio (Mr)	Università di Padova, Dipartimento Territorio e Sistemi Agro-Forestali, Padova, Italy
POTTING Roel (Mr)	National Plant Protection Organization, Wageningen, Netherlands
WANG Xiao-Yi (Mr)	Chinese Academy of Forestry, Beijing, China
EPPO	
GROUSSET Fabienne (Ms)	OEPP/EPPO, 21 boulevard Richard Lenoir, 75011 Paris, France
SUFFERT Muriel (Ms)	hq@eppo.int

All personal communications in this PRA were obtained in November/December 2017 from the following experts: Wang XY (EWG member – Chinese Academy of Forestry), L. Montecchio (EWG member, Università di Padova, Italy), B. Hoppe (EWG member - Julius Kühn-Institute, Germany), Meng QF (Beihua University, China), H. Moylett (USDA APHIS PPQ CPHST CAPS, Raleigh, USA), and in February 2017 from Oleg Kulinich and Andrei Shamaev (All-Russian Center of Plant Quarantine, Russian Federation).

Following the EWG, the PRA was further reviewed by the following core members: Nuria Avendaño Garcia (Spain), Johanna Boberg (Sweden), Jose Maria Guitian Castrillon (Spain), Salla Hannunen (Finland), Alan MacLeod (UK), Robert Steffek (Austria), Nursen Urstun (Turkey), as well as by EPPO Staff (Françoise Petter).

The Panel on Phytosanitary Measures considered the management options in 2017-03. EPPO Working Party on Phytosanitary Regulation and Council agreed that *Massicus raddei* should be added to the A1 Lists of pests recommended for regulation as quarantine pests in 2018.

CONTENTS

Summary of the Pest Risk Analysis for *Massicus raddei* (Coleoptera: Cerambycidae)
PRA area: *EPPO region*
Describe the endangered area: The pest could establish where oak (*Quercus* spp.) and chestnut (*Castanea* spp.) are grown (given the diversity of Asian host species – see section 7) (with an uncertainty on the tree species attacked). The climatic conditions would not be limiting (although there is a high level of uncertainty for warm and arid areas in North Africa, the Near East and Central Asia - see section 9.1). However, it is expected that impact would be higher in areas where climatic conditions are more similar to Northeast China where outbreaks have been reported, and oak coverage is important.
Main conclusions *Overall assessment of risk:* *M. raddei* has hosts in the genera *Quercus*, *Castanea* and *Castanopsis*. It has caused epidemic outbreaks in several provinces of Northeast China (Jilin, Liaoning and adjacent areas in Inner Mongolia) on *Q. mongolica* and *Q. liaotungensis*. Such outbreaks occur only in a small part of its wide distribution in Asia. Limited or no data was found on the situation and impact on other hosts, or in other areas where the pest occurs (i.e. many other Chinese provinces, as well as Japan, Far-East Russia, Korea Rep, Korea Dem. Rep., Vietnam). For all pathways, entry would depend on very specific conditions, which would probably be fulfilled only for a small part of the trade (especially trees should have a diameter at breast height (DBH) or bonsai base diameter >9 cm). The likelihood of entry was considered moderate for host plants for planting, wood packaging material (if ISPM 15 is not applied) and firewood (as round wood). For plants for planting, the

EWG thought there would be relatively few trees of a sufficient DBH or diameter imported from Asian countries where *M. raddei* could occur. Regarding wood commodities, the likelihood of entry, especially on round wood, was reduced because of the ban on logging in areas of outbreaks in Northeast China. Round wood is otherwise highly favourable to allow entry of the pest from biological considerations. The assessment would change if the ban was lifted. Round wood (with or without bark, other than firewood), wood chips >2.5 x 2.5 cm in two dimensions, hogwood[1] and processing wood residues, as well as furniture and other objects made of wood, presented a low risk of entry. Hitchhiking also presented a low risk. Finally, hitchhiking presented a low risk of entry.

Establishment of *M. raddei* is likely to occur in the EPPO region and would not be limited by climatic conditions (although there is a high level of uncertainty for warm and arid areas in North Africa, the Near East and Central Asia). *Quercus* and to a lesser extend *Castanea* are widespread in the region. Although the host status of European species is not known, *M. raddei* has many *Castanea* and *Quercus* hosts. It has hosts in both subgenera of *Quercus* (*Cyclobalanopsis* and *Quercus*), and in the 3 sections of the subgenus *Quercus* that are present in Asia (out of 5, the remaining 2 being North American). It is reported on 4 Asian *Castanea* species (out of 9 in total, others being *C. sativa* and 4 North American species) (www.theplantlist.org). *M. raddei* is believed to present a higher risk of host switch (i.e. to European species) than a pest that attacks only species from one section (such as *Agrilus auroguttatus* (Coleoptera: Buprestidae) on white oaks). It is therefore assumed that it would be able to use some other *Quercus* and *Castanea* species as hosts. There are non-supported statements regarding non-Fagaceae hosts in the literature (section 7, Table 3), which would increase the risk if confirmed.

The likelihood of spread was rated as moderate because natural spread will be slow, but there may be long distance spread with commodities that would lead to multiple outbreaks and increase the spread.

The potential impact in the EPPO region is uncertain, but would probably be lower than that registered in areas of epidemic outbreaks in Northeast China. The potential impact would depend on the oak and chestnut species that are susceptible, especially if *Castanea sativa* or major *Quercus* spp. in the EPPO region are hosts. If only the currenly known hosts are attacked, damage would mostly be limited to ornamental hosts (noting that those are probably not very widely used), and to *C. crenata* where it is cultivated or present in the wild. In addition, considering the wide distribution of *M. raddei* in East Asia, significant damage is only reported in a small part of that area.

Because of the severe outbreaks in Northeast China, of the importance of oaks and chestnuts in the EPPO region, and of the potential impact, the EWG considered that phytosanitary measures should be recommended.

Phytosanitary Measures to reduce the probability of entry: Risk management options are considered for plants for planting of *Castanea*, *Quercus* and *Castanopsis*; wood of *Castanea*, *Quercus* and *Castanopsis*, wood chips, hogwood, processing wood residues; wood packaging material; furniture and other objects made of wood of host plants.

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

Other recommendations: The EWG made recommendations (detailed in section 18) relating to sentinel trees and surveys targeting Quercus species in areas where *M. raddei* occurs.

[1] See definition in Annex 3

Stage 1. Initiation

Reason for performing the PRA: *Massicus raddei* (Coleoptera: Cerambycidae) is a major pest of oaks (*Quercus* spp.) in Northeast China, and is also recorded on other hosts such as chestnuts. It was identified during the horizon scanning of literature which has been carried out for the UK Pest Risk Register. It was added to the EPPO Alert List in 2015 based on a suggestion by the NPPO of the United Kingdom (https://www.eppo.int/QUARANTINE/Alert_List/insects/Massicus_raddei.htm). In March 2017, the Panel on Phytosanitary Measures suggested *M. raddei* as one of the possible priorities for PRA, and the Working Party on Phytosanitary Measures selected it for PRA in June 2017.

The EPPO standard PM 5/5 *Decision-Support Scheme for an Express Pest Risk Analysis* was used, as recommended by the Panel on Phytosanitary Measures. Pest risk management (detailed in Annex 1) was conducted according to the EPPO Decision-support scheme for quarantine pests PM 5/3(5).

Very limited information was found for countries other than China where *M. raddei* is present (i.e. Japan, Korea Rep., Korea Dem. Rep., Far-East Russia), even when the literature search targeted publications in the original language of these countries.

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

Stage 2. Pest risk assessment

1. Taxonomy

Taxonomic classification. Kingdom: Animalia / Phylum: Arthropoda / Class: Insecta / Order: Coleoptera/ Family: Cerambycidae / Genus: *Massicus* / Species: *raddei*[2] (Blessig, 1872)

Synonyms. *Neocerambyx raddei* Blessig, 1872; *Pachydissus* (*Mallambyx*) *japonicus* Bates, 1873, *Mallambyx raddei* Aurivillus, 1912; *Mallambyx raddei* Blessig, 1872; *Massicus raddei* Kusama, 1973 (Bates, 1973; Cherepanov, 1991, cerambycidae.org).

M. raddei was described as *Neocerambyx (Mallambyx) raddei* in the Russian Far-East, and as *Pachydissus* (*Mallambyx*) *japonicus* in Japan. The name *Neocerambyx raddei* is used mostly in Russian sources.

English common names. Chestnut trunk borer (Yang et al., 2013a), oak longhorn beetle (Wang et al., 2012, 2013), mountain oak longhorn beetle (Sabbatinia Peverieri & Reversi, 2012). *M. raddei* was known as a pest of chestnut before causing damage to oaks (see 7. Hosts).

2. Pest overview

2.1 Morphology

- Eggs are creamy-white when oviposited, becoming yellow. They are elongate ovoid, ca. 4-5 mm x 1.5-2.5 mm (Kojima, 1931; LY, 2016, Wang XY cited in USDA, 2015), with one end rounded and the other prolonged into a thick stalk (Kojima, 1931).
- Larvae are creamy-white, and reach ca. 65 mm long x 11 mm wide when close to pupation (the term 'mature larvae' is used in the rest of the PRA). The average length is about 5 mm for 1st instar larvae, and 50 mm for 6th instar larvae (Wang et al., 2012). Pupae are yellowish-white and measure 31-65 mm long (depending on sources, Kojima, 1931, LY, 2016).
- Adults are large (ca. 35-63 mm long - LY, 2016, Kojima, 1931) and elongated, brownish in colour with yellow setae on newly emerged adults. The antennae of males are much longer than the body, and of females slightly shorter than the body (never longer) (Lin et al., 2016).

Photos of the life stages are given in Annex 2.

[2] A recent article, Li et al. (2017) states: «*Neocerambyx raddei* (Blessig & Solsky) (previously placed in the genera *Massicus* and *Mallambyx*)» citing a 2010 reference. No confirmation of a change was found in taxonomic sources, and the name *Massicus raddei* is used in this PRA.

2.2 Life cycle

The life cycle was outlined by Kojima (1931) for Japan, and further details were reported from further researches carried out in Northeast China since the 1990s. It is stressed that no study of its biology is known from other areas where *M. raddei* occurs. In particular, its biology may be different in warmer climates, such as southern China or Vietnam.

General:

- In Liaoning (Northeast China) on *Quercus liaotungensis*[3], one generation is completed in 3 years (over four calendar years) (Wang et al., 2012). In some more northern regions, development can require 4 years for a generation (Wang XY, cited in USDA, 2015).
- In Northeast China, population development is highly synchronous in the highly infested areas on *Q. mongolica* and *Q. liaotungensis* (i.e. adults emerge in the same year every three years, 2017, 2014, 2011, etc.) (for Liaoning: Wang et al., 2012, LY, 2016; for Jilin and Inner Mongolia: Tang et al., 2011b; Wang XY, pers. comm.). Due to differences in development time of individual larvae, there can nevertheless be small numbers of adults in no-adults years (Wang et al., 2012). LY (2016) states that in Shandong and other places (unlike in the North-East), there are adults every year.
- No information was available on the number of accumulated degree-days needed for larval development. However, temperatures influence larval development. It is not known whether in warmer areas (such as Southern China or Vietnam), the development of *M. raddei* may be faster, and whether it could complete a generation in fewer than 3 years. This is the case for *Anoplophora glabripennis* (MacLeod et al., 2002) and *Apriona* sp. (Cerambycidae); the latter complete their life cycle in 2-3 years depending on climatic conditions, with larval development taking from 9-10 months in warm conditions to 2 years in colder conditions (EPPO, 2013a).

Adults and eggs:

- Adults were reported to emerge in July-August in Japan, Northeast China and Primorskii krai in Far-East Russia (Kojima, 1931; Yang et al., 2011; Kuprin, 2016).
- Sun (2001) studied the biological characteristics of *M. raddei* (in field studies and experiments indoors). The average pre-oviposition and oviposition periods were respectively 4.6 and 14.8 days, and a female laid in average 20 eggs during their lifespan. Adults lived about 16 days. Adults begin to mate 2-3 days after emergence, and lay eggs 2-3 days after mating (Sun, 2001; Hou et al., 2000).
- Females generally lay eggs in crevices of the bark. Immediately after egg-laying, the female covers the egg with a white mucus/jelly that protects and stabilizes it (Tang et al., 2011a, Lin et al., 2016). The average duration of the egg stage is about 11 days (Wang cited in USDA, 2015). Eggs are generally laid singly (Sun, 2001).
- Observations made on *Q. mongolica* show that adults feed on the sap of trunk through wounds they have themselves inflicted (Zheng et al., 2014b; Tang, 2011).
- Adults are most active in the evening/night, and have a strong phototaxis (Yang et al., 2011).
- Tang et al. (2011a) stated that *M. raddei* does not lay eggs on dead trees. They found live larvae in dying or dead trees, but possibly because adults had laid eggs on the trees when still alive and larvae had been able to continue their development.

Larvae and pupae:

- First instar larvae drill the bark and enter the phloem. The first four instars feed on phloem and cambium under the bark; they are not restricted to linear galleries but may feed in a wider chamber-like area. Later stages bore tunnel-like galleries and feed in the xylem; pupae are mostly in the xylem/heartwood (Tang et al., 2011a; Cao et al., 2015). Larvae start feeding on the xylem in the second year (Wang et al., 2012). According to Xing (2015), each gallery has an average volume of 144 cm. See photos of galleries in Annex 2.
- There are 6 larval instars. In Liaoning (Northeast China) on *Q. liaotungensis*, the average duration of the larval instars were ca. 9, 267, 48, 51, 260 and 386 days, for a total larval stage of over 1021 days in the

[3] According to some sources (incl. Flora of China), *Q. liaotungensis* (*Q. wutaishanica*) is a synonym of *Q. mongolica*. It was left separate in this PRA, because treated separately in the literature on *M. raddei* and taxonomic databases, and considered distinct in some molecular studies (Zeng et al, 2010). In this PRA, the names used correspond to those in the articles cited. However, some Chinese articles mentioning only one may apply to both.

field (including overwintering periods). The larvae overwintered in the first winter as 2nd-3rd instar, in the second winter as 4th-5th instar and in the third winter as full-grown larvae (Wang et al., 2012).
- The pupal stage lasts on average 26.5 days (Tang, 2011).
- The population density per tree in Northeast China is on average 26.5 individuals, with a maximum of 156 individuals (Yang et al., 2014 citing others). Higher numbers are mentioned by others, such as a maximum of 200 larvae and 500 galleries (incl. galleries from previous generations) (Tang et al., 2011a, Xing, 2015).
- Larvae excrete frass through one frass ejection hole during their entire lifetime (Tang et al., 2011a). There may be frass and sawdust on trunks or at the tree base (LY, 2016) (see *Detection* below). Larvae bore galleries both upwards or downwards in the xylem, but not in the trunk below the ground or in the roots (Wang XY, pers. comm.).

2.3 Temperature requirements
Temperatures are important for emergence and activity of adults (mating, feeding, egg-laying). Daily temperatures between 22°C and 26°C and relative humidity between 50% and 80% favour the level of activity of adults (Tang et al., 2011c). Using data from trapping, Yang et al. (2011) analysed the relationship between adult emergence, and temperature and humidity in forest stands in Jilin. From the figures in that article, emergence occurred already when the average daily temperature was 19°C but was highest above 24°C; the lowest humidities reported in this study were around 60-70% and favoured emergence compared to higher humidities. No data were found on the lowest temperature or humidity thresholds.

2.4 Dispersal of adults
Gao (2001) reports that adults of *M. raddei* can fly 50-80 m each time, dozens of times one night, and calculates from these values that the total flight distance per night could therefore reach 300-1000 m. Other observations instead have shown shorter single flights: 30-80 m long and 15-30 m in height (Sun, 2001); 20-70 m (Jiang, 2011); 10-15 m (Xie et al, 1999). However, none of these studies give details as to how these data were obtained. The spread of *M. raddei* is analysed in detail in section 11.

2.5 Nature of the damage
The main damage is caused by larvae boring into trees (mostly trunks, less often branches – see below). "The damage done is tremendous both physiologically and mechanically as the larvae attacking the living tree eat out chambers under the bark and tunnels in the wood so as to make the trunk almost entirely hollow." (Kojima, 1931). There may be numerous larvae in one tree (see 2.1). Infestations affect tree growth (Tang et al., 2011b). Reduced tree vigor and wind-breakage are often mentioned as impacts in the literature (e.g. Cao et al., 2015).

Tree mortality directly due to *M. raddei* in severe infestations is reported in some Chinese publications (e.g. Zheng et al., 2004a, Xing, 2015). Tang et al. (2011b) found that the proportion of dead oak trees on upper slopes and ridges of some oak forests attacked by *M. raddei* was high, sometimes up to 90%. The EWG noted however that, because larvae do not move to wood below the ground (see 2.6), the roots would remain alive and many *Quercus* and *Castanea* species are known to resprout from roots. This is the case in particular for *Q. mongolica* (Bazarova, 2014).

According to Xing (2015) and Tang et al. (2011b), the wood value of attacked trees decreases and it can only be used as firewood. In addition, the wood of attacked trees is also used for growing mushrooms (Wang XY, pers. comm.).

Finally, feeding of adults on sap of *Quercus mongolica* through bite wounds (Zheng et al., 2014b) presumably causes insignificant damage to trees.

2.6 Trees attacked in a stand and location of the pest in the tree
Information was found only for *Quercus* in Northeast China. In Liaoning, *M. raddei* attacks mostly oak trees over 35 years; this relates to the females' egg-laying behaviour, as it prefers trunks with rough bark (i.e. with crevices) (Xing, 2015). Tang et al (2011a) found larvae of *M. raddei* only when the bark thickness was above ca. 0.5 cm.

However, *M. raddei* is also reported to attack smaller oak trees. In forests where larger oak trees had died or were felled, oak trees with a smaller DBH[4] (12-15 cm) were also infested, though with lower population densities (Tang et al., 2011b). Available data regarding the minimal size of material attacked point towards the following minimum for *Quercus*, and there is no data for *Castanea* and *Castanopsis*.

- Zhao et al. (2005) and Meng QF (pers. comm.) report no infestation in oak trees of a DBH <10 cm.
- In studies on the distribution of larvae and pupae in *Q. liaotungensis* (Tang et al., 2011a) (cutting trees in 1-m sections), *M. raddei* was found when the trunk diameter was above ca. 9 cm, with a significant increase in the number of larvae above 16-cm diameter. The number of larvae per trunk was positively correlated with bark thickness and trunk diameter. Larvae were also found in primary branches.

The EWG, based on the biology of other cerambycids, did not exclude that larvae during their development may bore into material of smaller diameter (e.g. if moving upwards in a 9-cm-DBH tree).

Referring to trees of *Q. liaotungensis* in Northeast China with an average DBH of 25-cm, larvae and pupae were mostly found in the lower part of the trunks, up to 9-10 m high. In trees showing complete dieback, larvae were mostly in trunks at a height of 0-4 m and pupae at a height of 1-4 m, while in trees showing partial dieback, larvae were found below 6 m and pupae at 3-7 m; there were no larvae in trunks above 9 and 10 m for completely and partially diebacked trees, respectively (Tang et al., 2011a).

Massicus raddei attacks both healthy and weakened trees (Wang XY, pers. comm.). Nevetheless, the literature available for Northeast China reflects more damage on weakened trees. Damage by *M. raddei* mostly occurred on oaks situated on upper slopes, ridges and sunny slopes of mountains corresponding to trees with a DBH of about 26 cm. Oak stands in lower slopes or valleys (where trees are healthier with a higher crown density) presented no or low infestation, and no tree dying from infection. Trees on upper slopes were larger and weaker, with a lower crown density, and suffered higher damage. The high ratio of dead oaks on upper slopes and ridges of some forests led to a progressive increase of damage in middle slopes, but with a decrease in *M. raddei* population density (healthier trees) (Sun et al., 2010; Tang et al., 2011a & b).

2.7 Detection and identification

Guidelines for monitoring in forest stands are given in LY (2016), and include observations of withered crowns on large trees, emergence holes, larval frass ejection holes in tree trunks and lateral branches, as well as frass and sawdust on tree trunks and around tree bases.

Symptoms

- *M. raddei* causes dieback of branches or the whole tree.
- There are no specific signs of oviposition (unlike for some other Cerambycidae). Eggs are difficult to detect (Lin et al., 2016).
- Frass on the ground can be used to detect the presence of insect attacks (EWG).
- Observation of frass ejection holes ((defecation holes) can be used to estimate the number of larvae (Tang et al., 2011a). Tang et al. (2011a) also mention that larval defecation can be observed from one year after egg-laying. This is because *M. raddei* has three types of frass. The first type is only feces, dark brown with long thin shape, and not easy to recognize. The second type is feces combined with sawdust, which is yellow brown, powder-like and easy to recognize. The third type is a mixture of feces, sawdust and water, which is yellow brown and sticky, and is the easiest to recognize.. Tang et al. (2011b) mentions using binoculars for detecting frass ejection holes on the middle and upper parts of oak trees. In new infestations with few individuals, frass ejection holes may be overlooked, especially before symptoms start appearing on the trees. In conclusion, signs of larval presence might be difficult to see by visual examination of standing trees.
- When adults emerge, many exit holes can be seen on one trunk (Cao et al., 2015). Flying adults might also be observed: they are large and may all emerge during a limited period of the same year. They fly at night and are attracted by light (Yang et al., 2011).

Trapping

The pheromones of *M. raddei* have not been isolated, and there is no species-specific trapping method to date. However, adults of *M. raddei* are strongly attracted by light. A black light trap has been found

[4] Diameter at Breast Height

especially effective and is used in China for monitoring and control (Yang et al., 2011; Xing, 2015). Black light attracted twice as many adults than ordinary flashlight (Jiang et al., 2010). Other light traps may also be used, the best being 30 W black light trap and 250 W high pressure mercury lamp (LY, 2016). Light traps (including black light traps) are known to attract many insect species (Ramamurthy et al., 2010).

Studies have been conducted on other types of traps, but according to available information have not resulted in new field/commercial trapping techniques yet. For example, a mixture of sugar, vinegar, alcohol and water was successfully used in experiments (Tang et al., 2016). In investigations on trapping lures (including pheromones of other Cerambycinae, as well as some pheromone components that attract many other Cerambycinae species) and trap height, Li et al. (2017) concluded that females are attracted to ethanol and that canopy traps baited with ethanol were effective; other components tested were not effective.

Identification

Chen et al. (1959 – in Chinese) and Hua et al. (2009 – in English) provide a morphological description of adults. Some morphological characters [in Latin] are also given in the original description (Bates, 1873). However, there are morphologically similar Cerambycidae species, such as *Apriona germari* in China. Benzel (2015) provides screening aids for the identification of *M. raddei* should it be found in the USA, i.e. discriminating with US species; it is not known if these would apply in the EPPO region.

Immature stages are described in detail in Kojima (1931). The EWG noted that morphological identification of immature stages of Cerambycidae is very complicated. However, the complete mitochondrial genome of *M. raddei* has been sequenced (Wang et al., 2016) and reference material is deposited in GenBank. EPPO Standard PM 7/129 (*DNA barcoding as an identification tool for a number of regulated pests;* EPPO, 2016a) could be used for identification.

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

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

5. Regulatory status of the pest

M. raddei is not listed as a quarantine pest by EPPO countries (EPPO, 2017 - EPPO Global Database). It was added to the EPPO Alert List in 2015. *M. raddei* was not found in the lists of regulated pests for other countries on www.ippc.int (neither under its previous names). In the USA, it is included in early detection programmes for alien forestry pests at least in some states (EPPO, 2015a). It was on the national priority pest list for surveys at least in 2013-2017, but dropped from the 2018 list as considered as a low impact pest for the USA (using a prioritization model; CAPS, 2017; Moylett H, pers. comm.).

6. Distribution

M. raddei is present only in East Asia (See Table 1, and Figures 1 and 2). It was described from Japan and Far-East Russia in the 1870s (respectively as *Pachydissus* (*Mallambyx*) *japonicus* and *Neocerambyx raddei*) (see section 1). Its native or introduced status in other countries is not clear:

- In China, it was first reported from 1932 in checklists of insects (e.g. Wu, 1932 & 1937). It is not known if there has been some more recent spread within China; it was present in the North-East before outbreaks started in the 1990s (Sun, 2001; Tang, 2011). The only known areas of severe outbreaks/high infestations are Jilin, Liaoning and part of Inner Mongolia (see Figure 1).
- In the Korean peninsula, it was recorded as early as the 1920s (Okamoto, 1927, from individual places now in the South of Korea Dem. Rep.).
- In Vietnam, the first record dates from 2014 (Nga et al., 2014).

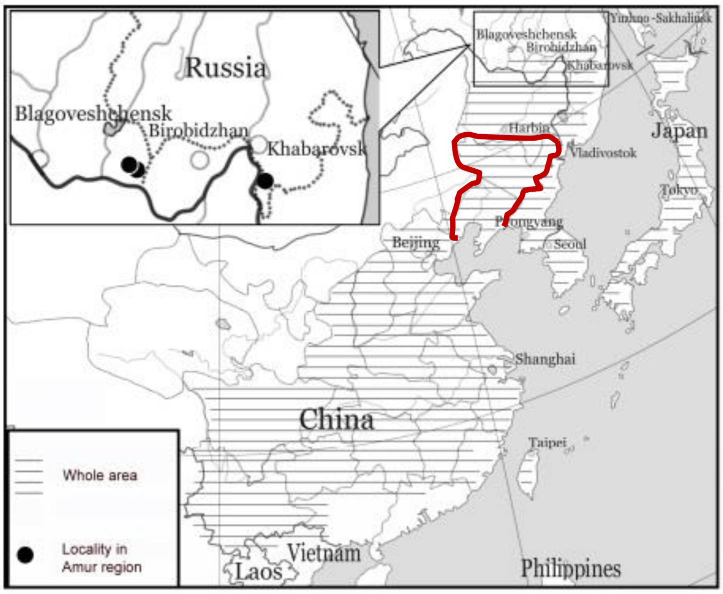
Table 1. Distribution of *M. raddei* (details and uncertainties in the table)

Region	Distribution	Additional details, references and uncertainties
EPPO region	**Russia**	Far-East only: 'south parts of Amurskaya oblast and Khabarovskii krai, Primorskii krai' (Anisimov and Bezborodov, 2017)

Region	Distribution	Additional details, references and uncertainties
Asia	**Japan**	Bates (1873 - description). • Honshu, Shikoku, Kyushu (Kojima, 1931; Leksono et al., 2006) • Hokkaido (Mokuroku Database, 2017)
	China (Fig. 1)	• Anhui, Fujian, Guizhou, Hebei, Heilongjiang, Hubei, Hunan, Jiangsu, Jilin, Jiangxi, Liaoning, Sichuan, Shaanxi, Shandong, Shanxi, Yunnan, Zhejiang (Danilevsky, 2017 citing Löbl & Smetana 2010; Cerambycidae.org, no date) • Neimenggu (Inner Mongolia) (Tang et al., 2011b) • Hainan, Henan, Guangdong (Lin et al., 2016) • Chongqing (Forest Pest Control Station of the State Forestry Administration. 2008), Shanghai (Luo et al., 2005; Forest Pest Control Station of the State Forestry Administration, 2010) Uncertain records: • *Beijing*, *Tianjin*. Mentioned in Anisimov and Bezborodov (2017), but there is no record in the Chinese literature. However, present in all surrounding provinces. • *Guangxi*. Present in all surrounding provinces, and found in Vietnam very close to Guangxi.
	Korea Dem. Rep.	Okamoto, 1927; Lim et al., 2014
	Korea Rep.	Danilevsky, 2017 citing Löbl & Smetana 2010; Lim et al., 2014. At least: South-West (Mt Juwang; Cho et al., 2010); Demilitarized Zone (Kim et al., 2006)
	Taiwan	Lin et al., 2016, Anisimov and Bezborodov, 2017
	Vietnam	Nga et al., 2014 (new record for northern Vietnam, in Phia Oac and Lao Cai)

Figure 1. Distribution of *Massicus raddei* in China. Whole provinces are marked, not detailed distribution within provinces (prepared by the EPPO Secretariat). in red: provinces with severe outbreaks; in orange: other provinces where the pest has been reported; in blue: uncertain records (no record in the Chinese literature, but probably present). Other colours have no specific meaning.

Figure 2. Distribution map showing the northern and southern limits of *M. raddei* distribution (from Anisimov and Bezborodov, 2017) (see above for details of the distribution in China). Red line: approximative limit of the area of severe outbreaks in China, added by the EPPO Secretariat.

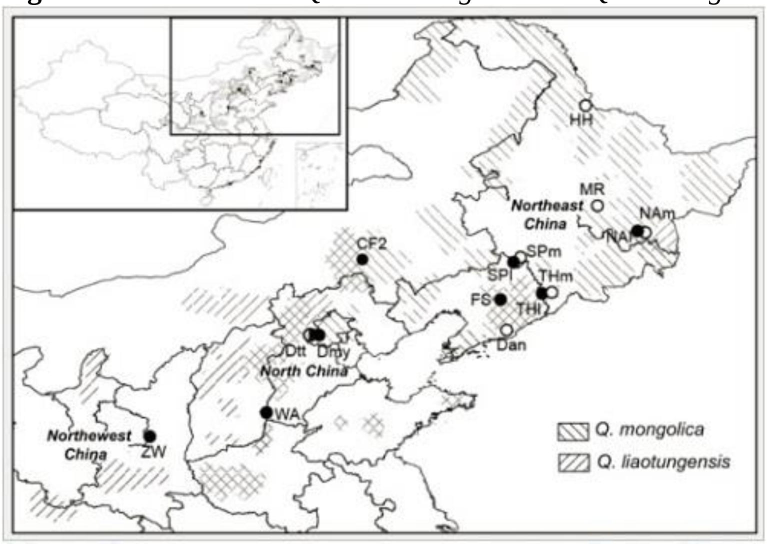


7. Host plants, associated plants and their distribution in the PRA area

M. raddei attacks Fagaceae, mainly *Castanea* spp. and *Quercus* spp. and has also been reported on *Castanopsis cuspidata*. Hosts are listed in Table 2. All known hosts are trees of Asian origin. Details on the presence of hosts in the EPPO region are given in Table 2 and section 9.2.

In China, *M. raddei* was originally reported as a pest of *C. mollissima* and 'other trees' in the South, and it later became a major pest of *Quercus mongolica* and *Q. liaotungensis*[3] in the North (Lin et al., 2016) (see distribution of these species in Figure 3). It is not known if certain oak hosts in China represent a passage to new hosts. It was noted that in areas of high infestation in Northeast China, non-infested *Castanea mollissima* forests were observed adjacent to heavily-infested *Quercus mongolica* (Wang XY, pers. comm.).

Figure 3. Distribution of *Quercus mongolica* and *Q. liaotungensis*[3] in China (from Zeng et al., 2010)



Whether other *Quercus* and *Castanea* spp. could be attacked in the EPPO region is not known. So far, *M. raddei* has not been reported on *Quercus* species that are present naturally in the EPPO region (except *Q. mongolica* in Far-East Russia). See also section 9.2) and the record on *C. sativa* (European chestnut) is doubtful (see below Table 3). Some European species are known to occur in China (e.g. *Q. robur*: Xinjiang, Beijing; *Q. suber*: Sichuan, Jiangsu, Zhejiang, Taiwan) as well as *Q. rubra* (North American species but grown in EPPO – see section 9.2 - Middle-lower areas of Yangtze River) [from Internet searches in Chinese search engine – Wang XY, pers. comm., December 2017]. No report of infestation by *M. raddei* on these species was found. Similarily, no report of *M. raddei* was obtained in relation to two sentinel plant projects[5].

Nevertheless, *M. raddei* has many *Castanea* and *Quercus* hosts. It has hosts in both subgenera of *Quercus* (*Cyclobalanopsis* and *Quercus*), and in the 3 sections of the subgenus *Quercus* that are present in Asia (out of 5, the remaining 2 being North American). It is reported on 4 Asian *Castanea* species (out of 9 in total, others being *C. sativa* and 4 North American species) (www.theplantlist.org). The EWG assessed that *M. raddei* presents a higher risk of host switch (i.e. to European species of *Quercus* and *Castanea*) than a pest that attacks only species from one section (such as *Agrilus auroguttatus* (Coleoptera: Buprestudae) on white oaks). It is therefore assumed that it would be able to use some other *Quercus* and *Castanea* species than those confirmed as hosts.

In China, the host species reportedly include 38 species in 17 families (with the genera *Quercus* and *Castanea* predominating); however the host species reported outside the Fagaceae may require verification (Wang XY, cited in USDA (2015)). A number of non-Fagaceae host records in the literature have been repeated in articles over time, but it was not possible to find publications mentioning direct observations, nor to trace-back original publications. It was also noted that adults of the cerambycid *Apriona germari* are very similar to those of *M. raddei*, and may have been confused in earlier publications. These species are listed in Table 3 and are not covered in the PRA.

Table 2. Hosts of *Massicus raddei*
For species marked with *****: not possible to find publications mentioning direct observations, nor to trace-back original publications.
Regarding presence in the PRA area, where 'ornamental' is indicated without a reference, availability was checked in the PPP-Index (http://www.ppp-index.de/).

Host	Presence in PRA area (Yes/No/Not known)	References
Fagaceae		
Castanea crenata	Yes, fruit, wood, rootstock, ornamental (EPPO, 2013b); wild (SE Russia, S Ukraine, W Transcaucasus) (EPPO, 2000)	Lim et al., 2014
Castanea henryi	Yes, ornamental	Hua et al., 2009; Yang et al. (2013) (cited in USDA, 2015), Feng and Du, 1997
Castanea mollissima (= *C. bungeana*)	Yes, ornamental No data found on whether cultivated for fruit, but hybrids with *C. sativa* are used.	Feng and Du, 1997; Wu et al., 2000; Lim et al., 2014
*Castanea seguinii**	Yes, ornamental	Yang et al. (2013) (cited in USDA, 2015)
*Castanopsis (Pasania) cuspidata**	Yes, ornamental	Kojima, 1931; Lim et al., 2014
Castanopsis cuspidata var. *sieboldii* (*C. sieboldii*)*	Yes, ornamental	Lim et al., 2014
Cyclobalanopsis	**Note**: this genus is considered outside of China as a subgenus of *Quercus*. Of the known *Quercus* hosts, *Q. glauca* is a *Cyclobalanopsis* (based on Flora of China)	LY, 2016 (forestry standard)
*Quercus acuta**	Yes, ornamental	Lim et al., 2014
Quercus acutissima	Yes, ornamental	Kojima, 1931; Lim et al., 2014; Hua et al., 2009; Yang et al. (2013) (cited in USDA, 2015); Chen et al., 1959
Quercus aliena	Yes, ornamental	Chen et al., 1959

[5] Contacts were taken with the International Plant Sentinel Network (IPSN), which links various institutes including botanic gardens and arboreta in Asia, to enquire whether the pest had been found on European *Quercus* spp.; no record was obtained. In addition, *M. raddei* was also not found during a sentinel tree project that included *Q. ilex*, *Q. petraea* and *Q. suber* (in Beijing and Zhejiang, 2007-2011; Roques et al., 2015), but the project used seedlings, which would not have reached a sufficient diameter during the project period (1-1.5 cm at soil level at the start of the trial).

Host	Presence in PRA area (Yes/No/Not known)	References
*Quercus dentata**	Wild in S.Far East (EPPO, 2000). Yes, ornamental	Lim et al., 2014; Yang et al., 2013 (cited in USDA, 2015)
Quercus glauca	Yes, ornamental	Chen et al., 1959
Quercus liaotungensis (*Q. wutaishanica*)	Yes, ornamental	Tang et al., 2011b; Li et al., 2017; Sun, 2001
Quercus mongolica	Wild in S. Far-East; cultivated in C.E.Russia (not known as ornamental or forest tree) (EPPO, 2000). Available as ornamental	Tang et al., 2011b; Sun, 2001
*Quercus phillyreoides**	Yes, ornamental	Wang et al., 2009
Quercus serrata	Yes, ornamental	Kojima, 1931; Lim et al., 2014; Chen et al., 1959
*Quercus variabilis**	Yes, ornamental	Sun, 2001

Table 3. Non-Fagaceae species reported as hosts in the literature but original source is missing and no recent observations were found

Regarding presence in the PRA area, where 'ornamental' is indicated without a reference, availability was checked in the PPP-Index (http://www.ppp-index.de/).

Host	Presence in PRA area (Yes/No/Not known)	References
Fraxinus mandshurica (Oleaceae)	Yes, ornamental. Wild in S. Far East (EPPO, 2000)	Sun, 2001
Morus spp. (Moraceae)	Yes, cultivated, wild, ornamental (EPPO, 2013a, citing others)	Lim et al., 2014 Sun et al., 2006
Morus alba	Yes, cultivated, wild, ornamental (EPPO, 2013a, citing others)	Chen et al., 1959
Paulownia spp. (Paulowniaceae)	Yes, ornamental, also wood and biomass production (http://www.ipaulownia.co.uk/paulownia-info/why-paulownia/)	Wu, 2007, Lim et al., 2014
Paulownia tomentosa	Yes, wood, ornamental (Essl, 2007; Hakan Akyildiz H, Sahin Kol, 2010). Considered invasive in some EPPO countries)	Wei et al., 2009
Citrus reticulata (Rutaceae)	Yes, cultivated (mandarin)	Ye et al, 1996
Citrus maxima	Yes, cultivated (pomelo)	Xu et al, 1995
Xylosma (Salicaceae)	Yes, ornamental	Hua et al., 2009
Zelkova (Ulmaceae)	Yes, especially bonsais	Hua et al., 2009

Doubtful host records

- *Castanea sativa* is reported in Kojima (1931), but no other positive/direct record on *C. sativa* from any country where the pest occurs was found in the literature. Kojima (1931) refers to a book on forest pests in Japan from the start of the 1900s, implying that *C. sativa* would have been used as a forest tree. *C. sativa* is a European species and it is doubtful that it was cultivated in Japan at that time. The native chestnut in Japan (widely grown for fruit and in forests) is *C. crenata* (which is not mentioned in Kojima, 1931). In addition, both *C. sativa* and *C. crenata* have changed names at numerous occasions in the past. In particular, two names of *C. crenata* at the start of the 1900s were *C. sativa* var. *japonica* and *C. sativa* var. *pubinervis;* and in the 1800s, a name for *C. sativa* was *C. vulgaris*, and for *C. crenata* was *C. vulgaris* var. *japonica* or var. *kusaruki* (Strijk, 2017). The record for *C. sativa* is therefore considered doubtful and probably refers to *C. crenata*.
- *Quercus robur*. A wikipedia page on *Mallambyx raddei* (rcfh.ru, 2017 - Russian Federal Forest Protection Center - Roslesozashchita) mentions *Q. robur* as a host, without references. No other reference was found. In addition, no reference to *Q. robur* being a host of *M. raddei* was found when a PRA was prepared for Russia (2017), and *M. raddei* does not cause damage to this host (Oleg Kulinich and Andrei Shamaev, All-Russian Center of Plant Quarantine, Russian Federation). *Fagus crenata*. Okada and Nagahata (1996), in a survey on longhorn beetles of *F. crenata* in Hyogo Prefecture, mentions finding

one adult in the forest studied. This cannot be considered as a host record (as there is no indication that the pest can complete its life cycle), and no other reference was found.

8. Pathways for entry

All pathways are considered from areas where the pest occurs to the EPPO region.

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

- Eggs are on the bark, the first to fourth larval instars are in the phloem, and older larval instars and pupae are in the xylem. Especially the sixth larval instar has a long life (over 1 year; Wang et al., 2012).
- *M. raddei* will not be associated with small diameter-trees. Based on the information available for *Quercus* (see section 2.6), the EWG considered that *M. raddei* can be associated with host trees of a DBH > 9 cm (or, for bonsais, trunk base diameter > 9 cm).
- There may be up to 200 larvae or pupae in one tree (see section 2.2).
- Last instars are large (65 mm long x 11 mm wide when mature) and bore into the xylem, and therefore larval development requires considerable wood volume (see section 2.2 and pictures in Annex 2).
- Tang et al (2011a) found live larvae in dying or dead trees, and assumed that larvae had continued their development as the tree was dying. The EWG therefore assumed that mature larvae and pupae are able to survive even in dry wood and adults could emerge (as known for other Cerambycidae). Survival and development of earlier larval instars would depend on the state of the material (i.e. the wood should contain some moisture). Small material (small trunks or branches, wood pieces) would dry and become unsuitable rapidly, and even big logs may not allow the full development of larvae if this still requires 2-3 years.
- *Transfer from commodity to host trees: M. raddei* has many *Quercus* and *Castanea* hosts, which in the EPPO region are mostly used as ornamentals. There are many other *Quercus* and *Castanea* species native in the EPPO region, and some may also be hosts (see section 7).

Specific issue for wood commodities: In China (including the areas of high infestations, on *Quercus* only, in Jilin, Liaoning and Inner Mongolia), oaks are mostly found in natural forests and not in plantations (Forest Trends, 2015; NEPCon, 2017a). Since the end of 2016, all state-owned natural forests in China are protected by law, by extension of the National Forest Protection Program implemented since 2000 in some provinces (Wu et al., 2013, Yang, 2001; Ji et al., 2011; Forest Trends, 2016; Zhao, 2015; news.sosu.com, 2017). The law includes a ban on commercial logging [6] (Yuexian, 2001, Forest Trends, 2016; State Forestry Administration of the People's Republic of China, 2016; new.cnr.cn, 2017). It is being extended by the end of 2017 to other natural forests (collectively-owned and private forest farm-owned land) (NEPCon, 2017b). Felling of any trees is subject to official authorization by the central forestry administration, and is only allowed for sanitary and scientific purposes. Trade of wood from these areas would not occur, and Sun (2016) mentions that *Q. mongolica* may mostly not be available for trade after 2017 (although maintenance can be allowed and timber from this species sold legally; NEPCon, 2017b). Rating of the wood pathways was influenced by this, with the understanding that there would not be commercial logging of oak trees from areas of severe outbreaks (Liaoning, Jilin and part of Inner Mongolia) (and oak occurs mostly in natural areas, and not plantations). If trade of wood from these areas was allowed, the likelihood of entry would be higher. It is not known whether there is trade of wood from commercial plantations in other areas in China (or from other countries) where *M. raddei* occurs at lower population levels.

The *EPPO Study on wood commodities* (EPPO, 2015b) distinguishes many commodities (definitions in Annex 3). In this PRA, they were grouped into several pathways. This is because the existence of 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 on wood commodities*. The PRA relied on existing data (from Eurostat, using existing CN customs codes) that cover together several EPPO wood commodities, hence the groupings proposed. Finally, the *EPPO Study on wood commodities* 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 or untreated wood). Such distinctions are not used here as there is no indication of the type of material entering the EPPO region.

[6] For provinces that include high infestation areas, the ban was implemented in Jilin and Inner Mongolia from 2015 (State Forestry Administration of the People's Republic of China, 2016), and in Liaoning from 2017 (new.cnr.cn, 2017).

Finally, it was noted that several railway freight routes have opened since 2011 between China and various European countries, through the CIS (Shanghaiist.com, 2011; DB Schenker, 2017). They shorten transport time by about 15 days compared to maritime transport (which may be over 40 days). Railway freight from China is planned to increase in volume, and in 2020 a high-speed freight train to Russia should further decrease transport times (GCR, 2017).

The following pathways for entry of *M. raddei* are discussed in this PRA. Pathways in bold are studied in section 8.1; other pathways were considered very unlikely and are in section 8.2. Definitions of wood commodities are given in Annex 3.

- **Host plants for planting**
- **Roundwood and sawn wood of hosts**
- **Wood chips, hogwood, processing wood residues (except sawdust and shavings)**
- **Wood packaging material**
- **Hitchhiking**
- **Furniture and other objects made of wood of host plants**
- Cut branches of hosts
- Bark of hosts
- Fruit of hosts (chestnuts)
- Sawdust and shavings, processed wood material, post-consumer scrap wood
- Seeds, bulbs and tubers, grain, pollen, stored plant products, soil and growing medium
- Natural spread from countries where the pest occurs
- Movement of individuals, shipping of live Cerambycidae, e.g. traded by collector

8.1 Pathways studied

Host plants for planting are studied in Table 4, wood commodities in Tables 5 and 6. Furniture and other objects made of wood of host plants, as well as hitchhiking, cannot be studied in detail and brief evaluations of these pathways are therefore provided before the tables.

For all pathways and at the scale of the PRA area, it is considered that the current phytosanitary requirements in place are not sufficient to prevent the introduction of *M. raddei*. There are prohibitions on the movement of some plants for planting (e.g. in the EU, for plants of *Quercus* and *Castanea* with leaves – EU Directive 2000/29), but not for other plants for planting or wood.

Examples of prohibition or inspection are given for some EPPO countries (it was not possible in this express PRA to fully analyse the regulations of all EPPO countries). Similarly, the current phytosanitary requirements of EPPO countries 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.

Hitchhiking. Adults fly and are strongly attracted to light, and may become associated with commodities at packing. There can be large populations of adults at emergence in highly-infested forests. It is not known how frequently infested hosts are present in areas other than forests (e.g. urban areas from whose ports or airports commodities would be dispatched). However, adults have a relatively short life (ca. 20 days) and would need time to fly and find a host at destination (see *Transfer from commodity to host trees* at the start of section 8 in general considerations on pathways), which limits the risk of entry in case of long storage and transport times. Adults may be able to feed on some non-host commodities (for example they have been shown experimentally to be able to feed on fruit, and sap of non-hosts may also be suitable). There is insufficient data to study this pathway. Hitchhiking seems relevant for local spread with short transport times, and was included in section 11.
Likelihood of entry: low*; Uncertainty:* moderate

Furniture and other objects made of wood of host plants. There is no data on the use of host wood in China for producing furniture or other objects. There is some trade of wooden furniture at least from China and Vietnam. Emergence of beetles from furniture is reported for similar pests such as *Monochamus* spp.,

and *Semanotus* spp., *Chlorophorus* spp., *Batocera* spp. (EPPO, 2015c, citing others). Longhorn beetles emerging from wooden decorations have also been found, e.g. in Germany (B. Hoppe, pers. comm.). However, galleries of mature larvae and pupae of *Massicus raddei* are wider than the larvae itself, i.e. >1 cm, and it is unlikely that pieces of infested wood are used for producing furniture. In addition, oak wood from highly-infested areas in China would not be used as these are part of protected natural areas (see section 8).
Likelihood of entry: low*; Uncertainty:* moderate

Table 4. Host plants for planting

Pathway	Host plants for planting (except seeds, cuttings, tissue culture, pollen)
Coverage	Plants for planting in pots or similar (including bonsais), plants with bare roots. Cuttings are excluded because *M. raddei* requires material of a certain size, and it is also not associated with seeds, tissue culture or pollen
Pathway prohibited in the PRA area?	Partly: e.g. in the EU: Plants of *Castanea* and *Quercus*, with leaves, other than fruit and seeds
Pathway subject to a plant health inspection at import?	Presumed in most EPPO countries, e.g. in the EU, general inspection requirement for all hosts (incl. for trees and shrubs, and for bonsais), and specific requirements for some genera: *Castanea* and *Quercus* (general inspection + symptoms of non-European *Cronartium* + requirements on *Cryphonectria parasitica*). The requirements for *Castanea* also apply within the EU (regarding *Cryphonectria parasitica*).
Pest already intercepted?	No interception reported for the EU, not known for others.
Plants concerned	*Quercus* and *Castanea* are the main hosts. It is not clear how often/in which conditions *M. raddei* is associated to *Castanopsis*, and there is no confirmed record on non-Fagaceae (see section 7).
Most likely stages that may be associated	All life stages can be present on/in trees with a DBH >9 cm. It is expected that all life stages of *M. raddei* could also be associated with bonsais that have a trunk base diameter above 9 cm.
Important factors for association with the pathway	Larval frass ejection holes and frass may be observed, but may be overlooked if there are only few individuals present. They are more likely to be observed on bonsais because of their dimensions and high value. In addition, larvae are not active in dormant plants (overwintering), defecation cannot be used for detection of attacks on such plants. Furthermore, the frass Is easy to see on the bark only from one year after egg-laying. Infestations may be detected if adults start to emerge and there are exit holes (this is only likely to occur if plants are transported in non cool conditions).
Survival during transport and storage	Eggs, larvae and pupae would survive and continue their development once at destination. If adults emerge during transport, they may feed on the sap of their hosts. If individuals of both sexes are present, adults can mate 2-3 days after emergence, therefore leading to the presence of mated females. The plants would be suitable for egg-laying, which could occur on the same host after a few days in favourable conditions. Mated females may also be present in consignments at destination.
Trade	For the period 2000-2011, ISEFOR data (regarding imports from non-EU countries into the EU – Eschen et al., 2017) indicate imports of 192.000 *Castanea mollissima* from China in 2010, and no imports of other *Castanea* or of *Quercus*. It is not known if the imported trees would be of a sufficient size. However, for amenity purposes within the EU, trees of 2-3 m height and ca. 10 cm DBH are commonly used (L. Montecchio, pers. comm.). Much bigger trees are also available in nurseries (for example for some European species - not known hosts to date - see http://www.majestictrees.co.uk/tree-shrub/463-quercus-ilex; http://www.majestictrees.co.uk/tree-shrub/475-quercus-suber). However this is thought to relate mostly to trade between neighbouring countries. The EWG thought there would be relatively few trees of a sufficient size imported from Asian countries where *M. raddei* occurs. No data was available on whether there is a trade of old/thick-trunked bonsais of *Castanea* or *Quercus*.
Transfer to a host	Emerging adults would already be on a suitable host. For adults that emerge from bonsais intended for use indoors, there is a low risk of transfer to a host that may allow establishment of the pest.
Likelihood of entry and uncertainty	**Host plants for planting including bonsais :** moderate with a moderate uncertainty (very favourable from a biological point of view, but only plants >9 cm DBH (or base diameter for bonsais) could carry the pest; uncertainty on trade) ***Subrating:* Host trees with a DBH > 9 cm / bonsais with a base diameter > 9 cm**: High (very favourable from a biological point of view, but seemingly low trade) with a moderate uncertainty (existence of a trade of trees above 9-cm DBH or bonsais with a base diameter above 9 cm from Asian origins).

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

Pathway	**Roundwood and sawn wood of hosts**	**Wood chips, hogwood, processing wood residues (except sawdust and shavings) of hosts**
Coverage	This pathway intends to cover all types of roundwood and sawn wood, including with or without bark. The understanding of sawn wood is as per definition in ISPM 5. Roundwood includes logs, but also other types of material. Whole trees including branches, twigs, possibly stumps, may be harvested (e.g. as fuel wood). In addition, part of the commodity described in the EPPO Study as 'harvesting residues' is a type of roundwood (when in the form of top of trees, branches, twigs etc.). - *composition*: Consignments of roundwood (as logs) would generally be of one species. Harvesting residues (in the form of roundwood) arise from the harvest of logs and may initially be from one species, but it is not known if they would be grouped with other species (possibly also from other origins) when traded (e.g. as fuel wood). Roundwood 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 roundwood may have bark attached. - *size*. Logs would normally be of a large size. For harvesting residues (in the form of roundwood) and any material sold as fuel wood, the material may be of variable size (including branches, top of trees, branches, twigs etc.). - *intended use*. Such commodities may be used for construction, furniture, long poles, energy purposes or processed (such as chips, pulp, fibreboard etc.).	*Note '(except sawdust and shavings)' is not repeated below to simplify, but is intended throughout this pathway.* Where harvesting residues are in another form than roundwood (e.g. residues from squaring), the EPPO study considers that they would either be left on-site or be transformed on-site, in which case they become another commodity (e.g. wood chips, hogwood). All these commodities may be used for different purposes, such as pulp, fibreboard production, energy purposes, mulch. - *composition*. depending on the intended use, wood chips are produced from one or a mixture of species. This is not known for other commodities, but would presumably be the same. → consignments may include a mixture of species. - *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. → at least part of these commodities may include some bark. - *size*. wood chips are produced through a shredder using a round-hole sieve that defines the dimension of chips (e.g. <2.5 cm) on two sides (not the third). The European Standard on solid fuel (Alakangas, 2010; CEN, 2011) identifies four classes of wood chips according to size; in the largest class, 75% of wood chips should be comprised in the range 16-100 mm, and 6% can measure 200-350 mm. Hogwood or processing wood residues have no size requirement. → even wood chips can be quite large. The size of all these commodities would vary. - *intended use*. use of the wood commodities as mulch is presenting the highest risk (as facilitating transfer of pests to nearby trees), but this is a minor use of such commodities. Energy and fibreboard production would be the main uses of such products.
Pathway prohibited in the PRA area?	No	No
Pathway subject to a plant health inspection at import?	Partly, e.g. in the EU. *Castanea* general inspection requirements. Some EU countries have protected zones for *Castanea* wood (requires bark-free, or PFA for *Cryphonectria parasitica* or kiln drying)	Partly. e.g. *Castanea*, *Quercus*: general inspection requirement

Pathway	Roundwood and sawn wood of hosts	Wood chips, hogwood, processing wood residues (except sawdust and shavings) of hosts
	Quercus: squared so as to remove entirely the rounded surface, or bark-free and water content <20 %, or bark-free and hot-air or hot water treatment, or if sawn, with or without residual bark attached, kiln-dried to below 20 % moisture content	
Pest already intercepted?	No interception reported for the EU (but intercepted cerambycids may be identified only to the family level – Eyre et al., 2018), not known for others	No interception reported for the EU (but intercepted cerambycids may be identified only to the family level – Eyre et al., 2018), not known for others.
Plants concerned	*Quercus* and *Castanea* are the main hosts. It is not clear how often/in which conditions *M. raddei* is associated to *Castanopsis*, and there is no confirmed record on non-Fagaceae (see section 7).	As for wood.
Most likely stages that may be associated	Larvae and pupae may be associated with wood with or without bark. Adults would be associated with consignments of wood only if they emerge during transport or storage.	Given the size of larvae and pupae, small life stages are most likely to be associated. Live mature larvae or pupae are likely to be killed during processing if wood pieces are smaller than 2.5 x 2.5 cm in two dimensions.
Important factors for association with the pathway	Handling and processing may destroy or remove eggs and young larvae (by removing/damaging the bark). The presence of bark on the wood would favour survival of younger larvae. The pest is mostly found in trunks, but there may be eggs or larvae in branches. 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. There may be many larvae or pupae in one trunk. Due to the presence of galleries, the infested wood looses its value and could be traded only for limited uses. Tang et al. (2011a, b) mentions that severely infested wood is used as firewood, and there may be a risk that infested logs end up as firewood in trade (incl. trunks and branches), or as wood chips or similar (see next column). The highest risk of introduction would arise from the presence of mature larvae or pupae in roundwood (see other considerations below).	Heavily infested trees cannot be used as round wood or sawn wood, and may be processed into e.g. wood chips. For wood chips, there are existing requirements (e.g. in the EU) based on size, i.e. that chips should be below 2.5 x 2.5 cm in two dimensions, which would make it very unlikely that mature larvae, pupae and recently formed adults would survive the process. Such requirements do not exist for hogwood, however the great majority of wood pieces would not be suitable for this pest. 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 they have sufficient wood at their disposal, and that the wood remains suitable for feeding/boring galleries. This is considered possible as there are reports of live larvae having survived on dying or dead trees (although it may be more difficult on small diameter wood). Pupae would survive. If adults emerge, they may be able to feed on sap depending on the moisture content. If individuals of both sexes are present, adults emerging can mate 2-3 days after emergence, therefore leading to the presence of mated females. The material would not be suitable for development if any eggs were laid. Mated females may be present in consignments at destination.	Eggs and young larvae would not be able to survive and complete their development since the amount of wood would not be sufficient. Mature larvae and pupae would only need the piece of wood in which they have survived processing. Such commodities may be stored in big piles. The temperature in the core of the bulk for wood chips may become high (e.g. 60° C) due to composting effect, which will affect the pest. Temperatures in the periphery of the pile are expected to be much lower and seldom lethal. 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, the wood would be too dry for feeding. They are less likely to feed and to reproduce.

Pathway	Roundwood and sawn wood of hosts	Wood chips, hogwood, processing wood residues (except sawdust and shavings) of hosts
Trade	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. There were major imports from Russia (but the provenance is not known) with >5 million m^3 in 2014 and 2015. In 2015, imports from China had greatly increased compared to 2014 (over 174000 m^3 against 4600m^3). Imports were minor from Japan, Korea Rep. and Vietnam in 2012, 2014 and 2015 (in total 233 m^3, 15 m^3, 170 m^3) (see Annex 4A). Trade data is 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 (see Annex 4B). Together, this would cover logs and whole trees sold as firewood, and one type of harvesting residues (that may contain branches, twigs, etc.). According to the EPPO Study, it also covers bark. Data was extracted for 2012, 2014 and 2016. - <u>Firewood</u>. imports were mostly from Russia (80000-135000 t per year in 2012, 2014 and 2016) (but it is not known if such wood comes from the Far-East). There were small and irregular imports from China (60 t in 2012, 106 t in 2014, 22 t in 2016) and from Vietnam (1270 t in 2012, 22 t in 2014, none in 2016). - <u>Logs</u>. There was no import of *Castanea* over the period considered. <u>For *Quercus*:</u> **Logs*: irregular imports from China to only 4 EU countries (473 t in 2012, 56 t in 2014, 16 t in 2016), from Vietnam (0.9 t in 2016 to one country), and Russia (182 t in 2014, 123 t in 2016). **Sawn wood*: There were imports from China (ca. 1100 t in 2014, 700 t in 2016) and Russia (ca. 2900 t in 2014; 13 300 t in 2016), and very minor from Japan (235 t in 2016), Korea Rep. (11 t in 2012, 3 t in 2014) and Vietnam (4 t in 2012). Commercial logging in natural forests (where *Q. mongolica*/*Q. liaotungensis* occur) is banned in China, and therefore the wood from the only known highly-infested areas (Jilin, Liaoning and Inner Mongolia) would not be traded commercially (see section 8).	FAOStat (which includes data for most EPPO countries) groups coniferous and non-coniferous wood chips, and was not useful here. Trade data is available in Eurostat (i.e. into the EU) for 'deciduous wood chips', and for 'wood waste and scrap (whether or not agglomerated in logs, briquettes or similar forms (excl. sawdust and pellets)'. 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, 2014 and 2016. <u>- Wood chips</u> Major imports from Russia (around 280 000 t in 2014 and 2016), mostly to Finland, also Estonia and Denmark. Minor and irregular imports from other countries: *China: 33 t in 2012, 57 t in 2014, 5455 t in 2016 (it is not known if this represents a long term trend for increase in trade or just a temporary increase) *Korea Rep.: 0.2 t in 2012, 112 t in 2014, 64 t in 2016; *Japan: 16 t in 2012, none in 2014, 2016; *Vietnam 103 t in 2012, none in 2014 and 2016. - <u>Wood waste and scrap</u> Major imports from Russia (165 000 t to 243 231 t depending on years) Minor and irregular imports from other countries: *China: 716 t in 2012, 125 t in 2014 and 153 t in 2016 * Vietnam: 1077 t in 2012, 16 t in 2014, 50 t in 2016. * Japan and Korea Rep. : 1.5 t to 10 t depending on the year Commercial logging in natural forests (where *Q. mongolica*/*Q. liaotungensis* occur) is banned in China, and therefore the wood from the only known highly-infested areas (Jilin, Liaoning and Inner Mongolia) would not be traded commercially (see section 8).
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 not considered impossible. Emerging adults would need to find a suitable host (see *Transfer from commodity to host trees* at the start of section 8 in general	Transfer would be similar as for wood. In addition, transfer would be facilitated if the commodities are used outdoors (e.g. ground cover, mulch). However, products for ground cover (mulch) likely constitutes a small part of imports. Wood chips or hogwood would mostly be used for processing

Pathway	Roundwood and sawn wood of hosts	Wood chips, hogwood, processing wood residues (except sawdust and shavings) of hosts
	considerations on pathways). The survival of young larvae would depend on their stage and the availability of suitable quantity of wood in a suitable state. It also supposes that the wood is not used/processed during a longer period. Big logs may remain suitable for the development of larvae for several months. However, this is not likely for small diameter wood, nor for younger larvae that would still need 2-3 years to complete their development.	(e.g. fibreboard, pulp) or energy. In that case transfer would be possible only if they are stored outdoors for a sufficient period prior to processing, allowing emergence. Adults would need to find a suitable host (see *Transfer from commodity to host trees* at the start of section 8 in general considerations on pathways).
Likelihood of entry and uncertainty	**Firewood**. moderate (higher than for other round wood due to lower wood quality) with high uncertainty (trade volumes and proportion that is from host tree species, and from infested areas; proportion of wood that would be infested in areas of lower infestation). **Other round wood.** Low with moderate uncertainty (pathway highly favourable to entry of the pest from biological considerations. However, no trade from areas in China where the pest causes high infestation. Low trade volume to the EU, but uncertain if trade will remain as such in the future, and uncertainty on whether there is a trade to non-EU EPPO countries). **Sawn wood**. very low with low uncertainty (less risk of association, low volume)	**Wood chips >2.5 x 2.5 cm in two dimensions.** low (low uncertainty) **Hogwood, processing wood residues.** low (moderate uncertainty – wood used; whether the trade from Russia includes trade from regions where *M. raddei* occurs) **Wood chips <2.5 x 2.5 cm in two dimensions.** very low (low uncertainty)

Table 6. Wood packaging material

Pathway	Wood packaging material
Coverage	Pallets etc. moving in trade
Pathway prohibited in the PRA area?	In international trade, WPM must be treated according to ISPM 15.
Pathway subject to a plant health inspection at import?	In the EU, consignments are inspected randomly, and certain consignments would be especially targeted, such as wood packaging material carrying stone from China, for which Implementing decision 2013/92/EU requires plant health checks at specified frequency (Eyre et al., 2018).
Pest already intercepted?	Not known
Plants concerned	Wood packaging material is built from wood of many species. However *Quercus* and *Castanea* wood are not known amongst the main species used in China for wood packaging material (EC, 2013). However, wood of bad quality (e.g. infested) may be redirected to produce wood packaging material.
Most likely stages that may be associated	Solid wood packaging is a proven pathway for entry of longhorn beetles into Europe (ISPM 15, Haack et al., 2010). Larvae and pupae may be present in big/thick pieces of wood used to build pallets. Larvae of *Apriona* (which have a similar size) and *Anoplophora glabripennis* have been intercepted in wood packaging material in trade (EPPO, 2013a), and this is considered possible.
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) big/thick pieces of wood are used to build the wood packaging material; 2) treatments according to ISPM 15 *Regulation of wood packaging material in international trade* (FAO, 2009) were not applied. These treatments should be effective in destroying eggs, larvae and pupae. ISPM 15 requires that all wood packaging material moved in international trade has to be debarked and heat treated (either 56°C for 30 min at the core if using a conventional steam or dry kiln heat chamber; or 60 °C for 1 minute throughout the entire profile of the wood if using dielectric heating) or fumigated with methyl bromide (and stamped or branded with a mark of compliance). These treatments are internationally considered adequate to destroy insects and nematodes present in wood packaging material at the time of treatment.
Survival during transport and storage	If ISPM 15 treatments were not applied, mature larvae and pupae would survive , allowing adults to emerge
Trade	There are very large quantities of wood packaging material moving in trade (although only a small part would contain infested host wood material). Estimates based on the number of shipping containers moving goods from China to the EU suggest that approximately 4 million shipping containers containing solid wood packing material arrive in the EU annually from China (PRA on *Aromia bungii;* EPPO, 2015c, citing Anderson *et al*., 2013).
Transfer to a host	If mature larvae or pupae are still present at destination, they may emerge, and adults may find hosts. Transfer would require special circumstances, i.e. that the wood packaging material is kept outdoors at destination, within flight distance to host plants (see *Transfer from commodity to host trees* at the start of section 8 in general considerations on pathways). In places where used wood packaging material is collected in large quantities (e.g. for recycling), the probability of having several infested items increases, and therefore the probability of adults mating (PRA on *Aromia bungii*, EPPO, 2015c).
Likelihood of entry and uncertainty	If ISPM 15 is applied: very low (low uncertainty) If ISPM 15 is not applied: moderate with moderate uncertainty (how much *Castanea* and *Quercus* wood are used)

Overall rating of the probability of entry (based on the highest rating of the pathways assessed:

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

- *Cut branches of hosts.* It is unlikely that traded cut branches are of a diameter sufficient to support the pest. No data on trade is available. *Uncertainty:* low.
- *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 or young larvae could be present on the bark before harvest, and can be associated to thicker bark, which may be used for some purposes (but there is not information on that). Mature larvae and pupae are deeper in the wood and are unlikely to be associated with bark consignments. Some eggs or larvae would be destroyed during removing of the bark and further processing. Small life stages would not complete their development in the absence of a sufficient quantity of phloem and xylem, and because the material would degrade. Even if there was sufficient wood material, the further development to pupa would take 2-3 years, during which the bark and wood attached would have dessicated and become unsuitable for larvae. There is no information on the trade of bark of hosts into the EPPO region. In the EU, *Castanea* bark is prohibited, and *Quercus* subject to specific requirements. The intended use of bark may vary, from energy purposes to mulch, but there is no information on this. Mulching would present a higher risk. If adults emerge, they would need to fly and find a suitable host (see *Transfer from commodity to host tree* in section 8, italics). *Uncertainty: low*
- *Fruit of hosts (chestnuts)*. *M. raddei* has been shown experimentally to be able to feed on soft fruits, not chestnuts. Incidental association of adults to consignments is covered under hitchhiking in 8.1. *Uncertainty*: low.
- *Sawdust and shavings, processed wood material, post-consumer scrap wood* (see definitions in Annex 3). EPPO Study (EPPO, 2015b) assesses the risk as being low for all pests. Such wood material is processed to a level that would not allow survival of the pest. Any eggs, larvae or pupae present in the initial material would die or not be able to pursue development. *Uncertainty*: low.
- *Seeds, bulbs and tubers, grain, pollen, stored plant products, soil and growing medium*. No life stages are associated with these. *Uncertainty*: low.
- *Natural spread from countries where M. raddei occurs* to the rest of the EPPO region. *M. raddei* has been present in Far East Russia for many decades, and has apparently not spread significantly westwards to date. *Uncertainty*: low.
- *Movement of individuals, shipping of live Cerambycidae, e.g. traded by collectors.* Cerambycids are striking insects and *M. raddei* may circulate between hobbyist entomologists, but is most likely sent dead. This pathway is also difficult to regulate as such. *Uncertainty*: low.

9. Likelihood of establishment outdoors in the PRA area

9.1 Climatic suitability

Climate in the EPPO region does not seem to be a limiting factor. *M. raddei* occurs in a wide range of climates, from southern Japan (humid subtropical) to Russian Far-East (Khabarovskii Krai - subartic). In the EPPO region the temperature would not be a limiting factor for the survival of larvae and completion of the life cycle. In particular cold winters would not limit the pest, which overwinters within the trees and is currently present in areas of very cold winters. The climate chart for one location in an outbreak area of *M. raddei* (Changchun, Jilin, China) is given in Annex 5 (Fig. 1).

Tang et al. (2011b) qualifies their experimental plots, infested by *M. raddei*, as belonging to the 'temperate semi-humid monsoon climate zone with an annual precipitation of 800-1000 mm' in Jilin and Liaoning, and to 'temperate semi-arid monsoon climate zone, with an annual precipitation of about 500mm' in Inner Mongolia (Ningcheng County).

Temperature and relative humidity are important for the emergence and activity of adults, but the exact ranges are not known, especially their lower limits. Temperatures between 22°C and 26°C and relative humidity between 50% and 80% favoured the level of activity of adults under experimental conditions. Emergence occurred already when the average daily temperature was 19°C but was highest above 24°C;

humidities around 60-70% favoured emergence (compared to higher humidities) (see section 2.3). Regarding comparisons of areas where *M. raddei* occurs and the EPPO region:

- The maps of degree-day accumulation for Europe/the Mediterranean area and Asia in Annex 5 (Fig. 2) shows similarities between a large part of the PRA area and areas where *M. raddei* occurs.
- In relation to plant hardiness, the distribution of *M. raddei* includes hardiness zones (at least) 3-12 (Annex 5, Fig. 3), which also corresponds to a large part of the EPPO region.
- According to the classification of climates of Köppen-Geiger (maps in Annex 5, Fig 4), *M. raddei* is present in climatic zones that occur in the EPPO region from Norway to the Far-East in the North, and from the Eastern part of Eastern Europe to the European part of Russia to Siberia in the South. Such climates probably also occur in mountains in Western Europe.
  Japan, China and Taiwan also include limited areas that correspond to the prevalent climate (Cfb) from Western Europe (to UK and coastal Norway in the North) to the Black-Sea in the South-East. However, it is not known if *M. raddei* occurs in these limited areas. From the biological data above, such areas are nevertheless likely to be suitable.

Considering the above, in relation to climatic conditions, establishment of *M. raddei* is assessed to be likely in most of the EPPO region. Establishment is more likely from Western Europe through to the European part of Russia to Siberia, northwards to Norway and the Far-East. It was assessed to be less likely in arid areas such as the Mediterranean Basin, as well as in the warm (at least in summer) and arid areas in North Africa, the Near East and Central Asia. However, the latter assessment is associated with a high level of uncertainty due to the absence of data on temperature and humidity threshold values.

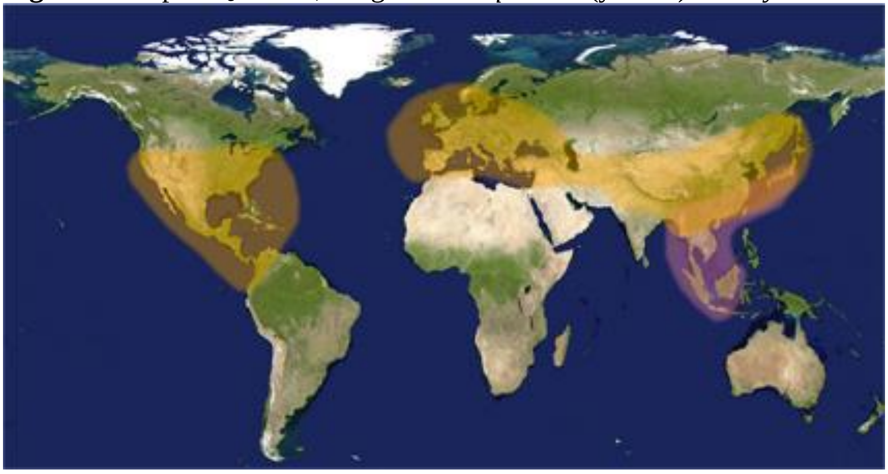
9.2 Host plants

Quercus. All known hosts are available as ornamentals (see Table 2 in section 7). The native *Quercus* species in the EPPO region are not reported as hosts to date (apart from in Far-East Russia where *M. raddei* occurs). However, *M. raddei* has many *Quercus* hosts, and it is assumed that it would be able to also use some other species as hosts (see section 7).

Quercus species are widespread in the PRA area (Fig. 4). The dominating native *Quercus* in Europe and the Mediterranean area are *Q. robur*, *Q. pubescens*, *Q. petraeae* and *Q. cerris*, and there are many other species such as *Q. suber*, *Q. ilex*, *Q. afares* (incl. North Africa). A list of native *Quercus* (applying at least for Europe and Turkey, probably wider) is provided in Annex 6. In addition, some introduced species are widely planted, such as *Q. rubra* (e.g. 55 000 ha in Germany, B. Hoppe, pers. comm.).

The Quercus Portal (2017, citing other references) mention that oaks grow from Northern Africa (*Q. suber*, *Q. ilex*, *Q. afares*) across the Mediterranean region up to southern Scandinavia (where only *Q. robur* and *Q. petraea* occur), and that most European species grow in the Mediterranean area (see Figure 4 and list in Annex 6).

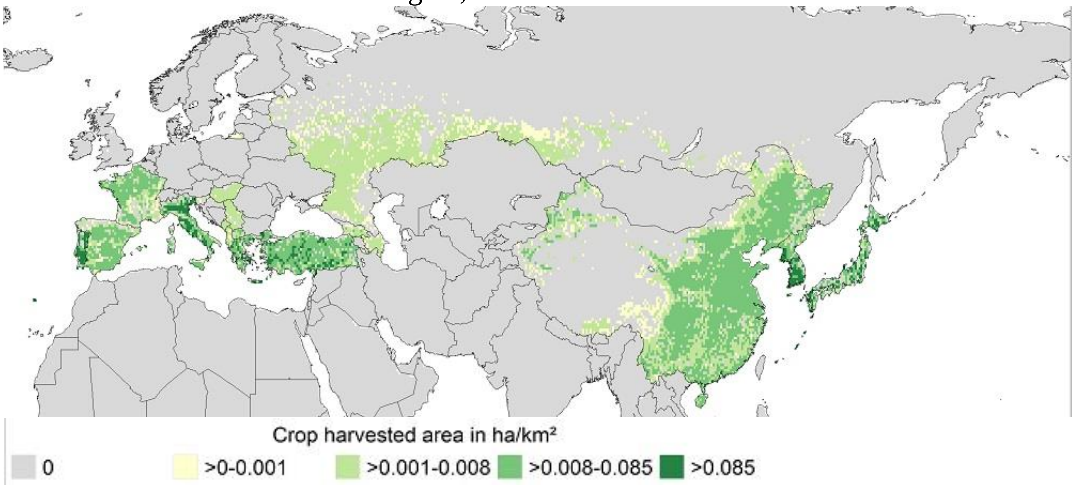
Figure 4. Map of *Quercus*, subgenera *Euquercus* (yellow) and *Cyclobalanopsis* (pink). Quercus Portal, 2017



Castanea. The known *Castanea* hosts (*C. henryii*, *C. seguinii*, *C. crenata* and *C. mollissima*) are available as ornamentals in the EPPO region (see Table 2 in section 7). In addition, *C. crenata* is also used (probably on a small scale) for fruit or wood production (EPPO, 2013); it is also present in the wild in SE Russia, S Ukraine and W Transcaucasus (EPPO, 2000) and is subspontaneous in the Basque country (France) (Bourgeois, 2004). *C. mollissima* may also be used for fruit production (although no confirmation was found). According to ISEFOR data, 192.000 *C. mollissima* were imported to Germany in 2010, which may indicate some occasional large scale planting in Europe, but no information was found to support this. In France and Italy, hybrids of *C. sativa* with *C. crenata* or *C. mollissima* (both hosts) are used and traded (Borowiec & Brancaccio, 2014; www.bassivivai.com).

The only widespread *Castanea* species in the EPPO region, *C. sativa* is not a known host to date (see distribution in Fig. 5). 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 according to EEA (2006) covering ca 2 millions ha (from Turkey to the Iberian peninsula, through Southern Switzerland and France, incl on the Mediterranean islands). Such forest may be used for wood production, fruit or they may be unmanaged. There are also old established and naturalised plantations of *C. sativa*, especially in the Mediterranean area.

Figure 5. Chestnut crop distribution (from Monfreda et al., 2008). Note: this map presumably covers *C. sativa* in the Euromediterranean region, but also *C. mollissima* and *C. crenata* in Asia.



***Castanopsis*.** The last known host, *Castanopsis cuspidata* is used as ornamental in the EPPO region.

There is currently no evidence that other Fagaceae would be hosts, including *Fagus sylvatica* (European beech), which is a widespread and economically and environmentally important tree in the EPPO region.

9.3 Biological considerations

For the establishment of a population, there should be simultaneous entry of individuals of both sexes, and adults are able to mate 2-3 days after emergence, which increases the risk that mating occurs before dispersal. Adults have a limited lifespan (about 20 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 establish a population.

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

Uncertainty: susceptibility of native *Quercus* and *Castanea* species.

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

M. raddei is a pest of woody plants, which are normally not grown under protected conditions in the PRA area (especially not since *M. raddei* require a tree DBH or bonsai base diameter >9 cm). However bonsais and ornamental plants may be grown in some protected conditions, e.g. in nurseries or botanical gardens. Establishment would require that large host plants are present in the protected conditions, or that *M. raddei* is able to leave those to search for hosts. However, the pest would be easy to detect and eliminate in protected conditions.

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

11. Spread in the PRA area

M. raddei may spread naturally and at longer distances could be transported in wood and wood products, including wood packaging material (if not treated according to ISPM 15) or in plants for planting. Hitchhiking may play a role locally.

There are reports of observations on the natural spread of *M. raddei*. Gao (2001) reported that the beetle can fly 50-80 m each time (other studies report shorter distances – see section 2.4), dozens of times in one night (and calculated from these values that the total flight distance per night could therefore reach 300-1000 m). However, the EWG noted that an adult is unlikely to fly far in one night, and would mostly remain close to the tree from which it emerged. The spread would also depend on whether other species of oak and chestnut may be attacked: if *M. raddei* attacks only the current known hosts, spread will be limited because those have a limited distribution and use in the PRA area (mostly as ornamentals). In China, outbreaks have been limited to Jilin, Liaoning and Inner Mongolia, but do not seem to be due to introduction of new populations (and subsequent spread), since *M. raddei* was present before outbreaks started at the beginning of the 1990s (Sun, 2001; Tang, 2011).

As limited data on natural spread of *M. raddei* is available, the EWG considered dispersal of other longhorn beetles of the same size active in forests and attacking the lower part of trees. The spreading behaviour of *M. raddei* seems to be similar to some other cerambycids for which some information on spread distances is available. It is generally agreed that dispersal will be related to the size of the insect. Adults of *M. raddei* (35-63 mm) are a bit larger than those of *Apriona germari* or *A. cinerea* (26-50 mm in length) or *Cerambyx cerdo* (41-45 mm) and also larger than adults of *Anoplophora glabripennis* and *A. chinensis* (25-35 mm).

For *Apriona* (EPPO, 2013a, citing several sources), a survey in Baoding, Hebei Province suggested that 400 m was a safe distance from source sites of *A. germari*. However, another field survey accompanied with bait revealed that adults of *A. germari* can fly as far as 2500 m for food, although most individuals were caught between 250 and 550m. For *A. cinerea*, new plantations more than 1 km from an infestation site are unlikely to be infested during the first two years.

For *Anoplophora*, adults of *A. glabripennis* and *A. chinensis* can disperse 1 to 3 km during their life span, although most remain near the tree where they emerged (Dumouchel, 2004; Smith et al., 2001, 2004; Sacco, 2004; Williams et al., 2004; Van der Gaag et al., 2008 cited in Dutch PRA, 2010, Haack et al., 2010).

Cerambyx cerdo and *C. welensii* are European species within the subfamily Cerambycinae and their hosts are mainly *Quercus* and other Fagaceae. Mark-recapture studies in Spain (Torres-Vila et al. 2016) showed a low-dispersal tendency with a mean flight of 91-100 m for both species, but a subset of adults exhibited a huge propensity to disperse and flew several hundreds of metres (with longest flight lengths of 1108 m for males and 581 m for females of C. *welensii* and 885 m for males and 1722 m for females of *C. cerdo).* Torres-Vila et al. (2016) considered that only 3% of adults fly further than 100 m and only 0.5% fly further than 500 m and conclude that "mean and maximum displacements of *C. cerdo* and *C. welensii* agree with those of large cerambycids, such as *A. glabripennis* and *R. alpina".* However Drag and Cizek (2018), using radio-tracking techniques, recorded longer flights for *C. cerdo* in Czech Republic: the median distance over the tracking period (up to 14 days) was 279 m for males and 559 m for females. They observed that the tracking distance was longer than 2200 m for 15% of individuals (4 out of 26). It should be noted though that, as the beetles did not fly always in the same direction, they did not disperse more than 2000 m away from the release point. Differences were explained by the differences in methodology as well as differences in landscape configuration, habitat structure and climatic conditions.

Therefore, in the absence of detailed data on *M. raddei*, it is considered acceptable to extrapolate dispersal data from these species.

The flight distance is influenced by the availability of susceptible hosts; if no host is available, *M. raddei* has apparently the capacity to fly very long distances to find a host.

In conclusion, natural spread will be slow, but there may be 'jumps' on commodities that would lead to multiple outbreaks and increase the spread.

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

12. Impact in the current area of distribution
Nature of the damage: See details in section 2.5.

Impact in different countries
China
M. raddei rarely caused significant damage in forests before the 1990s, but has occurred at outbreak levels since 1993 in Northeast China (Sun, 2001; Zheng et al., 2014a). Although it has been recorded in most provinces of China (see Figure 1 in section 6), it is only regarded as a severe pest in Liaoning and Jilin provinces of Northeast China (Yang et al., 2011, Cao et al., 2015), as well as adjacent parts of Inner Mongolia (Tang et al., 2011b), where it attacks *Quercus* spp.

The first record found for China dates from 1932 (Wu, 1932). Early references cited in Lin et al. (2016) relate mostly to chestnut (*C. mollissima*), and *M. raddei* has been listed amongst the main pests of *C. mollissima* (Wu et al. 2000). No more details were found on impact on chestnut (which is otherwise an important crop in China). No details were found for any other hosts in the Chinese literature. Recent literature relates to *Quercus mongolica and Q. liotungensis*. Since the 1990s, *M. raddei* has triggered extensive research on its biology and control. It has also triggered extensive and costly control programmes.

In Northeast China, it has infested ca. 2640 km^2 (Yang et al., 2014). Cao et al., 2015 (citing Tang et al., 2010) mentions that 1600 km^2 of forests have been damaged, threatening natural forests in Northeast Asia. About 45% of trees in oak forests have been affected, resulting in great ecological and economic losses (Yang et al., 2013b). In plots with serious infestations, over 80% of oak trees in a stand were found infested (Tang et al., 2011b). In Liaoning, a survey conducted in 2014 showed that *M. raddei* occurs on 1460 km^2, with 310 km^2 being severely infested (trees dying), 430 km^2 moderately infested and 710 km^2 slightly infested; control measures (biological control, light traps, tree felling) have been applied and have had some success (Xing, 2015).

For Liaoning, an article of 2001 reported the loss of 200 million m^3 valuable wood and economic losses over 10 billion €[7,8]; in 2005, the loss of wood amounted to ca. 8 million m^3 wood and economic losses were over 8.3 billions € (cited in Tang et al., 2011a). Still in Liaoning, Xing (2015) estimated losses per km^2 for 3 plots presenting low (8% infested trees), moderate (16%) or severe (45%) infestations (one plot for each), to ca. 96000 €, 166000 € and 325000 €; based on these figures, they estimated that the direct economic losses in Liaoning to ca. 76 million €.

Environmental impacts include: reduction of the water conservation ability by over 50%, increased erosion especially in mountains; negative effect on natural tree regeneration, with lower number of trees and longer times for regeneration of the canopy (Xing, 2015).

Social impact is mentioned (without details) as well as effects on the implementation of natural forest protection projects in Northeast China (Xing, 2015).

Japan. Kojima (1931) mentions *M. raddei* as an injurious borer of forestry and horticultural plants, citing earlier sources (including books on forest pests). It is mentioned to «practically hollow out the trunk». A publication from 1991, which is cited in Lin et al. (2016) as the only report they found for Japan, but the EWG did not have access to that publication. No other information was found.

[7] All amounts in dollars or yuans were converted into euros, but using current exchange rates
[8] It is not known from Tang et al. (2011a) if the figures relate to damage caused during the outbreak year 1999 (2001 was not an outbreak year) or to accumulated damage since the start of the outbreak.

Russian Far-East. The only article found (Anisimov and Bezborodov, 2017) deals only with distribution, but gives the impression that *M. raddei* possibly occurs at low densities, as the authors had difficulties finding specimen for confirming its distribution. No additional published information on damage was found, but a few oak trees damaged by *M. raddei* were observed in and near Vladivostok (A. Shamaev, March 2017, pers. comm.)

***Korea Rep., Korea Dem. Rep. and Vietnam*.** No information was found.

Existing control measures

A research programme was conducted in China in 2000-2012 to study the biology of the pest and develop an integrated management approach; application of this programme for 5 years (relying on mass-trapping and biological control) has resulted in control of the pest “to a large extent” (Yang et al., 2014). In Liaoning, control has relied on mass-trapping, biological control and removal of infested trees (Xing, 2015), and other methods are also indicated in the Chinese forestry standard against *M. raddei* (LY, 2016).

Mass-trapping of adults. Black light traps were used in some regions (Sun et al., 2010, Yang et al., 2011). Trapping with black light is considered very effective, one trap attracting a maximum of 20 kg of adults in a night (430 adults per kg on average). Females carrying eggs are also trapped, allowing to remove a large proportion of the population. The pest density was reduced by about 90% (Yang et al., 2014). In Liaoning, five mass-trapping activities using black light traps were conducted since 1999, resulting in reduced pest population density and speed of spread (Xing, 2015). It should be noted that mass trapping with black light would likely also trap massive amounts of non-target insects.

Biological control: The parasitoids *Scleroderma guani* and *Dastarcus helophoroides*, respectively against young/ mature larvae and pupae, are reared and released (Wei et al., 2009; Tang et al., 2012; Xing, 2015, LY, 2016). Other parasitoids have also been investigated, such as *Sclerodermus pupariae* (Wang et al., 2010), *Cerchysiella raddei* (Yang et al., 2013a, 2014), *Rhoptrocentrus quercusi* sp. nov., *Doryctes petiolatus*, *Zombrus* bicolor (Cao et al., 2015). Finally LY (2016) and rcfh (2017) mention favouring woodpeckers.

Silvicultural and physical methods. The Chinese forestry standard on *M. raddei* (LY, 2016) mentions the methods below:

- proper silvicultural management of forests
- high density stands with an infestation level below 10% should be thinned.
- sanitary felling of infested trees, dead trees and dying trees are required in stands with moderate infestation (10%-20%), including trees infested with other pests.
- for stands with severe infestations (>20%), selective cutting (in winter) of trees older than 30 years. In 1999-2000, in Kuandian County of Lianoning, selective cutting were performed on ca. 67 km^2 with good results, but this method was forbidden after 2000 (Xing, 2015).
- harvesting of host trees older than 50 years and replanting with non-hosts (conifers or non-host deciduous species)

Felling of trees in high infestation areas has been primarily applied in the 1990s when outbreaks started, but not to the same extent recently, because felling of trees in protected areas is limited and subject to official authorization (see section 8).

Chemical control. Chemical control is not commonly applied in practice (Wang XY, pers. comm.). LY (2016) mentions the following possible control methods: trunk injections (thiamethoxine, imidacloprid, avermectin), insect hole injection (plug), and sprays against adults (in areas with high population densities). Studies have also been conducted with chlorbenzuron, diflubenzuron and triflumuron as chemosterilants (Jiang et al., 2011). In a study, trunk injections on *Q. mongolica* were not effective due to the pattern of water transport in the trunk (the pesticide could not reach the whole transverse section of the trunk, reducing the probability of *M. raddei* coming in contact with the pesticide) (Liu and Li, 2012).

Impact in non-epidemic areas of the distribution

Rating of the magnitude of impact in the	*Very low*	*Low*	*Moderate*	*High*	*Very high*

current area of distribution	☐	✓	☐	☐	☐
Rating of uncertainty			*Low* ☐	*Moderate* ☐	*High* ✓

Uncertainty: no record of damage from such areas, but not sure if the relevant literature was found for all countries.

Impact in areas in Northeast China where epidemic outbreaks occur

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* ☐

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 Northeast China

Recent experience with the introductions of Cerambycidae wood borers (e.g. *Anoplophora* spp., *Aromia bungii)* showed that they can adapt to new hosts in the area of introduction and that they can cause more damage in their invasive range than their native range. However, the potential impact would depend on the oak and chestnut species that are susceptible, especially if *Castanea sativa* or major *Quercus* spp. in the EPPO region are hosts, such as *Q. robur, Q. suber, Q. ilex, Q. petraea*, or exotic species that are widely planted such as *Q. rubra* (see section 9.2). If only the currenly known hosts are attacked, damage would mostly be limited to ornamental hosts (noting that those are probably not very widely used), and to *C. crenata* where it is cultivated or present in the wild.

Many oak species are widely present in the EPPO region for forestry, and amenity purposes (see section 9.2). In China, the impact of *M. raddei* in the North-East is due to various factors, but one is large areas of *Q. liaotungensis* and *Q. mongolica* situated in favourable environments and having reached a size more susceptible to attacks by *M. raddei*. It is not known how the situation compares in the EPPO region, but there is a wide presence of older oak trees, including in mountains. Large oaks, of a size and bark characteristics suitable for egg-laying, are widespread in most environments.

As for other wood borers, early detection and control would be rendered difficult by the hidden life habits of larvae and pupae. Larvae would be detected at best one year after egg-laying.

Nevertheless, the rating also took account of the fact that, considering the wide distribution of *M. raddei* in East Asia, significant damage is only reported in a small part of that area (see figures 1 and 2, section 6), and this is expected to also be the case at the scale of the EPPO region.

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

14. Identification of the endangered area

The pest could establish where oak (*Quercus* spp.) and chestnut (*Castanea* spp.) are grown (given the diversity of Asian host species – see section 7) (with an uncertainty on the species attacked). The climatic conditions would not be limiting (although there is a high level of uncertainty for warm and arid areas in North Africa, the Near East and Central Asia - see section 9.1). However, it is expected that impact would be highest at least in areas where climatic conditions are more similar to Northeast China where outbreaks have been reported, and oak coverage is important.

15. Overall assessment of risk

Summary of ratings:

	likelihood	**Uncertainty**

Entry[9]		
Overall	moderate	moderate
Host plants for planting including bonsais	moderate	moderate
WPM if ISPM 15 is not applied	moderate	moderate
Firewood	moderate	high
Wood chips > 2.5 cm x 2.5 cm in two dimensions	low	low
Hogwood, processing wood residues	low	moderate
Round wood	low	moderate
Hitchhiking	low	moderate
Furniture and other objects made of wood of host plants	low	moderate
Establishment outdoors	high	high
Establishment in protected conditions	very low	low
Spread	moderate	moderate
Magnitude of impact in the current area of distribution – in non-epidemic areas of the distribution	low	high
Magnitude of impact in the current area of distribution - for areas in Northeast China where epidemic outbreaks occur	high	low
Magnitude of potential impact	moderate	high

M. raddei has caused epidemic outbreaks in several provinces of Northeast China (Jilin, Liaoning and adjacent areas in Inner Mongolia) on *Q. mongolica* and *Q. liaotungensis*. Such outbreaks occur only in a small part of its wide distribution in Asia. Limited or no data was found on its situation and impact on other hosts, or in other areas where it occurs (i.e. many other Chinese provinces, as well as Japan, Far-East Russia, Korea Rep, Korea Dem. Rep. Vietnam).

For all pathways, entry would depend on very specific conditions, which would probably be fulfilled only for a small part of the trade (especially plants for planting should have a diameter at breast height (DBH) or bonsai base diameter >9 cm). The likelihood of entry was considered moderate for host plants for planting, wood packaging material (if ISPM 15 is not applied) and firewood (as round wood). For plants for planting, the EWG thought there would be relatively few trees of a sufficient DBH or diameter imported from Asian countries where *M. raddei* could occur. Regarding wood commodities, the likelihood of entry, especially on round wood, was reduced because of the ban on logging in areas of outbreaks in Northeast China. Round wood is otherwise highly favourable to allow entry of the pest from biological considerations. The assessment would change if the ban was lifted. Round wood (with or without bark, other than firewood), wood chips >2.5 x 2.5 cm in two dimensions, hogwood and processing wood residues, as well as furniture and other objects made of wood, presented a low risk of entry. Finally, hitchhiking presented a low risk of entry.

Establishment of *M. raddei* is likely to occur in the EPPO region and would not be limited by climatic conditions (although there is a high level of uncertainty for warm and arid areas in North Africa, the Near East and Central Asia). *Quercus* and to a lesser extend *Castanea* are widespread in the region. Although the host status of European species is not known, *M. raddei* has many *Castanea* and *Quercus* hosts. It has hosts in both subgenera of *Quercus* (*Cyclobalanopsis* and *Quercus*), and in the 3 sections of the subgenus *Quercus* that are present in Asia (out of 5, the remaining 2 being North American). It is reported on 4 Asian *Castanea* species (out of 9 in total, others being *C. sativa* and 4 North American species) (www.theplantlist.org). *M. raddei* is believed to present a higher risk of host switch (i.e. to European species) than a pest that attacks only species from one section (such as *Agrilus auroguttatus* (Coleoptera: Buprestidae) on white oaks). It is therefore assumed that it would be able to use some other *Quercus* and *Castanea* species as hosts. There are non-supported statements regarding non-Fagaceae hosts in the literature (section 7, Table 3), which would increase the risk if confirmed.

The likelihood of spread was rated as moderate because natural spread will be slow, but there may be long distance spread with commodities that would lead to multiple outbreaks and increase the spread.

The potential impact in the EPPO region is uncertain, but would probably be lower than that registered in areas of epidemic outbreaks in Northeast China. The potential impact would depend on the oak and chestnut species that are susceptible, especially if *Castanea sativa* or major *Quercus* spp. in the EPPO region are

[9] Pathways rated with a very low likelihood of entry are not listed here and can be found in Sections 8.1 and 8.2.

hosts. If only the currenly known hosts are attacked, damage would mostly be limited to ornamental hosts (noting that those are probably not very widely used), and to *C. crenata* where it is cultivated or present in the wild. In addition, considering the wide distribution of *M. raddei* in East Asia, significant damage is only reported in a small part of that area and this is expected to also be the case at the scale of the EPPO region. It is expected that impact would be higher in areas where climatic conditions are more similar to Northeast China where outbreaks have been reported, and oak coverage is important.
Because of the severe outbreaks in Northeast China, of the importance of oaks and chestnuts in the EPPO region, and of the potential impact, the EWG considered that phytosanitary measures should be recommended.

Stage 3. Pest risk management

16. Phytosanitary measures

16.1 Measures on individual pathways

Measures were studied (Annex 1) for host plants for planting, wood of hosts, and wood chips, hogwood and processed wood material. ISPM 15 should be applied for wood packaging material. Measures for furniture and other objects 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 host genera (*Castanea*, *Quercus* and *Castanopsis*), and not only known host species, because *M. raddei* is likely to find other hosts at destination (see section 7).

Possible pathways ***(in order of importance)***	**Measures identified** (see Annex 1 for details)
Plants for planting (except seeds, cuttings, tissue cultures, pollen) of *Castanea*, *Quercus* and *Castanopsis*	Phytosanitary certificate and Diameter less than 1 cm diameter or Pest Free Area (PFA) + Plants packed in conditions preventing infestation during transport or Grown under complete physical isolation (following EPPO Standard 5/8; EPPO, 2016b) + Plants packed in conditions preventing infestation during transport or Pre-entry quarantine (3 years) in the framework of a bilateral agreement or Post-entry quarantine (3 years) in the framework of a bilateral agreement
Wood of *Castanea*, *Quercus* and *Castanopsis* (including firewood)	Phytosanitary certificate and PFA or Heat treatment (EPPO Standard PM 10/6(1) *Heat treatment of wood to control insects and wood-borne nematodes*) 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 - FAO, 2017))
Wood chips, hogwood, processing wood residues	Phytosanitary certificate and PFA or For wood chips: chipped into pieces of less than 2.5 cm in two dimensions or heat treated (56°C for 30 min throughout the material)

Wood packaging material	ISPM 15
Furniture and other objects made of wood of host plants	Made from pest-free wood (originating from a PFA or treated)

16.2 Eradication and containment

Monitoring for *M. raddei* will be complicated as early signs of infestation are difficult to observe (such as eggs and larval frass ejection holes). Adults may be detected early (especially through public awareness). There are no species-specific traps, but light traps could be used as a monitoring tool. In forests or semi-natural environments, early detection would be difficult. The pest may attack hosts in gardens, natural areas, forests, which would complicate eradication because removing potential hosts (*Quercus* and *Castanea*) around an outbreak would also be difficult. In addition, adults fly and may spread before eradication is completed.

Eradication will depend very much on the time of detection and the willingness to apply measures such as felling trees etc. Removing host trees can be politically or socially very difficult. Eradication measures will be more difficult to apply in areas where the density of host plants is high. However, some eradications of cerambycids have been successful, e.g. *Anoplophora chinensis* and *A. glabripennis* in some countries (EPPO GD, 2017).

Eradication or containment outdoors would require buffer zones without hosts and intensive surveys. A similar eradication plan as for *Anoplophora* would be appropriate (EU Implementing Decision 2015/893 - EU, 2015).

The EWG discussed the size of the demarcated area that would be necessary. This was done using the draft EPPO guidance on buffer zone (EPPO, under development) and the software MATCH Uncertainty Elicitation Tool (http://optics.eee.nottingham.ac.uk/match/uncertainty.php#). The objective of this guidance is to provide information to risk assessors and risk managers to define zones in which the vast majority of the population will spread, and is not intended to cover rare events of very long dispersal.

There was not sufficient evidence to define flight distances for *M. raddei*, and the EWG therefore extrapolated from the data on the flight of *Anoplophora glabripennis* (Smith et al., 2001) as it was considered that they had a similar biology and flight pattern (see also section 11). The EWG considered that the probability of dispersal of *M. raddei* was best estimated with a log normal distribution (μ=5.09; σ=0.76), with a median (50th percentile) at approximatively 160 m, 95th percentile at approximatively 560m and 99^{th} at approximatively 950m. This distribution could be used as guidance for determining the size of demarcated areas (infested area, buffer zone and surveillance area): the EWG proposed to use the estimate of the median dispersal distance (160m) as a guidance for the host plant removal radius and the 99th percentile value (950m) as a guidance for the surveillance area. The EWG noted that, based on this estimation, a buffer zone of 2km (as recommended in EU, 2015) is not necessary, but can be done if a precautionary approach is preferred to take into account the uncertainties.

There are uncertainties whether the dispersal data of *M. raddei* will be lower or higher than this dispersion curve. These figures are consistent with the dispersal data obtained by Torres-Villa et al. 2016 for *C. cerdo* but are lower than the data obtained by Drag and Cizek (2018).

Trace-back and trace-forward studies would also be needed to identify possible areas infested by the pest.

17. Uncertainty

- Major:

  Hosts, whether European *Quercus* or *Castanea* (and hybrids between *Castanea sativa* and Asian *Castanea*) are hosts and the impact *Massicus raddei* would cause; host status of the non-Fagaceae plants in Table 3.

  Reasons why *M. raddei* has caused problems only in a very limited part of its distribution; and current situation in areas other than Northeast China.

  Current risk of entry, because limited trade data is available (and no data on the size of hosts that are traded).

  Uncertainties that would need to be addressed to design better management measures in case of entry relate to the biology: flight distance, minimum trunk size for hosts other than *Quercus*, accumulated degree-days needed for larval development, life cycle in EPPO conditions.

18. Remarks

- Sentinel trees (European/EPPO species) in infested areas would be useful.
- A survey targeting *M. raddei* on all *Quercus* species present where the pest occurs would be useful to determine their susceptibility.

19. References (including for Annexes) (all websites mentioned were accessed in October 2017)

Anisimov NS, Bezborodov VG. 2017. On the northern border of the distribution of *Neocerambyx raddei* (Coleoptera, Cerambycidae) in East Asia). Far Eastern Entomologist. 2017. N 332: 22-24.

Bates HW FLS. 1873. XXI.—On the Longicorn Coleoptera of Japan. Annals and Magazine of Natural History Vol. 12, Issue 68: 148-156.

Bazarova VB. 2014. Spreading of Broadleaved Species in Amur River Basin in the Holocene. Botanica Pacifica. A journal of plant science and conservation, Vladivostok, Volume 3, No. 2, 3(2): 47–54

Benzel J. 2015. Mountain Oak Longhorned Beetle, *Massicus raddei* (Blessig). Screening Aid. CAPS (Cooperative Agricultural Pest Survey) screening aid produced for and distributed by USDA-APHIS-PPQ National Identification Services (NIS). Available at: http://caps.ceris.purdue.edu/taxonomic_services.

Borowiec N, Brancaccio L. 2014. Lutte biologique classique contre le cynips du châtaignier en France. [In Online information on biological control against Dryocosmus kuriphilus]. INRA, France. https://www6.inra.fr/cynips-chataignier/Contexte/Chataigneraie-en-France-et-en-Europe

Bourgeois C. 2004. Le châtaignier: un arbre, un bois. Forêt privée française, 347 pages. Available on Google Books

Cao L, Yang Z, Tang Y, Wang X. 2015. Notes on three braconid wasps (Hymenoptera: Braconidae, Doryctinae) parasitizing oak long-horned beetle, *Massicus raddei* (Coleoptera: Cerambycidae), a severe pest of *Quercus* spp. in China, together with the description of a new species. Zootaxa 4021 (3): 467–474.

CAPS. 2017. Priority Pest Lists for CAPS surveys. Cooperative Agricultural Pest Survey. https://caps.ceris.purdue.edu/pest-lists

Cerambycidae.org, no date. Database on Cerambycidae of the world. http://cerambycidae.org/

Chen SX, Xie YZ, Deng GF.1959. Economic Insect Fauna of China, Fasc. 1. Coleoptera: Cerambycidae. Science Press, Beijing. 43

Cherepanov AI. 1991. Cerambycidae of Northern Asia, Volume 3, Lamiinae, Part II. EJ Brill, Leiden, New York, København, Köln. (translation of a Russian version of 1991). Available on Google books.

Cho Y-H, Kim Y-J, Han Y-G, Cha J-Y, Jeong J-C, Seo J-K, Nam S-H. 2010. A Faunistic Study of Insects on Mt. Juwang National Park. Journal of National Park Research, Vol. 1, No. 3, pp. 225-254.

Danilevsky ML. 2017. Catalogue of the Palaearctic Cerambycoidea. Updated: 05.05.2017. Available from http://www.cerambycidae.net/catalog.pdf.

DB Schenker. 2017. Get your business rolling with innovative rail logistics solutions between China and Europe. Trans Eurasian rail logistics.

Drag L & Cizek LJ. 2018. Radio-Tracking Suggests High Dispersal Ability of the Great Capricorn Beetle (*Cerambyx cerdo*). Insect Behav 31: 138. https://doi.org/10.1007/s10905-018-9669-x

Dumouchel L. 2004. Plant health risk assessment, *Anoplophora glabripennis* (Mots.) Asian Longhorn Beetle (Starry Sky Beetle). Canadian Food Inspection Agency, Plant Health Risk Assessment Unit, Ontario, Canada

EC, 2013. Final report of an audit carried out in China from 18 to 28 June 2013 in order to evaluate the measures taken by China to ensure that wood packaging material exported to the European Union meets EU requirements. DG(Sanco) 2013-6813 - Mr Final. European Commission.

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

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

EPPO. 2009a. EPPO Standard PM 10/6(1) Heat treatment of wood to control insects and wood-borne nematodes. OEPP/EPPO, Bulletin OEPP/EPPO Bulletin 39, 31

EPPO. 2009b. EPPO Standard PM 10/8(1) Disinfestation of wood with ionizing radiation. Bulletin OEPP/EPPO Bulletin 39, 34-35

EPPO. 2013a. Pest Risk Analysis for *Apriona germari*, *A. japonica*, *A. cinerea* (13-18692). www.eppo.int

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

EPPO. 2015a. *Massicus raddei*. EPPO Alert List. https://www.eppo.int/QUARANTINE/Alert_List/insects/Massicus_raddei.htm

EPPO. 2015b. EPPO Technical Document No. 1071, EPPO Study on wood commodities other than round wood, sawn wood and manufactured items. EPPO Paris. https://www.eppo.int

EPPO. 2015c. Pest Risk Analysis for *Aromia bungii* (15-21043). www.eppo.int

EPPO. 2016a. EPPO Standard PM 7/129 (1) DNA barcoding as an identification tool for a number of regulated pests. EPPO Bull, 46: 501–537.

EPPO. 2016b. PM 5/8 (1) Guidelines on the phytosanitary measure 'Plants grown under complete physical isolation'. EPPO Bull, 46: 421–423.

EPPO. 2017. EPPO Global Database. Online database. https://gd.eppo.int/
EPPO. Under development. Guidelines on the design and implementation of a buffer zone. Document under development by the Panel on Phytosanitary measures. Last version reference is 18-23488

Eschen R, Douma JC, Grégoire JC, Mayer F, Rigaux L, Potting RPJ. 2017. A risk categorisation and analysis of the geographic and temporal dynamics of the European import of plants for planting. Biological Invasions 19 (11): 3243-3257
Essl F. 2007. From ornamental to detrimental? The incipient invasion of Central Europe by *Paulownia tomentosa*. Preslia 79: 377-389.
EU. 2015. Commission Implementing Decision (EU) 2015/893 of 9 June 2015 as regards measures to prevent the introduction into and the spread within the Union of *Anoplophora glabripennis* (Motschulsky) (notified under document C(2015) 3772). OJ L 146, 11.6.2015, p. 16–28
Eurostat. Online Database. European Statistics. European Commission. http://epp.eurostat.ec.europa.eu/portal/page/portal/eurostat/home/
Eyre D, Haack RA. 2017. Invasive Cerambycid Pests and Biosecurity Measures. Chapter 13, pp. 563-618. In Invasive Cerambycid Pests and Biosecurity Measures. Wang, Q. Cerambycidae of the world: biology and pest management. Boca Raton, FL: CRC Press: 563-607.
Eyre D, Macarthur R, Haack RA, Liu Y, Krehan H. 2018. Variation in inspection efficacy by member states of wood packaging material entering the European Union. Journal of Economic Entomology tox357, https://doi.org/10.1093/jee/tox357
FAO. 2009. ISPM 15 Regulation of Wood Packaging Material in International Trade. Available from https://www.ippc.int.
FAO. 2017. ISPM 28. Annex 22. Sulphuryl fluoride fumigation treatment for insects in debarked wood (2017). Rome, IPPC, FAO.
Faostat. Online database. Food and Agriculture Data. Food and Agriculture Organization of the United Nations. http://www.fao.org/faostat/en/#home.
Feng MX, Du LD (Eds). 1997. Pest Control of Castanea mollissima. Beijing: Jindun Publishing House, pp 127-128.
Forest Pest Control Station of the State Forestry Administration. 2008. A General Survey of Forest Insect Pests in China (2003-2007). Beijing: China Forestry Publishing House, pp105-106. (in Chinese)
Forest Pest Control Station of the State Forestry Administration. 2010. Calendar of Forest Pest Control. Beijing: China Forestry Publishing House. (in Chinese)
Forest Trends. 2015. China's domestic timber supply. Powerpoint presentation. Timber Regulation Enforcement Exchange: Chinese Supply Chains, Risk, and Legal Compliance. April 14, 2015 - April 16, 2015. Barcelona, Spain. http://www.forest-trends.org/event.php?id=1119
Forest Trends. 2016. China'sLogging Ban inNatural Forests: Impacts of Extended Policy at Home and Abroad.
Gao G. 2001. [Research on biological and ecological characters and controlling techniques of *Mussicus raddei*]. Ms Thesis. Northeast Forestry University, Harbin, China, May 2001 [in Chinese]
GCR. 2017. Russia announces 400km/h freight train for Moscow to China. Global Construction Review. http://www.globalconstructionreview.com/news/russia-announces-400kmh-frei7ght-tr7ain-mos7cow/
Goldson SL, Frampton ER, Geddes NJ, Braggins TJ. 2003. The potential of sensor technologies to improve New Zealand's border security. In: Goldson SL, Suckling DM ed. Defending the green oasis: New Zealand biosecurity and science. New Zealand Plant Protection Society Symposium. p. 63-71. http://www.nzpps.org/books/2003_GreenOasis/GreenOasis.pdf
Haack RA, Hérard F, Sun J & Turgeon JJ. 2010. Managing invasive populations of Asian longhorned beetle and Citrus longhorned beetle: a worldwide perspective. Ann. Rev. Entomol. 55, 521-546.
Hakan Akyildiz H, Sahin Kol H. 2010. Some technological properties and uses of paulownia (*Paulownia tomentosa* Steud.) wood.
Hou Y, Ji CL, Gao C, Lu J, Tan SK, Li MG, Zhang H. 2000. Study on biological characters and prevention techniques of *Massicus raddei*. Journal of Liaoning Forestry Science& Technology, 19(5): 15-18.
Hua LZ, Nara H, Samuelson GA, Lingafelter SW. 2009. Iconography of Chinese Longicorn Beetles (1406 Species) in Color. xii + 474 pp. Series Publications of Museum of Biology Sun-at-Sen-University Press, Guangzhou [in Chinese and English]
Ibáñez Justicia A, Potting R, van der Gaag DJ. 2010. Pest risk assessment Apriona spp. Plant Protection Service, Ministry of Agriculture, Nature and Food Quality, the Netherlands.
IPSN, 2017. Information provided to the EPPO Secretariat by the International Plant Sentinel Network. https://www.bgci.org/plant-conservation/ipsn/
ISEFOR. Database on trade data assembled during the course of the project ISEFOR, increasing sustainability of european forests: modelling for security against invasive pests and pathogens under climate change. Site of the project not available (www.isefor.com). outline here : https://www.eustafor.eu/eu-projects/isefor/
Ji L, Wang Z, Wang XY, An L. 2011. Forest Insect Pest Management and Forest Management in China: An Overview. Environmental Management (2011) 48:1107–1121
Jiang J, Yang Z-Q, Tang Y-L, Tang H, Gao C, Wang X-Y, Meng Q-W, Liu S-J. 2011. Sterilized impacts on adults of oak longhorn beetle, *Massicus raddei* by three bionical chemosterilants. Journal of Environmental Entomology, March 2011, 33(1) : 58-64 [In Chinese with English abstract]
Jiang J, Yang ZQ, Tang YL, Tang H, Sun GJ, Gao ZQ. 2010. Trapping technology about adults of *Massicus raddei* by a special black light. Journal of Environmental Entomology 2010-03. [English abstract]

Jiang J. 2011. Studies on Biology of *Massicus raddei* (Coleoptera Cerambycide) and Control Techiques for Adult Stage. Ms Thesis, Chinese Academy of Forestry. [In Chinese]

Kim S-T, Jung M-P, Kim H-S, Shin J-H, Lim J-H, Kim T-W, Lee J-H. 2006. Insect Survey Insect Fauna of Adjacent Areas of DMZ in Korea. J. Ecol. Field Biol. 29 (2): 125-141

Kojima T. 1931. Further Investigation on the immature Stages of some Japanese Cerambyeid beetles, with Notes of their Habits. Journal of the College of Agriculture, Imperial University of Tokyo 1931 Vol.11 No.3. pp. 263-308.

Kottek M, Grieser J, Beck C, Rudolf B, Rubel F. 2006. World Map of the Köppen-Geiger climate classification updated. Meteorol. Z., 15, 259-263. DOI: 10.1127/0941-2948/2006/0130.

Kuprin AV. The Longicorn Beetles (Insecta, Coleoptera: Cerambycoidae) of the Ussuri Nature Reserve and Adjacent Territories. Far Eastern Entomologist. 2016. N 309: 21-28.

Leksono AS, Takada K, Nakagoshi N, Nakamura K. 2006. Species composition of Modellidae and Cerambycidae (Coleoptera) in a coppice woodland, Journal of Forest Research, 11:1, 61-64, DOI: 10.1007/s10310-005-0181-8

Li Y, Meng Q, Silk P, Gao W, Mayo P, Sweeney J. 2017. Effect of semiochemicals and trap height on catch of *Neocerambyx raddei* in Jilin province, China. Entomologia Experimentalis and Applicata. 164: 94–101, 2017.

Lim J, Jung S-Y, Lim J-S, Jang J, Kim K-M, Lee Y-M, Lee B-W. 2014. A Review of Host Plants of Cerambycidae (Coleoptera: Chrysomeloidea) with new Host Records for Fourteen Cerambycids, Including the Asian Longhorn Beetle (*Anoplophora glabripennis* Motschulsky), in Korea. Korean J. Appl. Entomol. 53(2): 111-133.

Lin J, Tang H, Jiang G, Wang X. 2016. Studies on the reproductive biology of *Massicus raddei*. Journal of Liaoning Forestry Science & Technology, 5, 1-4.

Liu S, Li G. 2012. Research on water transport pattern and branch-borer control efficiency of *Quercus Mongolica*. World Automation Congress, 24-28 June 2012, Puerto Vallarta, Mexico, Mexico. [abstract only]

Luo YQ, Lu CK, Chen HJ, Liu JF, Yuan FQ. 2005. *Massicus raddei*, a forest pest that needs to be taken seriously. Plant Quarantine, 2005, 19(6): 354-356 (in Chinese)

LY. 2016. Technical regulation for controlling *Massicus raddei* (Blessig). LY/T 2687 Forestry Standard of the People's Republic of China. Published 27th July, 2016, Enforced from 1st December, 2016. Published by: State Forestry Administration, China. [In Chinese].

MacLeod A, Evans HF, Baker RHA. 2002. An analysis of pest risk from an Asian longhorn beetle (Anoplophora glabripennis) to hardwood trees in the European Community. Crop Protection, 21 (8) 635-645

Magarey RD, Borchert DM, and Schlegel JW. 2008. Global plant hardiness zones for phytosanitary risk analysis. Sci. agric. (Piracicaba, Braz.), vol.65, 54-59. Available from: http://www.scielo.br/scielo.php?script=sci_arttext&pid=S0103-90162008000700009&lng=en&nrm=iso

Mokuroku Database . 2017 http://konchudb.agr.agr.kyushu-u.ac.jp/mokuroku/

Monfreda, C., Ramankutty, N. & Foley, J. A. 2008. Farming the planet: 2. Geographic distribution of crop areas, yields, physiological types, and net primary production in the year 2000, Global Biogeochemical Cycles, 22, 1-19.

NEPCon, 2017a. Timber China. Nature Economy and People Connected. https://www.nepcon.org/

NEPCon, 2017b. China. Timber Legality Risk Assessment. Nature Economy and People Connected. https://www.nepcon.org/

New M, Lister D, Hulme M, Makin I. 2002. A high-resolution data set of surface climate over global land areas. Climate Research 21.

news.cnr.cn. 2017. 辽宁：全面禁止天然林商业性采伐[Liaoning: Commercial felling of natural forests is forbidden completely] http://news.cnr.cn/native/city/20170205/t20170205_523557952.shtml. 2017-02-05 12:02:00央广网

news.sohu.com. 2017. 中国国家林业局：中国已全面停止天然林商业性采伐 [State Forestry Administration of China: commercial felling of natural forests has already been forbidden completely in China]. News item, 2017-03-16. http://news.sohu.com/20170316/n483489374.shtml

Nga CTQ, Long KD, Thinh TH. 2014. New records of the tribe Cerambycini (Coleoptera: Cerambycidae: Cerambycinae) from Vietnam. Tap Chi Sinh Hoc 2014, 36(4): 428-443. doi: 10.15625/0866-7160/v36n4.6173.

Okada S, Nagahata Y. 1996. Longicorn beetles attacking *Fagus crenata* in the northern part of Hyogo Prefecture [in Japanese]. Transactions of Kansai Branch of the Japanese Forestry Society (5), 151-154, 1996-03-25

Okamoto H. 1927. The Longicorn Beetles from Corea. 1927-11 Insecta Matsumurana, 2(2): 62-86.

Pinkerton M, Hodges A. 2016. Mountain oak longhorned beetle – *Massicus raddei*. Powerpoint presentation

PPP-Index. Planzeneinkaufzführer für Europe. Online database on ornamental plants available in Europe. http://www.ppp-index.de/

Quercus Portal. 2017. A European Genetic and Genomic Web Resources for *Quercus*. https://arachne.pierroton.inra.fr/QuercusPortal/

Ramamurthy VV, Akhtar MS, Patankar NV, Menon P, Kumar R, Singh SK, Ayri S, Parveen S, Mittal V. 2010. Efficiency of different light sources in light traps in monitoring insect diversity. Mun. Ent. Zool. Vol. 5, No. 1, 109-114

Rcfh.ru. 2017. Forestry wiki on *Neocerambyx raddei*. [in Russian] http://rcfh.ru/wiki/index.php/Усач_Радде_(дубовый_восточноазиатский)

Sabbatini Peverieri G, Roversi PF. 2012. I principali insetti fitofagi del castagno a rischio di introduzione in Italia. 114 pages. Progetto «Bioinfocast», MiPAAF DD n. 4496 del 27/11/2012. Consiglio per la Ricerca e la sperimentazione in Agricoltura (CRA).

Sacco, J., 2004. The attack of the urban forest eaters: how a dedicated and educated group of volunteers is responding to the invasion of Asian long-horn beetles and gypsy moths in Chicago. In: Shaw et al. (eds.) Proceedings 4th International Urban

Wildlife Symposium. Shangaiist.com. 2011. A Silk Road for the 21st century: Freight rail linking China and Germany officially begins operations. July 4th 2011; http://shanghaiist.com/2011/07/04/a_cargo_train_filled_with.php

Smith MT, Bancroft J, Li G, Gao R, Teale S. 2001. Dispersal of *Anoplophora glabripennis* (Cerambycidae). Environmental Entomology 30: 1036 – 1040.

Smith MT, Tobin PC, Bancroft J, Guohong L, Gao R. 2004. Dispersal and spatiotemporal dynamics of Asian Longhorned Beetle (Coleoptera: Cerambycidae) in China. Environmental Entomology 33: 435 – 442.

State Forestry Administration of the People's Republic of China. 2016. 国家林业局关于扎实做好全面停止商业性采伐工作的通知 - 林资发[2015]22号 [Information on the stop of commercial felling in protected forests]. State Forestry Administration of the People's Republic of China. http://www.forestry.gov.cn/hljb/4994/content-825893.html

Strijk JS. 2017. *Castanea crenata*. In ASIANFAGACEAE.COM – The Complete Database for Information on the Evolutionary History, Diversity, Identification and Conservation of Over 700 Species of Asian Trees. http://www.asianfagaceae.com.

Sun J-L, Sun G-J, Dong X-N, Gao Z-Q, Tang Y-L, Jiang J, Yang Z-Q. 2010. Studies on biological characteristics and biocontrol techniques for *Massicus raddei*. Journal of Liaoning Forestry Science and Technology. 2010-4 [in Chinese with English abstract]

Sun X. 2016. China Expands Logging Ban In Natural Forests (Forest Trends). 2 December 2016, Beijing, China. China Responsible Forest Product Trade and Investment Alliance. http://chinarfa.net/

Sun X-L, Cheng B, Gao C-Q, Zhou G-P, Dong C-Q, Lu Y-B, Lu Y-Q. 2006. Review of Study on Outbreak and Prevention of *Mallambyx raddei* Blessig. Journal of Jilin Normal University (Natural Science Edition), Vol. 2, No. 1 Feb. 2006, 54-56 [in Chinese with English abstract]

Sun YP, 2001.Control techniques of *Massicus raddei* (Blessig). Liaoning Science and Technology Publishing House, Shenyang.

Tang Y, Jiang J, Yang Z-Q, Wang X-Y, Sun G-Y, LV J. 2011b. Oak stand description factors and risk assessment of harm extent of *Massicus raddei* (Coleoptera: Cerambycidae). Forest research 2011, 24(4): 476-480. [in Chinese with English abstract]

Tang Y, Yang Z, Jiang J, Wang X, Lü J, Gao C. 2011a. Distribution pattern of larvae and pupae of *Massicus raddei* in the trunk of *Quercus liaotungensis*. Scientia Silvae Sinicae, 2011-03. [in Chinese with English abstract]

Tang Y, Yang Z, Wang X, Tang H, Jiang J, Wei K, Lu J. 2012. Biocontrol of oak longhorn beetle *Massicus raddei* by releasing parasitoid *Dastarcus helophoroides* (Coleoptera: Bothrideridae) adults and eggs. Scientia Silvae Sinicae 48(7): 186-191[abstract]

Tang Y-L, Jiang J, Yang Z-Q, Wang X-Y, LV J, Suo M. 2011c. Activity rhythm of *Massicus raddei* adult (Coleoptera: Cerambycidae). Journal of Environmental Entomology, 2011-01 [abstract only]

Tang Y-L， Wei K, Yang Z-Q, Jiang J, Wang X-Y, LV J., Gao C. 2016. Investigation of the trapping effect of aconveniently mixed solution on *Massicus raddei* adults. Journal of Environmental Entomology， May 2016， 38 (3) : 595 — 601 [in Chinese with English abstract]

Tang Y. 2011. Studies on the ecology of *Massicus raddei* (Coleoptera: Cerabycidae) and its biological control. Beijing: Ph.D. thesis of Chinese Academy of Forestry

Torres-Vila IM, Mendiola-Diaz FJ and Sánchez-González Á. (2016), Dispersal differences of a pest and a protected *Cerambyx* species (Coleoptera: Cerambycidae) in oak open woodlands: a mark–recapture comparative study. Ecol Entomol, 42: 18-32. doi:10.1111/een.12355

USDA. 2015. New Pest Response Guidelines: *Massicus raddei* (Blessig) (Coleoptera: Cerambycidae), Mountain Oak Longhorned Beetle. USDA-APHIS, United States Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine. http://www.aphis.usda.gov/import_export/plants/manuals/online_manuals.shtml

Wang LZ, Lang QL, Xia XH, Sun J, Gao W, Wang FT, Na K, Zuo KH. 2009. Indices of Oak Pests (*Quercus*) of Cerambycidae Insect. Journal of Shenyang Agricultural University, 2009, 40(5):546-557.

Wang X-Y, Tang Y-L, Lu J-F, Yang Z-Q. 2013. Biomass evaluation of concealed insect pests at parasitism based on allometric scaling laws. Phytoparasitica, 41(4):435-441.

Wang X-Y, Yang Z-Q, Tang Y-L, Jiang J, Gao C, Liu Y-C, Zhang X-W. 2010. Parasitism of *Sclerodermus pupariae* (Hymenoptera: Bethylidae) on the young larvae of *Massicus raddei* (Coleoptera: Cerambycidae). Acta Entomologica Sinica, 53(6): 675-682

Wang X-Y, Yang Z-Q, Tang *Y-L, Jiang J, Yang Y-L, Gao C. 2012.* Determination of larval instar number and duration in the oak longhorn beetle, *Massicus raddei* (Coleoptera: Cerambycidae). Acta Entomologica Sinica, 2012, Vol. 55, Issue (5): 575-584

Wang YT, Liu YX, Tong XL, Ren QP, Jiang GF. 2016. The complete mitochondrial genome of the longhorn beetle, *Massicus raddei*. Mitochondrial DNA A DNA Mapp Seq Anal. 2016;27(1):209-211. doi: 10.3109/19401736.2014.880892.

Wei J, Yang Z, Wang P, Sun X, Sun L. 2009.Control of *Massicus raddei* (Blessig)(Coleoptera: Cerambycidae) by Parasitic Beetle *Dastarcus helophoroides* Sharp(Coleoptera: Bothrideridae). Chinese Journal of Biological Control, 2009-03

Williams DW, Gouhong L, Ruitong G. 2004. Tracking movements of individual *Anoplophora glabripennis* (Coleoptera: Cerambycidae) adults: application of harmonic radar. Environtmental Entomology 33: 644-649.

Wu C, Tang W, Chen G, Wu Y, Zhang R. 2000. [New features of chestnut pest species]. Forest research 2000, 13(2): 223-224. [In Chinese]

Wu CF. 1932. A preliminary check list of the insects heretofore recorded from Fukien. Marine Biological Association of China 1st Annual Report

Wu CF. 1937. Catalogues Insectorum Sinensium. Vol. III. Peiping: The Fan Memorial Institute of Biology, p676.

Wu J, Lin W, Peng X, Liu W. 2013. A Review of Forest Resources and Forest, Biodiversity Evaluation System in China. International Journal of Forestry Research, Volume 2013, Article ID 396345, 7 pages, http://dx.doi.org/10.1155/2013/396345 Hindawi Publishing Corporation

Wu LC, Cheng M, Xu JD, Tao D, Li GM, Zhang YZ. 2007. Risk analysis and management of *Mallambyx raddei* Blessig. Shaanxi Forest Science and Technology, 2007 (4): 112-115.

Xie Z, Zhang X, Zhang P, et al. 1999. Study on the biological characteristics of *Massicus raddei*. Jilin Forestry Science and Technology. 1999.141 (4): 1-3 [In Chinese]

Xing L. 2015. [The present occurrence situation and the control measures of Oak longhorn beetle (*Massicus raddei*) in Liaoning Province]. Journal of Liaoning Forestry Science ＆ Technology. 2015 (6), 56-58 [in Chinese]

Xu W, Li W, Lin M, Lin J, Huang H., Huang J, Fu S, Zheng X. 1995. Comparison of esterase isozymes of cerambycids. Chinese Journal of Tropical Crops, Volume 16, supplement, December 1995. p 71-78

Yang YX. 2001. Impacts and effectiveness of logging bans in natural forests: People's Republic of China. p 81-102 In Forests out of bounds: Impacts and effectiveness of logging bans in natural forests in Asia-Pacific (Ed. PB Durst, TR Waggener, T Enters, TL Cheng). Food and Agricultural Organization of the United Nations, Regional Office for Asia and the Pacific, Bangkok, Thailand

Yang Z Q, Wang X Y, Wang B, Yu Y P, Dong Z M, Mou Z H, Wang H S. 2011. Relationship between adult emergence of *Massicus raddei* (Coleoptera: Cerambycidae) and temperature and relative humidity. Acta Ecologica Sinica, 2011, 31(24):7486-7491. [in Chinese with English abstract]

Yang Z-Q, Tang H, Wang X-Y, Wei J-R, Zhao H-B. 2013a. A new species of *Cerchysiella* (Hymenoptera: Encyrtidae) parasitic in larva of chestnut trunk borer (Coleoptera: Cerambycidae) from China with notes on its biology. Journal of Natural History, Volume 47, 2013 - Issue 3-4, Pages 129-138.

Yang Z-Q, Wang X-Y, Cao L-M, Tang Y-L, Tang H. 2013b. *Cerchysiella mesosae* Yang sp. nov. (Hymenoptera: Encyrtidae), a parasitoid of *Mesosa myops* (Dalman) (Coleoptera: Cerambycidae) larvae in China. Zootaxa 3619 (2): 154–160.

Yang Z-Q, Wang X-Y, Zhang Y-N. 2014. Recent advances in biological control of important native and invasive forest pests in China. Biological Control 68 (2014) 117–128

Ye X, Ye Q, Li Z, Bao H, Chen D, Jin L, Zhen Y, Chen W, Wang Q. 1996. A preliminary report on citrus pests in Zhejiang Province: Acta Agriculturae Zhejiangensis 8 (5): 257- 268, 1996 [In Chinese with English abstract]

Zeng YF, Liao WJ, Petit RJ, Zhang DY. 2010. Exploring species limits in two closely related Chinese oaks. PLoS One. 2010 Nov 30;5(11): e15529. doi: 10.1371/journal.pone.0015529.

Zhao C. 2015. 把所有天然林严格保护起来 [Strictly protect all natural forests]. 2015-02-26. State Forestry Administration of the People's Republic of China. http://www.forestry.gov.cn/main/195/content-742128.html

Zhao XL, Yuan ZY, Tang SJ, Yang QS. 2005. Integrated control strategy of *Massicus raddei* in Liaoning province. Forestry Science & Technology, 30(4): 30-31.

Zheng Y, Tang Y, Yang Z, Tang H. 2014b. Characteristics of Supplementary Nutrition Feeding of *Massicus raddei* (Coleoptera: Cerambycidae) Adults and the Main Components of the Fed Sap of Host Tree *Quercus mongolica*. Scientia Silvae Sinicae, 2014-12 [English abstract]

Zheng Y-N, Tang Y-L, Yang Z-Q, Tang H. 2014a. [Nutrient uptake method of *Massicus raddei* adult, and major compound of host sap]. Forestry Science, 2014-12 [In Chinese, abstract only]

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 pieces (based on EPPO Standard PM 5/3).

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[10]. "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 of hosts**	**Wood chips, hogwood, processing wood residues (except sawdust and shavings)**
Existing measures in EPPO countries	Partly, see section 8	Partly, see section 8. Similar requirements will be implemented in EPPO countries applying regulations aligned to the EU.	Partly, 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[10]. Infestation is very difficult to detect at early stages (no obvious signs for eggs or young larvae). Frass ejection holes may be observed, but may be more obvious at high infestation levels and larval defecation can be observed from one year after egg-laying. Light trapping at suitable periods may allow detecting adults, but there are no species-specific traps.** Plants should be free from signs of infestation.	Yes, in combination*. As for plants for planting, but detection in a forest would be more difficult due to the size and number of trees. Frass might be observed at felling or during transport. Detection by visual inspection would be difficult in forests.	Yes, in combination*. As for wood.
Testing at place of production	No. **Not possible without destroying the trees. Systems for detecting larvae in trees are currently the subject of research, but are not yet available.**	No. As for plants for planting	No. As for wood
Treatment of crop	Yes in combination* Chemical treatments are reported in the Chinese literature, i.e. injections in trunks or insect hole, sprays against adults (LY, 2016), but are apparently not commonly applied in practice. Sprays would target only adults, and would not	Not relevant in forest.	Not relevant in forest.

[10] 'The integration of different risk management measures, at least two of which act independently, and which cumulatively achieve the appropriate level of protection against regulated pests' (ISPM 5).

Option	Host plants for planting	Round wood and sawn wood of hosts	Wood chips, hogwood, processing wood residues (except sawdust and shavings)
	be effective in eliminating the pest, and would only lower pest populations. Regarding trunk injections, it is not known if they could be used on young trees or bonsais. They were not found fully effective in China.		
Resistant cultivars	Not relevant	Not relevant	Not relevant
Growing the crop in glasshouses/ screenhouses	Yes for bonsais. Yes (theoretically) for others. Plants for planting could be grown under protected conditions with sufficient measures to exclude the pest (following EPPO Standard PM 5/8(1) *Guidelines on the phytosanitary measure 'Plants grown under complete physical isolation*' - EPPO, 2016b). 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.	Not relevant	Not relevant
Specified age of plant, growth stage or time of year of harvest	<u>Size of plant:</u> Yes. According to **section 2.6, *Quercus* trees with a DBH < 9 cm (or bonsais with a base diameter < 9 cm) are not reported to carry the pest.** Therefore the EWG considered that a possible measure would be to import only plants with a DBH <9 cm (and for bonsais, with a base diameter <9 cm). However, the Panel on Phytosanitary Measures noted that for other wood borers (e.g. *Anoplophora chinensis*) plantlets with a diameter of about 1 cm were found infested (whereas in natural stands trees with a DBH of at least 6 cm are preferred; Smith et al. 2004). The Panel considered that, as a precaution, only plants with a diameter of maximum 1 cm may be imported. <u>Growth stage/time of the year</u>: No. **Larvae may be present in trunks or branches throughout**	<u>Age/size of plant</u>: No. **Trees with a DBH < 9 cm are not reported to carry the pest (see section 2.6).** However, it is not possible to restrict import of wood commodities to tree smaller than 9 cm (this is not relevant for logs or sawn wood, and very difficult to implement for firewood). <u>Growth stage/time of the year</u>: No. As for plants for planting.	<u>Size of plant</u>: No. As for wood <u>Growth stage/Time of the year</u>: No. As for wood

Option	Host plants for planting	Round wood and sawn wood of hosts	Wood chips, hogwood, processing wood residues (except sawdust and shavings)
	the year. In particular, dormant plants may contain overwintering larvae		
Produced in a certification scheme	Not relevant	Not relevant	Not relevant
Pest free production site	Yes, grown under complete physical isolation (see above).	Not relevant	Not relevant
Pest free place of production	No. The EWG suggested that measures similar to the requirements in EU Implementing Decision 2015/893 for *Anoplophora glabripennis* (EU, 2015), may be relevant in particular: • Official inspections at the pest-free place of production at appropriate times (twice a year for *A. glabripennis*) • Plants should be grown in a site with either complete physical protection <u>or</u> where preventive treatments are applied and surrounded by a buffer zone (radius at least 2 km) with official surveys annually at appropriate times. • Official inspection prior to export, including destructive sampling However, the Panel on Phytosanitary Measures agreed that the systems approach where plants are grown outdoor with preventive treatments does not provide a sufficient level of protection.	Not relevant	Not relevant
Pest free area	**Yes, in theory, following ISPM 4. However, there are uncertainties as to whether there are areas free from the pest in countries where it occurs.** **In order to declare a PFA, the exporting country should provide surveillance data to demonstrate that the pest is absent from all or part of its territory and information on how pest freedom is maintained.**	Yes. As for plants for planting.	Yes. As for plants for planting.

Option	Host plants for planting	Round wood and sawn wood of hosts	Wood chips, hogwood, processing wood residues (except sawdust and shavings)
	If the pest is present in part of the country, specific surveys should be conducted to delimitate and to maintain the PFA. Measures should be in place to prevent that infested plants or wood are moved to the PFA. **To provide a buffer against the introduction of *M. raddei*, the PFA should be distant from any infestation. The EWG considered that at least 2 km (based on *Anoplophora* – EU Implementing decision 2015/893) is appropriate for a PFA situation. There should be at least two official inspections for any signs of *M. raddei* annually at appropriate times and no signs of the organism should have been found in the past 6 years (corresponding to 2 generations). Trapping should be performed.** **Immediately prior to export, consignments should be subjected to an official meticulous inspection, including targeted destructive sampling. Material from a PFA should not be mixed in an consignment with material from areas that may be infested**		
Options after harvest, at pre-clearance or during transport			
Visual inspection of consignment	Yes, in combination*. Visual inspection may detect some infested trees when older larvae are present (e.g. frass ejection holes). However, the pest would be difficult to detect in large consignments. In addition, eggs or young larvae are not likely to be detected. Plants are generally traded during the dormant season, when the larvae would be overwintering and not producing frass. Destructive sampling could be used	No. 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). Low levels of infestation may not be detected. Larval galleries may not be visible on cross-section (if located above the cut) but might show better on cut surfaces of sawn wood. The frass may be under the wood surface, and therefore may not be visible.	No. Inspection of consignments of wood chips and other such commodities is difficult. It is unlikely to detect *M. raddei* as consignments may contain several species, and signs of presence of the pest would not be easy to observe.
Testing of commodity	No. Trained sniffer dogs have been used for	Not relevant.	Not relevant

Option	Host plants for planting	Round wood and sawn wood of hosts	Wood chips, hogwood, processing wood residues (except sawdust and shavings)
	Anoplophora (Eyre and Haack, 2017), but not other species to date. Methods that can detect wood-boring larvae in branches, stems or roots (e.g. x-rays, acoustic methods, systematic destructive sampling, see Goldson et al., 2003; infrared thermography camera, laser vibrometry see Eyre and Haack, 2017) are not fully developed.		
Treatment of the consignment	No.	Yes. *Heat treatment.* According to EPPO Standard PM 10/6(1) *Heat treatment of wood to control insects and wood-borne nematodes* (EPPO, 2009a), Cerambycidae are killed in round wood and sawn wood which have been heat-treated until the core temperature reaches at least 56 °C for at least 30 min. Note: Kiln drying alone is not considered sufficient as a phytosanitary treatment, based on the results from the EUPHRESCO project (PEKID1) for other Cerambycidae. Yes. *Irradiation*. According to EPPO Standard PM 10/8(1) Disinfestation of wood with ionizing radiation (EPPO, 2009b), Cerambycidae 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 (FAO, 2017) only applies to debarked wood below 20 cm in cross-section. Note: methyl bromide has been phased-out and MBr fumigation is not considered here. No. *Processing*. Conversion of the wood into sawn timber might destroy larvae and pupae, and cause the wood to dry out more quickly, causing mortality. However, some life stages might survive in larger pieces of sawn wood. Processing will expose galleries and make it more likely that infestation is detected. This measure was not	Yes. *Chipping down to a certain size* Wood pieces below a certain dimension will not allow the survival of any stage of the pest. According to the EU Implementing Decision 2015/893 on *A. glabripennis* (EU, 2015), wood chips should be chipped into pieces of less than 2.5 cm in two dimensions. This would also be appropriate for *M. raddei*. Some treatments (heat treatment, fumigation, irradiation) could be effective but their practical implementation should be defined based on further research. The Panel on Phytosanitary Measures considered for similar pests that heat treatment of the wood chips and waste at 56°C for 30 min throughout the material could be recommended.

Option	Host plants for planting	Round wood and sawn wood of hosts	Wood chips, hogwood, processing wood residues (except sawdust and shavings)
		considered sufficient on its own.	
Pest only on certain parts of plant/plant product, which can be removed	No. **Life stages are on or in the trunk or branches.**	No. As for plants for planting. Debarking wood before movement is mentioned as a possible measure in Pinkerton and Hodges (2016). However, it would not remove older larvae and pupae that are in the wood.	No. As for wood.
Prevention of infestation by packing/handling method	Yes, associated with certain measures. Trees above 1 cm diameter should be packed in conditions preventing infestation during transport and storage.	No. Infestation occurs prior to felling the trees. Wood could be stored in the exporting country under strict control of the NPPO for a sufficient period to allow the development of immature life stages and emergence of adults. However, this would potentially require 3 years, and there is no data on the length of survival of larvae and pupae in cut wood (i.e. if they could survive and emerge after a longer period). In addition, given the difficulty to control the application of this measure in practice, it is not considered as an appropriate option for imported material.	No. As for wood.
Pre-entry quarantine	Yes, in the framework of a bilateral agreement. Plants may be kept in pre-entry quarantine for a sufficient time to detect the symptoms of larval activity or adult emergence (3 years 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 imports, but it may pose practical difficulties as trees of 9 cm diameter be over 3-m high.	Not relevant for wood	Not relevant for wood
Options that can be implemented after entry of consignments			
Post-entry quarantine	Yes, in the framework of a bilateral agreement. Plants may be kept in post-entry quarantine for a sufficient time to detect the symptoms of larval activity or adult emergence (3 years 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 imports, but it may pose practical difficulties as trees of 9 cm diameter be over 3-m high.	Not relevant for wood	Not relevant for wood

Option	Host plants for planting	Round wood and sawn wood of hosts	Wood chips, hogwood, processing wood residues (except sawdust and shavings)
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. **Wood for processing (e.g. furniture, pulpmills, fuel wood for energy production) could be imported during periods of the year outside of the emergence and flight period of *M. raddei*, and be processed before the next such period, provided that conditions in storage do not allow emergence of the pest. Waste or by-products from this wood should also be managed before the next suitable emergence and flight period, in such a way as to prevent emergence. However, the temperature thresholds for emergence are not known. In addition, this measure would be difficult to implement and control in practice and would require specific agreements. It would also be very difficult to apply to firewood, which is often stored for some time before being used.**	No. As for wood.
Only surveillance and eradication in the importing country	No. As for wood.	No. Adults are large and visible, and raising public awareness may increase the likelihood of early detection. Some measures can be put in place, but, as shown by experience with recent introductions of Cerambycidae, early detection is difficult and the pest may be detected only once established. Surveillance and eradication are difficult.	No. As for wood.

*The EWG considered whether the measures identified above as 'Yes in combination' (listed below) could be combined. This was not possible for wood commodities. For plants for planting, the EWG concluded that these measures could be combined but the Panel on Phytosanitary Measures considered that this combination would not provide a sufficient level of protection. **'Yes in combination' measures**

Wood	Wood chips, hogwood etc.	Plants for planting
Visual inspection at the place of production	Visual inspection at the place of production	Visual inspection at the place of production
		Treatment of crop at the place of production
		Visual inspection of consignment

ANNEX 2. Life stages and galleries of *Massicus raddei.*
Courtesy: Wang Xiao-Yi, Chinese Academy of Forestry

Life stages

Adult

Larva

Egg (recently laid, creamy-white)

Pupa

Galleries

Larva

Pupa and longitudinal galleries

Vertical galleries

Cross-section of galleries in the xylem

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

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

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

ANNEX 4. Trade data for wood commodities

A. Roundwood

FAO STAT - Import quantities (in m3) of non-coniferous non-tropical wood in 2012, 2014 and 2015 (from FAOStat). Countries without imports were deleted)

	China			Japan			Korea Rep.			Russian Fed.			Vietnam		
	2012	2014	2015	2012	2014	2015	2012	2014	2015	2012	2014	2015	2012	2014	2015
Albania	3														
Algeria		3													
Austria	17	6	11							25000	288	195			
Azerbaijan										8519	124	570			
Belarus										11861	16192	18511			
Belgium	50	25	54												
Croatia	32	14	18												
Czechia										1000	1000	1000			
Denmark	19									2000	1000	27			
Estonia										3000	11421	24138			
Finland		2								2974000	4083000	4056000			
France	20	89	400										1		
Germany	111	79	117	182	14	13			6	2206	13000	32000	15	34	27
Ireland	428										70				
Israel		2													
Italy	35	28	30								39				
Jordan	2														
Kazakhstan										2228	2084	10942			
Kyrgyzstan	69														
Latvia										13000	3000	27000			
Lithuania	15	9									412	9000			
Luxembourg	68		2							15	75				
Malta	3														
Morocco		1													
Netherlands	1793	3625	171931			24			9			8			5
Norway	7	18	336												
Poland	29	45	180							60000	79000	50000			
Portugal			4							31000					
Romania	24	21									19	121			
Russian Fed		3													
Slovakia											22				
Slovenia	3	40	205							61	38				
Spain	22														71
Sweden	55		54							550000	902000	813000			2
Switzerland	143	12	7										8	5	

	China			Japan			Korea Rep.			Russian Fed.			Vietnam		
	2012	2014	2015	2012	2014	2015	2012	2014	2015	2012	2014	2015	2012	2014	2015
Tajikistan										73		104			
Tunisia			24												
Turkey	3	4								42		8900			
Ukraine	2	3								10927	6100	4902			
UK	693	561	790							137			2		
Uzbekistan										23797	29013	25987			
Total	3646	4590	174163	182	14	37	0	0	15	3718866	5147897	5082405	26	39	105

Eurostat. All quantities in 100 kg.
Note: there was no import of *Castanea* wood during that period from countries where *M. raddei* occurs
Years without imports and countries without imports were deleted from the tables below.

"Firewood" Fuel wood, in logs, billets, twigs, faggots or similar forms – 44011000
No imports from Japan, Korea Dem. Rep. and Korea Rep.

	2012	2014	2016	2012	2014	2016	2012	2014
	China	China	China	Russia	Russia	Russia	Vietnam	Vietnam
Belgium	:	2	1	423	1 888	14 419	:	223
Croatia	12	:	:	:	:	:	:	:
Cyprus	:	:	:	456	:	:	:	:
Denmark	7	13	:	218 894	91 424	24 471	12 493	:
Estonia	:	:	:	13 627	14 636	9 642	:	:
Finland	:	:	:	311 981	104 002	125 901	2	:
France	0	23	59	560	17 771	:	:	:
Germany	:	:	:	99 402	890 370	92 261	:	:
Irland	206	1	:	734	1 699	1 450	:	:
Italy	:	:	:	216	:	404	:	:
Latvia	:	:	:	213	667	6 760	:	:
Lituania	:	:	:	212	207	2 956	:	:
Netherlands	:	4	:	2 215	1 076	4 560	1	:
Poland	:	:	:	200	300	5 704	:	:
Slovakia	:	:	:	:	1 720	:	:	:
Slovenia	:	:	:	:	:	197	:	:
Sweden	0	:	:	151 400	63 805	93 880	:	:
UK	373	1 017	157	:	156 192	499 382	216	:
Total	598	1060	217	800533	1345757	881987	12712	223

Sawlogs of oak "Quercus spp.", whether or not stripped of bark or sapwood, or roughly squared 44039110

No imports from Japan, Vietnam, Korea Rep. and Korea Dem. Rep.

	2012	2014	2014	2016
	China	China	Russia	Russia
Poland	:	:	1 823	1 136
Sweden	371	193	:	:

Oak "Quercus spp." in the rough, whether or not stripped of bark or sapwood, or roughly squared (excl. sawlogs; rough-cut wood for walking sticks, umbrellas, tool shafts and the like; wood in the form of railway sleepers; wood cut into boards or beams, etc.; wood treated with paint, stains, creosote or other preservatives) 44039190

No imports from Japan, Korea Rep. and Korea Dem. Rep.

	2012	2014	2016	2016	2016
	China	China	China	Russia	Vietnam
Belgium	79	:	:	:	:
Denmark	:	:	:	:	9
Finland	:	:	:	1	:
France	:	372	:	:	:
Ireland	4 285	:	165	:	:
Sweden	:	:	:	92	:

Oak "Quercus spp.", sawn or chipped lengthwise, sliced or peeled, of a thickness of > 6 mm, sanded, or end-jointed, whether or not planed or sanded 44079115

No imports from Korea Dem. Rep.

	2012	2014	2016	2016	2012	2014	2016	2012	201
	China	China	China	Japan	Russia	Russia	Russia	Vietnam	Viet
Belgium	845	:	1 898	:	:	:	90	:	:
Denmark	204	:	520	:	:	:	:	:	:
Estonia	:	:	:	:	229	:	:	:	:
Finland	:	:	3	:	:	:	:	:	:
France	6 476	229	:	:	:	:	:	39	
Ireland	5 501	:	:	:	:	:	:	:	:
Italy	:	:	:	2	:	435	:	:	:
Lithuania	:	:	:	:	:	:	138	:	:
Luxemburg	:	:	0	:	:	:	:	:	:
Netherlands	93	15	114	:	:	:	:	:	:
Poland	:	:	:	:	:	:	2 090	:	:
Sweden	:	:	169	:	:	:	:	:	:
UK	150	9 438	2 033	:	:	:	:	:	:
total	13269	9682	4737	2	229	435	2318	39	

Oak "Quercus spp.", sawn or chipped lengthwise, sliced or peeled, of a thickness of > 6 mm, planed (excl. end-jointed and blocks, strips and friezes for parquet or wood block flooring) – 44079139

No imports from Japan, Korea Rep. Korea Dem. Rep. and Vietnam

	2012	2014	2012	2014	2016
	China	China	Russia	Russia	Russia
Belgium	35	:	:	:	:
Cyprus	:	:	:	:	3
Denmark	:	92	:	:	:
France	:	:	:	222	220
Germany	:	:	:	711	61
Greece	401	:	:	:	:
Lithuania	:	:	1 423	179	1 903
Poland	:	:	:	:	46 433
Romania	:	:	:	:	611
Spain	50	:	:	:	:
Sweden	:	31	:	:	109
UK	528	138	270	:	:
total	1014	261	1693	1112	49340

Oak "Quercus spp.", sawn or chipped lengthwise, sliced or peeled, of a thickness of > 6 mm (excl. planed, sanded or end-jointed) – 44079190

	2012	2014	2016	2016	2012	2014	2012	2014	2016
	China			Japan	Korea Rep.		Russia		
Austria	:	:	:	:	:	:	797	331	161
Belgium	12	172	:	:	:	:	:	:	25
Bulgaria	:	:	:	:	:	:	:	:	198
Croatia	:	:	:	:	:	:	:	:	194
Cyprus	:	:	:	:	:	:	:	:	760
Czech R.	:	:	:	0	:	:	:	411	3 768
Denmark	770	:	:	:	:	:	1 060	:	:
Estonia	:	:	:	:	:	:	:	:	5 708
Finland	:	:	:	:	:	:	:	:	413
France	:	:	:	:	:	:	1 083	:	407
Germany	:	:	:	:	:	:	:	3 482	7 923

No imports from Vietnam and Korea Dem. Rep.

	2012	2014	2016	2016	2012	2014	2012	2014	2016
	China			Japan	Korea Rep.		Russia		
Greece	:	:	:	:	:	:	:	189	398
Hungary	:	:	:	:	108	27	:	:	778
Italy	572	511	:	233	:	:	235	917	1 731
Latvia	:	18	:	:	:	:	:	:	15 686
Lituania	:	:	:	:	:	:	2 508	21 521	109 564
NL	1 186	:	:	:	:	:	670	:	2 394
Poland	:	0	:	:	:	:	:	4 407	33 327
Romania	:	:	:	:	:	:	:	:	6 285
Spain	:	:	:	:	:	:	629	186	199
UK	249	200	2 192	:	:	:	458	:	:
TOTAL	2789	901	2192	233	108	27	7440	27962	181996

B. Wood chips and wood waste. From Eurostat. Years without imports and countries without imports were deleted from the tables below.

- **Wood in chips or particles (excl. those of a kind used principally for dying or tanning purposes, and coniferous wood) 44012200.** No imports from Korea Dem. Rep.

	2012	2014	2016	2012	2016	2012	2014	2016	2012	2014	2016	2014	2016
	China	China	China	Japan	Japan	Korea Rep.	Korea Rep.	Korea Rep.	Russia	Russia	Russia	Vietnam	Vietnam
Austria	0	:	:	:	:	:	:	:	:	:	:	:	:
Belgium	:	361	:	:	:	:	1 118	634	:	:	0	:	:
Croatia	1	:	:	:	:	:	:	:	:	:	:	:	:
Denmark	49	8	134	165	:	:	:	4	274	18 897	98 275	996	:
Estonia	:	:	:	:	:	:	:	:	73 336	15 608	180 370	:	:
Finland	:	:	1	:	:	:	:	:	3 140 574	2 851 621	2 379 079	:	:
France	13	21	:	:	:	:	:	:	:	:	:	:	:
Germany	0	:	60	:	:	:	:	:	:	:	:	37	:
Hungary	:	:	:	:	:	:	:	:	:	:	:	0	:
Italy	26	:	:	:	:	:	:	:	:	:	:	:	:
Malta	:	:	1	:	:	:	:	:	:	:	:	:	:
Netherlands	77	176	173	:	:	2	:	:	:	243	:	:	0
Poland	162	:	:	:	:	:	:	:	:	:	:	:	:
Slovakia	:	:	:	:	:	:	:	:	:	71	0	:	:
Spain	:	:	:	:	:	:	:	:	:	:	2	:	:
Sweden	0	6	54 157	:	:	:	:	:	:	0	155 593	:	:
UK	:	:	21	:	0	:	:	:	:	:	:	:	:
Total	328	572	54547	165	0	2	1118	638	3214184	2886440	2813319	1033	0

- **Wood waste and scrap. 2012 : Wood waste and scrap, whether or not agglomerated in logs, briquettes or similar forms (excl. sawdust and pellets) 44013990, after 2012 not agglomerated (excl. sawdust) 44013980** No imports from Korea Dem. Rep.

	2012 China	2014 China	2016 China	2012 Japan	2014 Japan	2016 Japan	2012 Korea Rep.	2014 Korea Rep.	2012 Russia	2014 Russia	2016 Russia	2012 Vietnam	2014 Vietnam	2016 Vietnam
Austria	:	:	:	:	:	100	:	:	1	:	:	:	:	:
Belgium	3 406	134	29	:	:	:	:	:	1 955	122 161	940 736	:	:	:
Bulgaria	15	69	:	:	:	:	:	:	:	:	:	:	:	:
Cyprus	150			:			:		:			:		
Czech Rep.	230			:			:		1 065			:		
Denmark	670	1	:	:	:	:	:	:	186 990	5 713	50 089	10 565	:	211
Estonia	:	:	:	:	:	:	:	:	114 611	29 174	38 608	:	:	:
Finland	4	:	:	:	:	:	:	:	1 933 800	1 440 445	1 092 309	:	:	:
France	41	24	2	:	:	0	:	:	:	:	2 641	2	0	:
Germany	:	13	8	6	:	:	:	:	160 523	13 870	:	170	49	:
Greece	:	:	:	:	:	:	:	:	:	210	:	:	143	:
Hungary	59	:	:	:	:	:	:	:	:	:	211	:	:	:
Italy	1 866	:	9	:	:	:	11	:	:	:	221	:	:	:
Latvia	:	0	:	:	:	:	:	:	8 202	653	9 144	:	:	:
Lituania	:	:	221	:	:	:	:	:	32 798	47 385	55 255	:	:	:
Netherlands	352	53	:	:	:	:	2	:	:	:	451	:	:	32
Poland	1	7	20	15	44	:	:	:	29 568	422	26 958	:	:	:
Romania	1			:			:		:			:		
Slovakia	:			:			:		596			:		
Slovenia	:			:			:		100			:		
Sweden	182	965	501	:	:	:	:	72	122 620	456	31	:	:	:
UK	185	2	748	:	:	:	:	:	:	:	5 161	203	16	257
Total	7162	1255	1530	15	44	100	13	72	2432306	1646619	2221815	10770	159	500

ANNEX 5. Basic comparison of climate between the area where the pests are present and the EPPO region

Fig 1. Climate chart for Changchun, Jilin province, China (prepared by Roel Potting using the CLIMEX software)

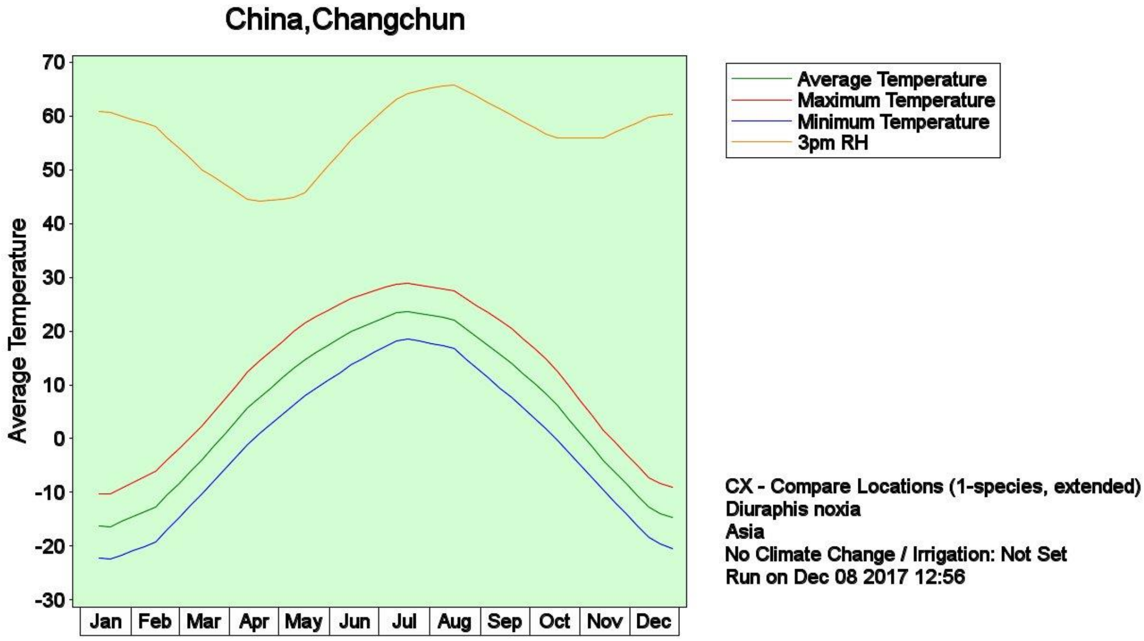
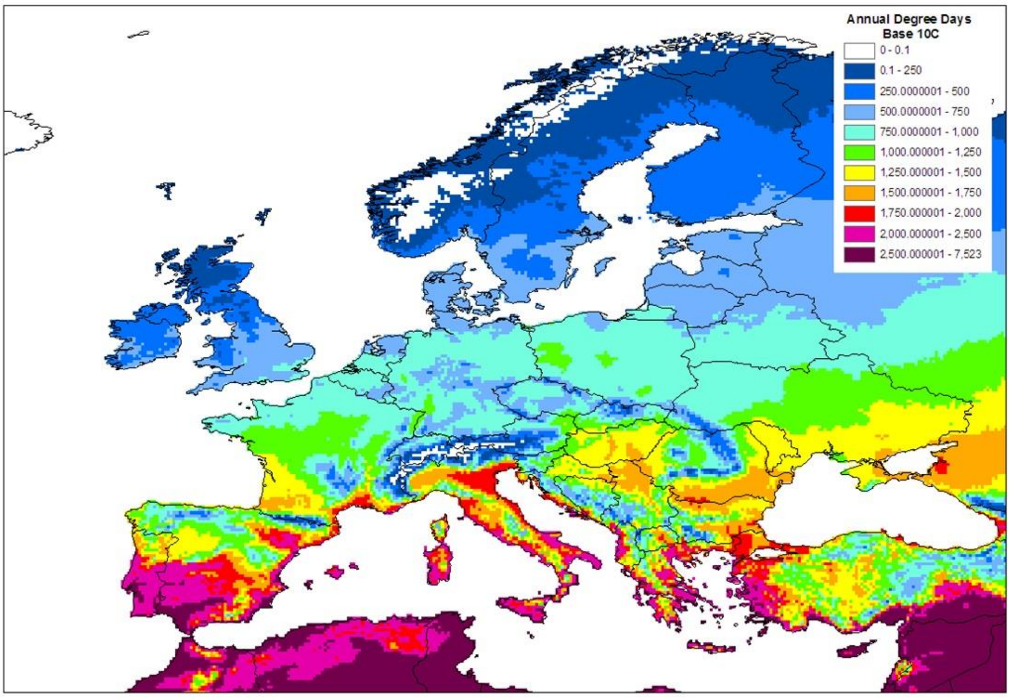


Fig 2. Maps of temperature accumulation (Degree Days) based on a threshold of 10°C using 1961-90 monthly average maximum and minimum temperatures taken from the 10 minute latitude and longitude Climatic Research Unit database (New *et al*., 2002).

- **For Europe and Mediterranean**



- **For Asia**

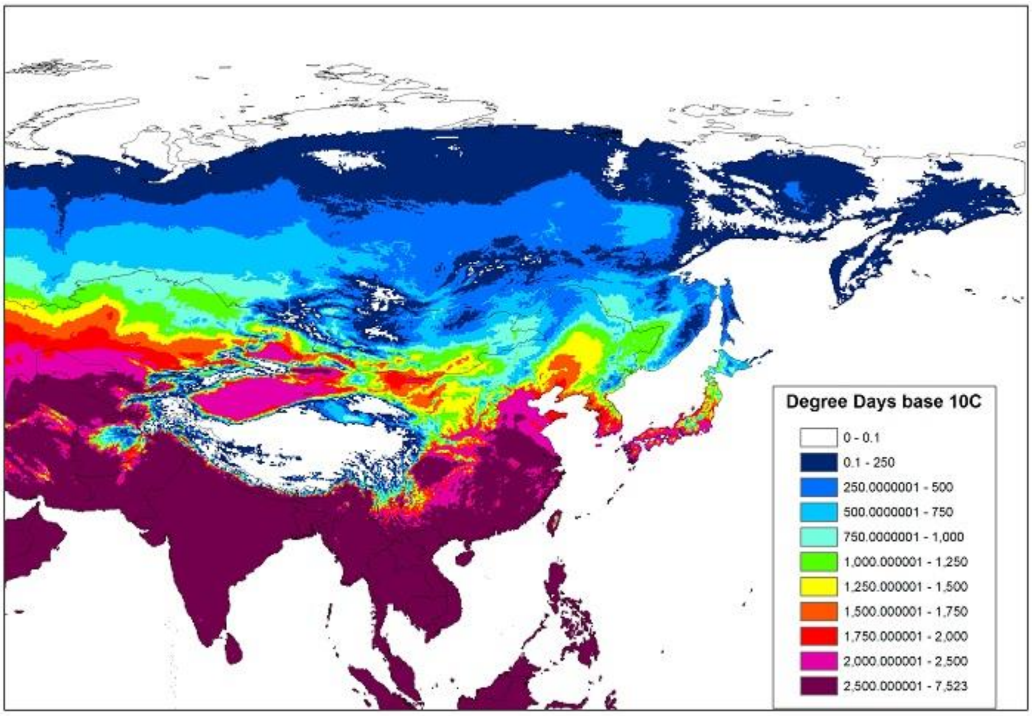


Fig 3. Plant hardiness zones

Thirty-year global plant hardiness zone map for the period 1978-2007**,** updated by Magarey et al. (2008) (map extract).

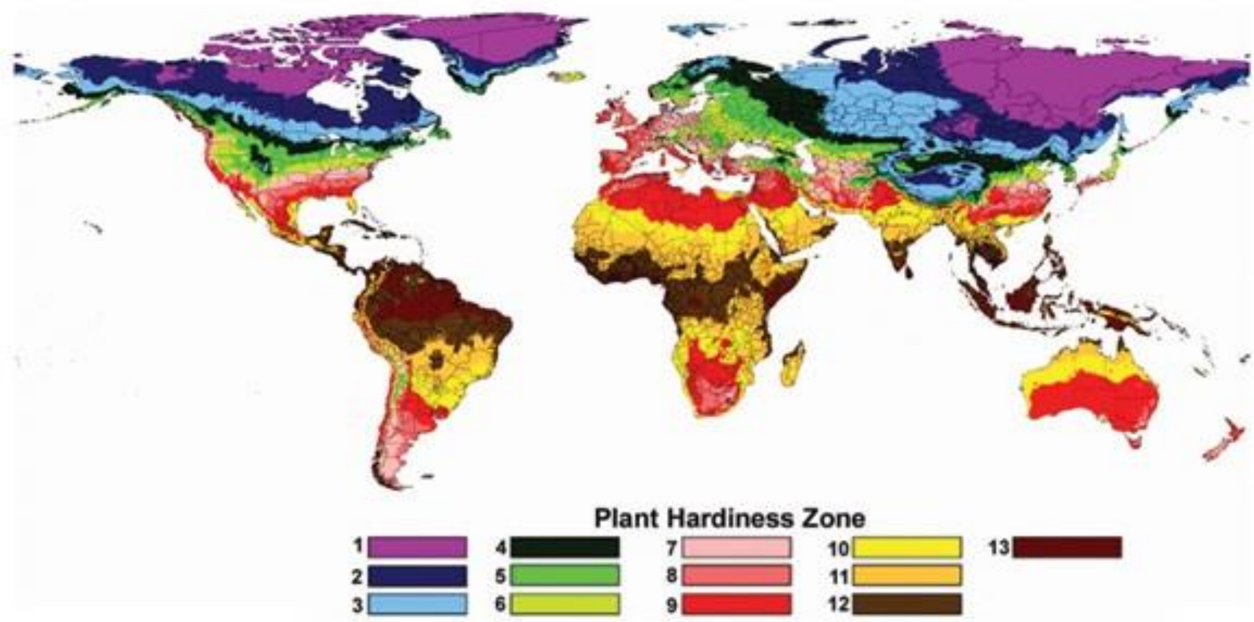


Fig 4.

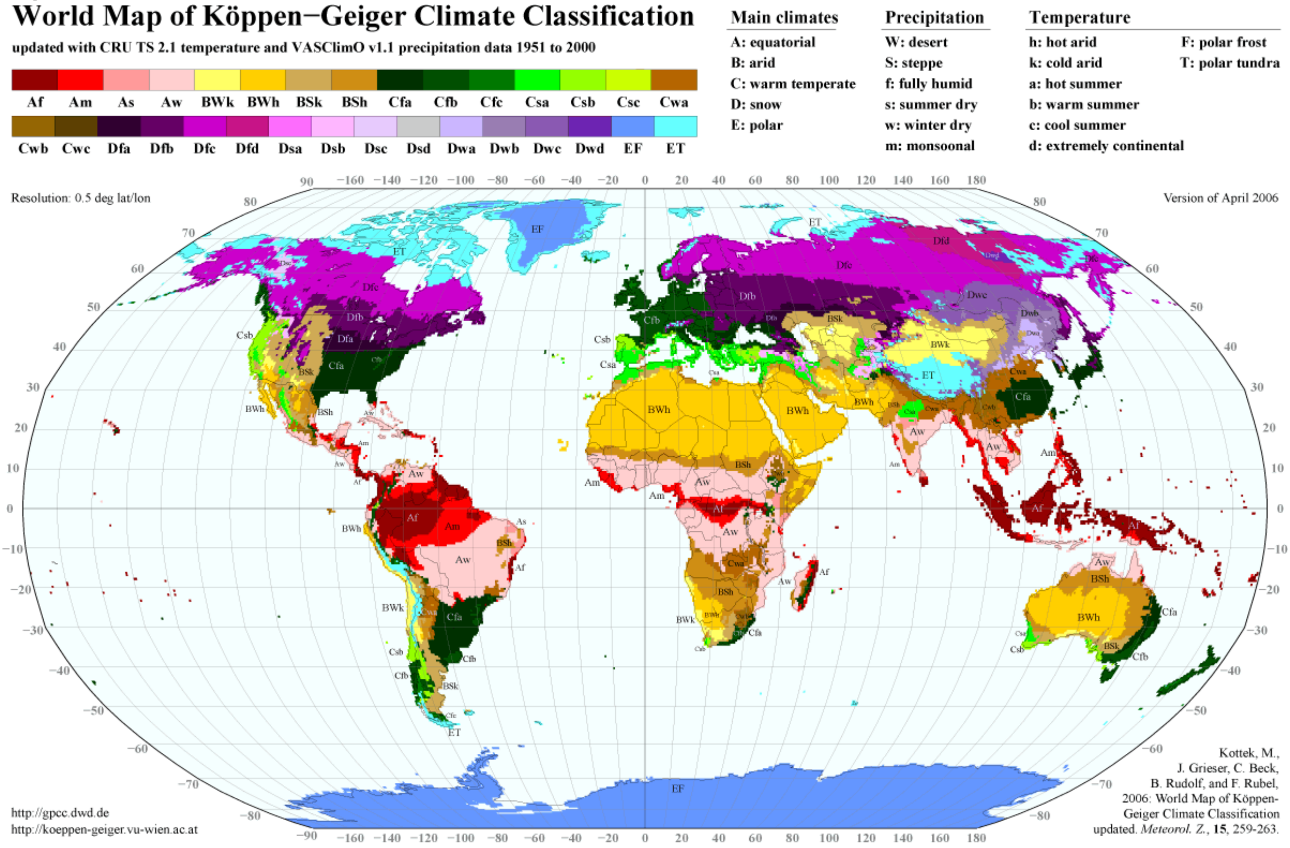
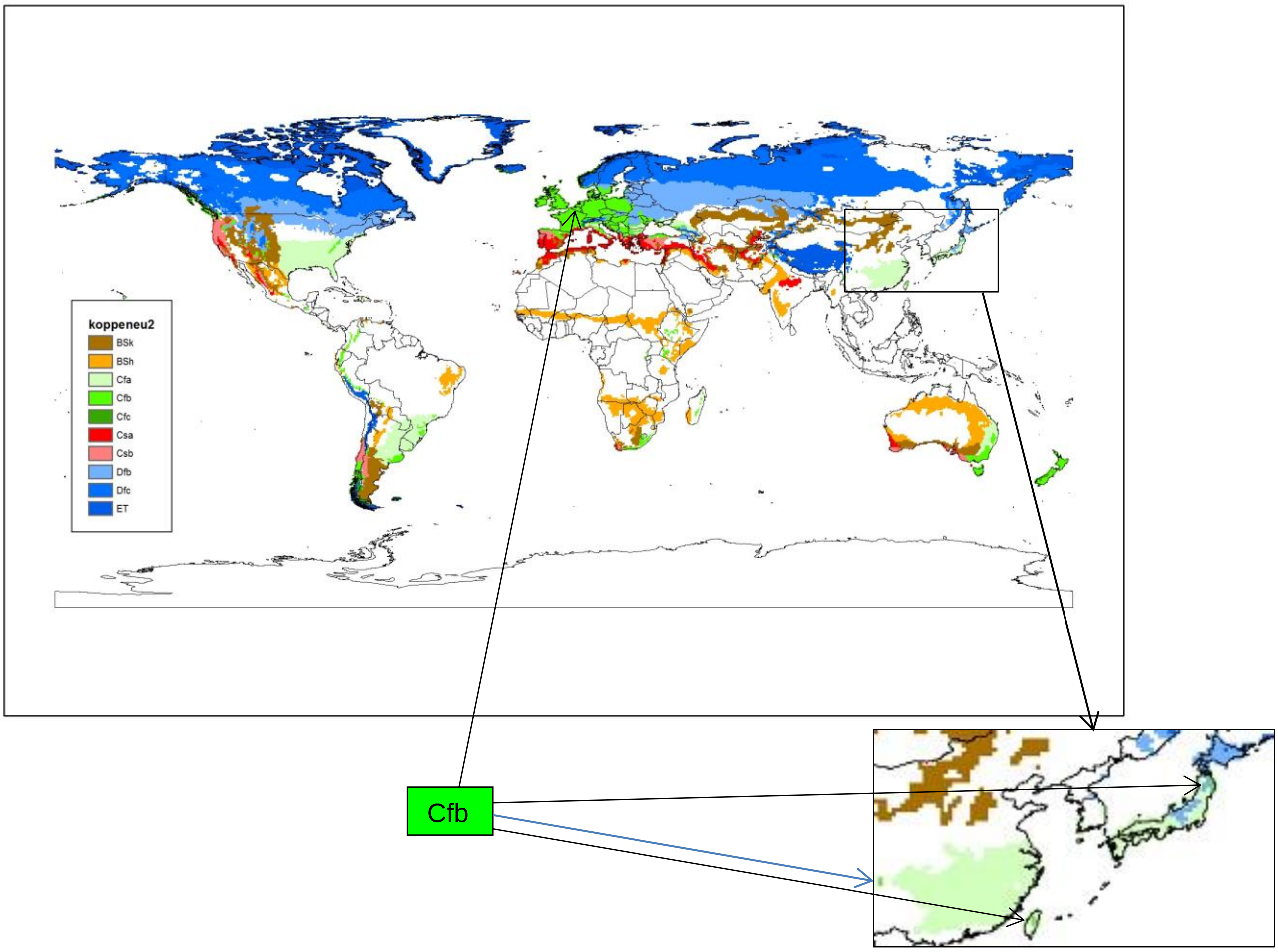


Fig 5. Updated Köppen-Geiger Climate Classification (Kottek et al., 2006) showing only the distribution of the specific climate types that occur in the EU



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

Note: This list 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