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

Pest Risk Analysis for

Chrysobothris femorata and *C. mali* (Coleoptera: Buprestidae)


Ovipositing female of *C. femorata* (N. Youssef, Tennessee State University, USA)

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

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Based on this PRA, *Chrysobothris femorata* and *C. mali* were added to the EPPO A1 List of pests recommended for regulation as quarantine pests in 2021. Measures for plants for planting, round wood, sawn wood (>6 mm), cut branches of host species; as well as for deciduous wood chips, hogwood, processing wood residues and wood packaging material are recommended

Pest Risk Analysis for *Chrysobothris femorata* and *C. mali* (Coleoptera: Buprestidae)

PRA area: EPPO region
Prepared by: Expert Working Group (EWG) on *Chrysobothris femorata* and *C. mali*
Date: The EWG met in 11-14 and 26-28 January 2021 (online meetings). The text was further reviewed and amended following comments by EPPO core members and the EPPO Panel on Phytosanitary Measures (see below).

Composition of the Expert Working Group (EWG)

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All personal communications in this PRA were obtained in July 2020-February 2021 from: J Basham (USDA-APHIS/Tennessee State University, TN, USA), W Barries (Austria), R Gottsberger (EU Reference Laboratory for Insects and Mites, Vienna, Austria), M Hallinen (University of Minnesota, MN, USA), DR Haviland (University of California Cooperative Extension, Kern Co., CA, USA), A LeBude (North Carolina State University, NC, USA), T MacRae (Monsanto, Missouri, USA), D McCullough (Michigan State University, MI, USA), A Murillo (Tennessee State University, TN, USA), J Oliver (Tennessee State University, TN, USA), J. Rijal (University of California Agriculture and Natural Resources, CA, USA), L Tewksbury, University of Rhode Island, RI, USA), N Wiman (Oregon State University, OR, USA).

Photos in ANNEX 3 were kindly provided by: J Basham, J Oliver, A Murillo, N Youssef (Tennessee State University).

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

The PRA was extensively reviewed by N Wiman (Oregon State University) in December 2020-January 2021.

The EWG met during videomeetings (instead of the ordinary face-to-face meetings), in January 2021 in accordance with the prevailing Covid-arrangements agreed for PRA EWGs.

Ratings of likelihoods and levels of uncertainties were made during the meeting. These ratings are based on evidence provided in the PRA and on discussions in the group. Each EWG member provided a rating and a level of uncertainty anonymously and proposals were then discussed together in order to reach a final decision. Such a procedure is known as the Delphi technique (Schrader et al., 2010).

Following the EWG, the PRA was further reviewed by the following core members: J Boberg, JM Guittian Castrillon, F. Petter, G Schrader, M Suffert, R Tanner.

The PRA, in particular the section on risk management, was reviewed and amended by the EPPO Panel on Phytosanitary Measures on 2021-04. EPPO Working Party on Phytosanitary Regulation and Council agreed that *Chrysobothris femorata* and *C. mali* should be added to the A1 Lists of pests recommended for regulation as quarantine pests in 2021.

CONTENTS

Summary of the Pest Risk Analysis for *Chrysobothris femorata* and *C. mali* (Coleoptera: Buprestidae)

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

Describe the endangered area: For both species, at least the southern part of the EPPO region, from the Mediterranean Basin to Central Asia. Economic damage is also expected in parts of temperate areas from Europe to Central Asia. For *C. femorata* the highest impact is expected in areas that climatically corresponds to the southeastern USA (i.e. parts of Northern Italy as well as the Mediterranean and Black Sea Coast). The northern limit for both species is uncertain, but there may be occasional outbreaks in more northern areas when conditions are most appropriate (e.g. during warm dry summers).

Main conclusions: *C. femorata sensu stricto* and *C. mali* are native to North America. *C. femorata s.s.*, further referred to as *C. femorata*, belongs to a complex of 12 species. *C. femorata* is recorded in all continental states of the USA (except Alaska) and in southern Canadian provinces, while *C. mali* has a more western distribution in the USA and Canada. Both species are polyphagous pests attacking many deciduous trees and shrubs. Both species have long been known as wood boring pests of trees in various environments such as in nurseries, orchards and landscapes. Both species primarily attack stressed trees, but there is also evidence that *C. femorata* can attack plants in nurseries after the post-transplant establishment period. Currently, impact by *C. femorata* is reported especially on commercial nurseries and landscape trees (incl. urban trees) in southeastern USA, while *C. mali* is an emerging concern for some fruit crops with damage reported on hazelnut and walnut in Oregon and California. Serious damage has not been reported in the northern part of their range, except for *C. mali* in dryer areas of Oregon and British Columbia.

The likelihood of entry for both pests was rated high, and round wood with bark is the pathway with the highest rating. The likelihood of entry on plants for planting, and sawn wood with bark (>6 mm), was rated as moderate, while the likelihood of entry on other pathways was assessed to be lower. Confirmed hosts are widespread in the EPPO region, and both species may expand their host range. Suitable climatic conditions exist in a major part of the EPPO region. The likelihood of establishment outdoors was rated as high but with a higher uncertainty rating for *C. mali* due to more uncertainty about environmental conditions needed for establishment. The magnitude of spread was rated as moderate with a moderate uncertainty. The flight capability of adults is unknown, but both species can be spread over long distances on human-assisted pathways, especially infested wood and plants for planting.

Impact in North America was assessed as moderate (in areas where economic damages have been reported), with large differences between areas. The potential impact (for the endangered area) in the EPPO region was assessed to be higher due to more limited availability of control options (insecticides), and it was rated as moderate to high. Eradication is likely to be difficult due to a high likelihood of late detection, the wide host range and cryptic life cycle, and the lack of treatments.

The EWG proposed that phytosanitary measures should be recommended for plants for planting of hosts, sawn wood (>6mm in thickness) and round wood of hosts, deciduous wood chips, hogwood and processing wood material, as well as cut branches of hosts. ISPM 15 was considered a sufficient measure for wood packaging material.

Phytosanitary risk for the *endangered area* (*Individual ratings for likelihood of entry and establishment, and for magnitude of spread and impact are provided in the document*) **Same rating for both species**.	High	Moderate X	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*) **Same rating for both species**.	High ☐	Moderate X	Low ☐

Other recommendations: The results from a multidisciplinary project on *Chrysobothris* flatheaded borers that recently started in the USA should be followed to determine if the new information obtained will change any of the assessments in the current PRA.

The EWG noted a number of research topics that would help solve some uncertainties raised in this PRA. They are detailed in section 18.

Stage 1. Initiation

Reason for performing the PRA: *Chrysobothris femorata* and *C. mali* (Coleoptera: Buprestidae) are both common North American wood borers that attack many species of deciduous trees. In 2019, the EPPO Panel on Phytosanitary Measures (PPM) suggested that *C. femorata* should be added to the EPPO Alert List (EPPO, 2019a). *C. femorata* was identified as a potential threat by a Norwegian pest characterization for wood chips (VKM, 2013), in a German express PRA conducted after an interception on *Juglans nigra* logs imported from the USA (JKI, 2017), and by the UK Risk register (DEFRA, 2020). In 2020, the PPM selected *C. femorata* as a possible priority for PRA, and in June 2020 the Working Party on Phytosanitary Measures selected it for PRA. When drafting the PRA for *C. femorata*, the EPPO Secretariat found information on recent re-emergence of *C. mali* as a pest in the USA, and the PPM agreed to analyse the risk posed by this species in the same PRA. Because of the taxonomic uncertainties explained in section 1, this PRA also provides limited information on the other species in the *femorata* complex.

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

PRA area: EPPO region in 2020 (map at https://www.eppo.int/ABOUT_EPPO/eppo_members).

EPPO PRAs on the Buprestidae *Agrilus bilineatus*, *A. fleischeri* (EPPO, 2019b, 2019c), *A. anxius* (EPPO, 2011a) and *A. planipennis* (EPPO, 2013a) were especially referred to. *C. femorata* and *C. mali* share pathways and many hosts with wood borers and other tree pests that have been subject to EPPO PRAs, and information from those was also used.

Stage 2. Pest risk assessment

1. Taxonomy

Taxonomic classification. Domain: Eukaryota; Kingdom: Metazoa; Phylum: Arthropoda; Class: Insecta; Order: Coleoptera; Family: Buprestidae; Genus: *Chrysobothris*

Table 1. Synonyms and common names

Species: *Chrysobothris femorata* (Olivier, 1790)	**Species:** *Chrysobothris mali* Horn, 1886
Synonyms: *Buprestis femorata* Olivier 1790; *Chrysobothris nigritula* Gory & Laporte 1837; *Chrysobothris obscura* LeConte 1860; *Chrysobothris horni* Kerremans 1903 (Wellso & Manley, 2007).	**Synonyms:** none
Common names: flatheaded appletree borer (ESA, 2020); flat-headed apple tree borer; bupreste du pommier, ver rongeur du pommier (EPPO, 2019a).	**Common names:** Pacific flatheaded borer (ESA, 2020)
EPPO code: CHRBFE	**EPPO code:** CHRBMA

Notes on the taxonomy of *C. femorata*

The PRA deals with *C. femorata sensu stricto* (*C. femorata s.s.*), which belongs to a complex of species that currently comprises 12 species ("*femorata* complex" in this PRA) (Wellso & Manley, 2007). *C. femorata* was described in 1790, followed by *C. quadriimpressa* in 1837. During the mid to late 19th century, three more species were described (Hansen *et al.*, 2015). The complex remained at four or five species (depending on the author) until Wellso & Manley's (2007) revision increased the complex to 12 species (ANNEX 2). It is worth noting that little information is available about these species (other than *C. femorata s.s.*) with the exception of some data on distribution, abundance and hosts (e.g. in Wellso & Manley, 2007). *C. femorata s.s.* is difficult to distinguish morphologically from some of the other species in the *femorata* complex (see section 2.7).

The taxonomy of some species in the *femorata* complex is debated. Some authors consider that, because of the considerable intraspecific morphological variation observed within some species, additional species will likely be added to the group (Oliver *et al.,* 2019b; Wellso & Manley, 2007). Others argue that some of the 11 other species may be synonyms with *C. femorata s.s.* Molecular analyses have not resolved the taxonomy of the *C. femorata* species complex to date. An analysis based on the cytochrome oxidase I (cox I) and arginine kinase (AK) genes for 7 species in the *femorata* complex (out of 12) concluded that specimens morphologically identified as *C. femorata*, *C. rugosiceps*, *C. quadriimpressa* and *C. shawnee* had nodes that were paraphyletic and *C. adelpha*, *C. viridiceps* and *C. wintu* had monophyletic nodes (Hansen *et al.*, 2015). Hansen et al. (2015) also concluded that imperfect taxonomy could not totally account for the observed molecular data, but results could also be due to ancestral polymorphism, lineage sorting or introgression. High Throughput Sequencing allowing a broader genomic analysis of *C. femorata* species group members may help clarify taxonomy uncertainties (Hansen et al. 2015).

Due to identification and taxonomic difficulties, species of the *femorata* complex are not always treated separately in the literature. In particular, some publications are not taxonomy-based and may group some species that are considered distinct by other authors. In relation to records of the US National Plant Damage Database, specimens identified as *C. femorata* «are only likely to be members of the *femorata* complex» (Addesso, 2019). Similarly, it seems that pest records are often made for the 'flat-headed apple tree borer', and pooled as *C. femorata* (EPPO, 2019a). Finally, all authors do not separate species in the same way. For example Paiero et al. (2012) do not recognize *C. quadriimpressa*[1] or *C. shawnee*[2], and treat *C. sloicola* as *C. femorata*.

In addition, several authors raise the hypothesis that interspecific breeding may occur within the *femorata* complex (Fischer, 1942; Hansen, 2010; Hansen *et al.,* 2015; Klingeman *et al.,* 2015). This hypothesis is based on: the existence of intermediate forms of morphological characters between populations of a species across its range; overlapping distribution; hosts and seasonal flight activity; and potential polyphyly of some species.

The issues above raise some uncertainties as to whether data on *C. femorata* relates to *C. femorata s.s.* or to the *femorata* complex. Old data on *C. femorata* (before recent taxonomic species separation by Wellso & Manley (2007) – e.g. on biology, hosts or distribution) may relate to one or more species in the *C. femorata* complex.

Consequently, this PRA mentions where the data is known to apply to *C. femorata s.s.* Information from the literature on other species in the *femorata* complex is provided in **Erreur ! Source du renvoi introuvable.**. Note that this information was collected when searching for data on *C. femorata*; the EWG did not conduct targeted search on each species. *C. femorata s.s.* will be further referred to as *C. femorata* unless stated otherwise (e.g. when comparisons are made with other species within the *C. femorata* species complex).

Notes on the taxonomy of *C. mali*

C. mali does not belong to the *femorata* complex, and its taxonomy is currently clear.

2. Pest overview

The biology of *C. femorata* and *C. mali* are mostly similar. A few differences are detailed further down. Even though *C. femorata* and *C. mali* have been recognized as pests in the USA since the 19th century, there are many knowledge gaps on their biology and ecology, and research is ongoing. With regards to other species in the *femorata* complex, field observations of behaviour are largely missing from the literature and experimental trials are lacking (Hansen *et al.,* 2015).

It is worth noting that some biological information arising from publications that pre-date Wellso & Manley (2007) (such as Fenton, 1942, Potter *et al.,* 1988) is repeated in more recent literature on *C. femorata*, but may partly relate to other species within the *femorata* complex. A similar situation arises for publications that group species in different ways or relate to the *femorata* complex, which were consequently used to a limited extent in this PRA (e.g. Paiero *et al.,* 2012; Addesso, 2019).

[1] separated at the end of the 1800s, synonymized with *C. femorata* by Fischer in 1942, re-separated by Wellso & Manley, 2007, possibly polyphyletic in Hansen et al., 2015.

[2] separated by Wellso & Manley, 2007, possibly polyphyletic in Hansen et al., 2015.

2.1 Morphology

Adults are typical Buprestidae, and larvae are typical flatheaded borers (which include various genera within Buprestidae). Broad elements of morphology are summarized in Table 2. Life stages are illustrated in ANNEX 3. Descriptions are provided for *C. femorata s.s.* in Wellso & Manley (2007) and for both species in Steed & Burton (2015) and Burke (1929) (the latter also details morphological differences between *C. femorata* and *C. mali*). Considerable variation exists between individuals of *C. femorata s.s.* (Wellso & Manley, 2007). Several authors note that many members of the *femorata* complex have a broadly similar size and appearance (see section 2.7).

Table 2 Morphology of life stages of *C. femorata s.s.* and *C. mali*

	C. femorata		***C. mali***	
Stage	**Colour/shape**	**Size**	**Colour/shape**	**Size**
Eggs	Disk-like, pale yellow, flattened, wrinkled (Steed & Burton, 2015)	1.5 mm in diameter	Disk-like, whitish, flattened, wrinkled (Burke, 1929)	ca. 1 mm in diameter
Larvae	Cream-colored, with brown head (Steed & Burton, 2015). Bell-shaped abdominal segments and flattened, enlarged and sclerotized thoracic segments (flatheaded wood borer) (Beddes & Caron, 2014; Frank *et al.,* 2013; Steed & Burton, 2015).	18-25 mm long (mature)	Yellowish-white to yellow; thoracic segments greatly enlarged and flattened (Steed & Burton, 2015). Larvae of *C. femorata* and *C. mali* are very similar. The head of *C. mali* larvae tends to be dark but not always (N. Wiman, pers. comm.).	15-18 mm long (mature)
Pupae	Pale yellow and may turn brown (Beddes & Caron, 2014).	7-19 mm long	Pale yellow and may turn brown (Beddes & Caron, 2014).	6-11 mm long
Adults	Metallic olive-grey to brown, with a broad oval shape and large compound eyes. Elytra are blackish gray with coppery-bronze reflections, with several irregular greyish to brassy spots. Beneath the wings, the abdomen is metallic purple/greenish blue and the ventral surface metallic bronze. Antennae are a dark reddish colour. Male face often bright green (Frank *et al.,* 2013; Hansen *et al.,* n.d.; Paiero *et al.,* 2012; Steed & Burton, 2015; Wellso & Manley, 2007).	7-16 mm long (average 12 mm) and up to 5-7 mm wide	Dark-bronze to reddish-copper, with dull to coppery spots and short inconspicuous white hairs covering elytra (Burke, 1929; Steed & Burton, 2015).	6-11 mm long, 3-5 mm wide

2.2 Life cycle

Note: All elements considered relevant to the PRA are presented in this section. However, readers wishing a rapid overview can focus on the bold highlighted text.

General

- ***C. femorata* and *C. mali* generally have one generation per year (Frank *et al.*, 2013; Hansen *et al.*, n.d.; Potter *et al.*, 1988; van Driesche *et al.*, 2012). However 2-3 years may be necessary in the northern part of their range (Beddes & Caron, 2014; Burke, 1919; Steed & Burton, 2015). As for other buprestids, larvae may require more than 1 year to complete their development if challenged by the host's defences (Oliver *et al.*, 2019a based on Brooks, 1919).**

Adults to egg

- **When adults of *C. femorata* and *C. mali* emerge from trees, they form a D-shaped to oval exit hole (typical of Buprestidae**). The D-shaped exit hole is sometimes covered by frass and unapparent unless the frass is scraped away (this may occur when the adult finds another route of exit, such as a crack or gap in the frass).
- ***C. femorata* adults can be found from March to November depending on latitude (Fenton, 1942; Solomon & Payne, 1986 citing Moznette *et al.*, 1931); data suggest a narrower emergence period in some locations (for example May to June in Kentucky; Potter *et al.*, 1988).** Adults are most abundant during May to mid-July in Tennessee (J. Oliver pers. comm.), Oklahoma (Fenton, 1942) and North Carolina (Klingeman *et al.*, 2015a), and in Pennsylvania over 50% of specimens were captured in July (Barringer, 2020; Fig. 1). *C. mali* adults emerge from April through August, but are most commonly seen in June-July (Steed & Burton, 2015). In Oregon, emergence of *C. mali* occurs until late July (N. Wiman, pers. comm.). In Californian walnut orchards, Rijal (2019), mentions May-June as the main emergence period of *C. mali*.

Still in California, Haviland (n.d.) mentions that adults are normally present in May-June, but may be observed in late March-early April when spring months are warm.

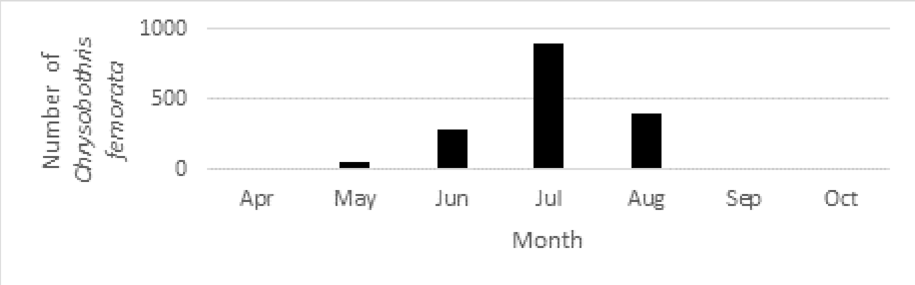


Fig. 1. Trap captures of *C. femorata s.s.* in Pennsylvania (Based on data in Barringer, 2020)

- In the literature, adults of *C. femorata* are reported to feed on tender bark (Burke, 1929; Fenton, 1942; Fenton & Maxwell, 1937), occasionally eating through leaf petioles (Fenton, 1942). Fenton and Maxwell (1937) mentioned specifically that adult *C. femorata* fed on the bark of young elm and apple trees, especially in the crotches and around bud scars.
  A few sources mention that adults of *C. femorata* and *C. mali* feed on the foliage of their host trees (Burke, 1929; Bright, 1987; van Driesche *et al.*, 2012), pollen (Capizzi *et al.*, 1982), or older bark and wood (Burke, 1929). However, in one cage study using apple and elm cuttings with twigs and leaves attached, adults did not feed on leaves (Fenton & Maxwell, 1937). Similarly, in laboratory observations, adults of *C. femorata* have been observed to feed on the bark of young branches, but not on leaves (A. Murillo, pers. comm.). It is unknown if adult *C. femorata* or *C. mali* utilize other food sources than mentioned above in the field (J. Oliver, pers. comm.).
  The duration of survival without food is unknown. Adults "in cages appear to live as long without food as with it" according to (Burke, 1929), while Fenton & Maxwell (1937) noted that adults that were not fed died within a few days. In laboratory conditions, adults survive longer on sugar water than without food (A. Murillo, pers. comm. cited by J. Oliver). Maturation feeding (on tender bark) is needed for females to oviposit (Fenton, 1942).
  From the above, it is understood that adults of *C. femorata* survive longer with food, although they may survive a few days without food. Females need maturation feeding prior to oviposition, mostly on tender bark. The thicker outer bark (characteristic of older trees), foliage and wood are assumed in this PRA to not be suitable, at least not for maturation feeding. It is assumed that adult feeding behaviour is similar for *C. mali*.
- ***C. femorata* adults spend most of their time on the sunny side of the tree where mating and egg-laying most often occurs** (Brook 1919, Burke, 1929, Capizzi *et al.*, 1982). *C. femorata* adults are also commonly collected from branches along the sunny edges of forests or from recently cut stumps (J. Oliver, pers. comm.).
- **Mate selection among members of the *femorata* complex (and buprestids in general) and of *C. mali* is poorly known. However, *C. femorata* and *C. mali* appear to use a tapping behaviour (males rapidly drum their abdomens on the surface on which they are resting) to attract females** (Fenton, 1942; N. Wiman, pers. comm.).
- **Adults of *C. femorata* live for about 3-5 weeks** (about 1 month for females (Solomon, 1995)). In cage experiments, the survival of 18 females ranged from 11 to 43 days (average 26 days) (Fenton, 1942). Adult longevity is unknown for *C. mali* (N. Wiman, pers. comm.).
- **Females of *C. femorata* feed during a pre-oviposition period of 4-8 days (Solomon, 1995). For both species, an average of 60-100 eggs per female are reported** (Fenton, 1942; Beddes & Caron, 2014; Frank *et al.*, 2013 citing Fenton and Maxwell 1937; Oliver *et al.*, 2019a; Solomon, 1995; Steed & Burton, 2015). In experiments, each *C. femorata* female laid a maximum of 24 eggs per 24 h (Fenton, 1942). Fenton & Maxwell (1937) reported that females laid a total of 21 to 166 eggs with an average of 65.7 eggs/female. However, from a larger sample of females, each female laid anywhere from 0 to 69 eggs per day depending on temperature (the warmer the day, the more eggs laid).
- **For both species, eggs are generally laid in bark scales, crevices, wounds, or irregularities (Bright, 1987; Burke, 1929; Frank *et al.*, 2013 citing Fenton & Maxwell, 1937; Steed & Burton, 2015), as well as at the graft union area (Ames, 2018 for apple).**

- **Eggs of *C. femorata* are deposited singly but sometimes close enough to form a group** (Beddes & Caron, 2014; Burke, 1929; Steed & Burton, 2015; Solomon, 1995). However, on nursery trees, larval tunnelling is normally not initiated at the same point (J. Oliver, pers. comm.). Eggs may be laid on a tree that has already been attacked in a previous year (see section 2.6). **The egg-laying habit of *C. mali* is not known (N. Wiman, pers. comm.).** In both species, eggs can be laid, and larvae can develop, on branches or trunks (see details in Section 2.6).
- Knowledge gaps about adult *Chrysobothris* attacks in fields, include: numbers of beetles involved, their source (local trees in the field or flying from outside), tree selection by females (e.g. directed or random oviposition), and whether females 'make multiple trips in and out of field sites to oviposit, or remain in the field and perform multiple oviposition bouts in the same area' (Oliver *et al.*, 2019a).

Eggs and larvae

- **Eggs hatch within 1-3 weeks depending on the temperature (Beddes & Caron, 2014; Capizzi *et al.*, 1982, covering *C. femorata* and *C. mali*; Solomon, 1995 on *C. femorata*). On hatching, first-instar larvae bore immediately into the bark directly underneath the egg (Capizzi *et al.*, 1982; Frank *et al.*, 2013; Solomon, 1995).**
- **For both species, larval galleries and feeding is primarily in the phloem, cambium (inner bark) and the sapwood (outer wood) (Frank *et al.*, 2013; Solomon, 1995).** The galleries may be just under the bark, or on weakened trees or shrubs, in the inner bark (i.e. phloem) (Capizzi *et al.*, 1982). Galleries are usually sinuous and tightly packed with fine frass on smaller trees (Beddes & Caron, 2014; Capizzi *et al.*, 1982; Eaton, 2011; Steed & Burton, 2015), but may also be circular in older trees (Brooks, 1919). As the larva feeds and grows, the gallery starts very small and gradually enlarges (see ANNEX 3).
  In vigorous trees, larvae of both species develop slowly and many die. In young trees with thin bark or in weakened trees, galleries can be long and winding, sometimes girdling the trunk or branch. In older trees with thick bark, the galleries are mostly confined to the inner bark (Bright, 1987), and may be confined to a circular area (Steed & Burton, 2015).
- **Mature larvae of both species tunnel radially from the cambium deeper into the sapwood (Solomon, 1995). They prepare pupal chambers by plugging burrows tightly with frass and overwinter in these chambers (Frank *et al.*, 2013; Solomon, 1995; Steed & Burton, 2015). They may also overwinter in the heartwood** (Frank *et al.*, 2013; Hansen *et al.*, n.d.; Potter *et al.*, 1988). In small trees and in shrubs, the mine and the pupal cell may extend through the heartwood, but in large trees they remain close to the surface (Burke, 1929, for *C. mali*). In young hazelnut trees, pupal cells of *C. mali* are typically found in the heartwood often some distance from the damage area (N. Wiman, pers. comm.). Full-grown larvae may bore 2.5-5 cm-deep in the wood of the tree (Capizzi *et al.*, 1982). In young nursery trees with smaller trunk diameters and restricted wood depth, pupal galleries occur at shallower depths (e.g. 1-2 cm) (J. Oliver, pers. comm.).
  In this PRA, it is understood that the presence of pupae of *C. femorata* or *C. mali* in the heartwood depends on the size of the tree and the thickness of the bark and sapwood. It is assumed that in large diameter material, they will be in the superficial layer of the sapwood, and never in the heartwood, and that they can be found up to 5 cm deep.
- **There may be one or several galleries in a tree, and one or more adults emerging from one tree.** In experiments on naturally-infested *Acer* in nurseries, which were brought into a caged field plot to monitor adult emergence, only one adult of *C. femorata* generally emerged from each tree (92%), although from a few trees two (6%) or three (2%) adults emerged (Potter *et al.*, 1988). There may be one or several galleries of *C. femorata* on a tree (J. Oliver, pers. comm. – see photo in ANNEX 3). On walnut, high-density of galleries of *C. mali* leading to flagging and breakage of nut-bearing branches are mentioned (Rijal & Seybold, 2019a), and multiple larvae can be present and feed on the same branch or twig (J. Rijal, pers. comm.). In hazelnut, 1 *C. mali* larva per stem is most common, but up to 7 larvae have been observed in one stem (N. Wiman, pers. comm.).

Pupae

Pupation occurs in late spring to early summer, and lasts 1-2 weeks (Frank *et al.*, 2013; Hansen, n.d., Solomon, 1985). For *C. femorata*, Fenton (1942) noted that in a great majority of cases, *C. femorata* pupates in the spring. Pupation of *C. mali* occurs from mid-March to mid-June (Burke, 1929). Some individuals may pupate into early July (northern Utah) (Beddes & Caron, 2014 dealing with both species).

Overwintering stage

In the literature, different authors report overwintering of feeding larvae, prepupal larvae (last instar larvae that have finished the feeding stage) and pupae. Potter *et al.* (1988) refer to the overwintering larvae and pupae of *C. femorata.* Burke (1919) noted that observations in California show that most individuals of both species overwinter as prepupal larvae. Steed & Burton (1995) also mentions the prepupal stage overwintering. However, Hansen et al. (n.d.) for Tennessee mentions that larvae may continue feeding even in cold winter months on sun-exposed portions of the trunk. For *C. mali*, a few specimens overwinter as feeding larvae, but no pupae or young adults were found in pupal cells in winter (Burke, 1929). When describing the lifecycle of *C. femorata* and *C. mali*, Capizzi *et al.* (1982) state that the pupae overwinter. **In conclusion, it is understood that, during the winter, there may be feeding larvae, prepupal larvae and pupae.**

2.3 Temperature requirements

- The emergence of *C. femorata* adults from 1st January at base 10°C (from the life stage present in the tree at the start of the year) corresponds to 412 Celsius degree-days (DDC) (Potter *et al.,* 1988). The required degree-days are not available for *C. mali* to date (N. Wiman, pers. comm.).
- Steed & Burton (2015) mention that 'larvae become dormant in cold weather'(Steed & Burton, 2015) while continued feeding on the sunny side of the trunk has been suggested by Hansen et al. (n.d.).

No other information was found on temperature requirements for *C. femorata*, and no data were found for *C. mali*, but their life cycle may be extended to 2-3 years in northern areas. Overwintering larvae are able to survive in areas with cold winter (see section 6. Distribution).

2.4 Dispersal capacity of adults

Adults of both species are active, move rapidly, and run or fly away if disturbed (Capizzi *et al.*, 1982; Steed & Burton, 2015). For *C. femorata*, Fenton (1942) reported "considerable movement from infested trees to those within easy flight range of the beetles". In recent observations, flatheaded borer damage was observed on experimental trees that were ca. 110 m from the nearest likely source trees (forest) and were free from borers at the beginning of the experiment (J. Oliver, pers. comm.). Adults are reported to attack adjacent areas from woodlands or old declining orchards (see section 2.6, *Location in the environment*). Sticky traps studies evaluating multiple trap colours indicated that *C. femorata* male and female beetles flew at least 12 m to reach traps in the middle of the open field test plot (J. Oliver, pers. comm.). Based on common nursery tree spacings in Tennessee (2.1 by 1.8 m), adults definitely fly this distance between trees to initiate new infestations and attacks have been observed in the middle of nursery blocks (i.e., ~10 m from next infested block) (J. Oliver pers. comm.). Similarly, based on observations in nursery blocks in Tennessee, adults definitely fly the distance between trees to initiate new infestations (common nursery tree spacings in Tennessee are 2.1 by 1.8 m), and attacks have been observed in the middle of nursery blocks (i.e. about 10 m from the next infested block) (J. Oliver, pers. comm.).

The EWG acknowledged that studies on dispersal capacity are available for the Buprestidae *Agrilus planipennis* and *A. anxius*, which are both strong fliers (data is summarized in the EPPO PRA on *A. bilineatus,* EPPO, 2019b). However the EWG noted that there is no evidence that *C. femorata* and *C. mali* behave as *A. planipennis* and *A. anxius.* On the contrary, known behavioural differences between *Chrysobothris* and *Agrilus* may influence dispersal patterns, such as their level of polyphagy (*Chrysobothris femorata* and *C. mali* are highly polyphagous, unlike *A. planipennis* and *A. anxius*), and their attack modes (e.g. *C. femorata* generally attack small nursery and landscape trees on the trunk, whereas *A. planipennis* adults spend considerable time in the canopy of trees (Rodriguez-Saona *et al.,* 2007)).

2.5 Nature of the damage

For both species, the most serious damage is caused by larval feeding on the cambium, which disrupts the development of phloem and xylem needed for nutrient and water movement in trees, as well as additional damage to xylem and phloem tissues (Coyle *et al.,* 2005; Frank *et al.,* 2013; Oliver *et al.,* 2010; Potter *et al.,* 1988).

In young trees, galleries of *C. femorata* may girdle the trunk and lead to tree death (Krischik & Davidson, 2013; van Driesche *et al.,* 2012). Steed & Burton (2015) note that this applies to young trees 5 cm diameter or less with thin bark. In young trees, larval galleries may measure 5 cm in length (Bright, 1987) but longer galleries (ca. 20 cm) are commonly observed for *C. femorata* on nursery trees in the field (J. Oliver, pers. comm.) (see ANNEX 3), and on young hazelnut trees, *C. mali* larvae may create spiralling galleries 50 cm-long or more (N. Wiman, pers. comm.). A single larva of *C. femorata* can girdle a young tree within one season

(Hansen *et al.,* n.d.). In addition, attacked trees may break more easily in windstorms (Krischik & Davidson, 2013). Breakage due to *C. mali* is also observed on hazelnut trees under heavy nut crop load (N. Wiman, pers. comm.). Nursery trees that survive attacks are often left scarred and unmarketable (Hansen *et al.*, n.d.).

Attacks by *C. femorata* and *C. mali* usually do not kill mature trees but borer activity can weaken trees or contribute to their death (Beddes & Caron, 2014). Rebek (n.d.) (Oklahoma) mentions that *C. femorata* sometimes attacks and kills large, well-established trees growing under drought or other stress conditions. However, in older trees with thick bark, galleries may be confined to a circular area, and wounds may be enlarged by succeeding generations (Steed & Burton, 2015). Branches may also be girdled. Landscape trees planted near heat sinks such as parking lots with large amounts of water impervious pavement and often poorly maintained are commonly attacked, and the size of wounds would suggest repeated attacks over multiple years, eventually leading to tree decline and death (J. Oliver, pers. comm.).

On walnut in California and hazelnut in Oregon and Washington, *C. mali* attacks young trees (1-2 years) and can seriously damage trees and lead to mortality (Rijal & Seybold, 2019a; N. Wiman, pers. comm.). In several walnut orchards, a wide range of tree ages were infested, from young (1-2 years old) to mature (15-20 years old). High-density of galleries led to the flagging and breakage of nut-bearing branches (Rijal & Seybold, 2019a).

Adult feeding normally causes little damage (Frank *et al.*, 2013; Hansen *et al.*, n.d.), although there have been reports of complete defoliation at unusually high population densities, caused by the adults cutting through the petioles (not by feeding on the leaf) (*C. femorata*; Fenton, 1942).

2.6 Tree condition, size of host material and location of attacks on the trees

Note: All elements considered relevant to the PRA are presented in this section. However, readers wishing a rapid overview can focus on the bold highlighted text.

Tree condition

Stressed versus apparently healthy plants. **In its current area of distribution, *C. femorata* is reported to preferably attack weakened/stressed trees (e.g. newly-planted), but when infestations are high, it may attack healthy trees (Hansen *et al.*, n.d.).** Other species in the *femorata* complex were reported by Wellso & Manley (2007) as being mostly secondary attackers of stressed trees, and are often collected on recently cut or injured plants. Nevertheless, some species of the *femorata* complex have been found attacking apparently healthy nursery trees (see section 12 and ANNEX 2).

***C. mali* also seems to prefer weakened or stressed trees (based on Beddes & Caron, 2014; Burke, 1929; Rijal, 2019). In Oregon, on hazelnut, the pest commonly attacks new plantings and may also attack branches in diseased mature trees (N. Wiman, pers. comm.). In observations in walnut orchards in California, *C. mali* damage was not limited to damaged branches, it also attacked healthy branches (Rijal & Seybold, 2019a).**

For both species, newly-planted trees are sensitive, and prone to attack especially during the first 2-3 years after planting (Beddes & Caron, 2014; Vanek *et al.*, 2012). For *C. femorata*, newly attacked nursery trees (*Acer*) were found each year throughout a 4-year period after planting, and the trees were beyond post-transplant stress (Oliver *et al.*, 2010; Addesso *et al.*, 2020). In experiments with stressed nursery trees, some trees became infested during the growing season following the year in which they were stressed (Potter *et al.*, 1988). Experience in non-treated research sites shows that nursery trees are attacked during the entire production cycle (~5 years) in contrast to growers' observations that attacks only occur 1-2 years after transplanting (Oliver *et al.*, 2019a, 2019b).

Stresses mentioned in the literature in relation to attacks by *C. femorata* and *C. mali* include: drought, plant disease, sunscald, transplanting/newly planted/improperly planted, defoliation, soil compaction, and leaning trees (Bright, 1987; Eaton, 2011; Fenton, 1942, Krischik & Davidson, 2013; Potter *et al.*, 1988; Steed & Burton, 2015; Vanek *et al.*, 2012) (for *C. mali* - Rijal, 2019). Phytotoxicity from an insecticide (acephate) also increased *Chrysobothris* attack rates (Oliver et al. 2010), so agrochemicals that damage trees (e.g. herbicides) are another likely stress factor for inducing attacks. Oliver et al. (2019a) notes nevertheless that the important stress factors that favour attacks are not known, and that transplant stress, which was considered important in the past, is not required for successful attacks.

Freshly cut material. Eaton (2011) mentions that *C. femorata* adults are strongly attracted to freshly cut parts of deciduous trees and bushes, especially from logging or firewood operations. In experiments in the field, females of *C. femorata* laid eggs on freshly-cut branches placed in trees and kept fresh by placing one of the cut ends in a bag of water (Fenton, 1942). Adult *Chrysobothris* species including *C. femorata*, are routinely collected on recently cut stumps or damaged trees and branches from timber harvesting, and appear to be attracted to such material (Oliver et al. 2019a; Oliver, pers. comm.). Recent studies with host volatiles were not conclusive, but the correct lure or release rate may not have been identified (Oliver *et al.,* 2019b).
In this PRA, it is considered that:
- *C. femorata* and *C. mali* may lay eggs on standing trees, as well as on freshly cut trunks or branches.
- Like *Agrilus* species or other Buprestidae, *C. femorata* and *C. mali* females may be more attracted to high concentrations of host volatiles (such as released when producing wood chips), although this has not been confirmed by research. However, *C. femorata* and *C. mali* are polyphagous (unlike many *Agrilus* that tend to be host specialists), so it is likely that if they do respond to host volatiles, the volatiles may be more tree-generic (general injured tree chemicals) rather than host-specific.

Delayed emergence. **Immature stages present in the trunk and branches before these are cut will continue their development as long as the material is suitable. The maximum period of continued development is unknown, nor are the conditions that would allow continued larval development.** However, it is noted that delayed emergence, sometimes for years, is observed in other Buprestidae genera (Basham *et al*., 2016). Fenton (1942) reported emergence of *C. femorata* (i.e. *femorata* complex) from cut wood 3 years after felling. The wood was held in conditions preventing egg-laying by females. It is not known if the pest continued its development during that period, or whether it was already at a mature stage. The conditions under which the wood was kept are not indicated (in particular, whether it was kept with high humidity or allowed to desiccate). Finally, in experiments, *C. femorata* adults emerged from sealed logs that had been cut 3 months before (Potter *et al.*, 1988).
In this PRA, it is considered that immature stages can continue their development on cut material. Complete development with adult emergence is assessed to be more likely for late larval stages, pupae and callow adults than for earlier stages. Adults may emerge for some period after the trees are cut (at least 3 months and possibly several years).

<u>Size of material attacked</u>
Both pests attack small and large trees. 'Trees of all sizes may be attacked [by *C. femorata*, on *Carya*]; those 5 cm or less in diameter may by girdled and killed, and larger trees may be severely weakened and scarred' (Solomon & Payne, 1986). Potter et al. (1988) reared *C. femorata* adults from infested maple trees of 2-4 cm diameter. In Tennessee, growers identified most issues for trees in the range of 2.5-3.8 cm, especially if stressed (Oliver *et al.*, 2019b). In insecticide studies, *Chrysobothris* species (most likely *C. femorata*) attacked trees with fairly small diameters (1.6-2.5 cm) (Oliver *et al.,* 2010). In experiments with cuttings, *C. femorata* showed a preference for laying eggs on cuttings of at least 1.7 cm, and rarely laid eggs on cuttings below 1.2 cm in diameter (Fenton, 1942). *C. femorata* was found in *Vaccinium darrowii* branches (Ashman & Liburd, 2019), which in cultivation is a small bush of 1-1.5 m high, i.e. presumably with thin stems and branches. Some other hosts are also small bushes, such as *Cotoneaster horizontalis*. In Oklahoma, *C. femorata* attacked many rose bushes (another shrub plant with likely small branches), as well as larger elm trees during a period of dry and stressful conditions (Fenton & Maxwell, 1937). *C. mali* also attacks small and large trees, although it is normally known as a pest of young trees (Rijal, 2019). On walnut in California, damage was found on twigs (pencil-sized), branches (ca. 5-10 cm), limbs, and even tree trunks (Rijal & Seybold, 2019a). In hazelnut, *C. mali* has emerged from 3-4 mm stems (measured at 15 cm above the soil line) (N. Wiman, pers. comm., noting also that plants with such size arise from tissue culture, and that bare root trees for planting are typically much larger).
- For *C. femorata*, the EWG noted that there was not sufficient information to identify the minimum diameter of stem or branches that may be attacked and allows larvae to complete their development.
- For *C. mali*, the minimum diameter is likely to be about 3-4 mm. However, the EWG noted that this diameter is so small that it would not make sense to take it into account at further stages of the PRA. (e.g. as part of phytosanitary measures).
Consequently, the EWG did not define a minimum size of plants that could contain *C. femorata* and *C. mali*.

Location in the trees

Larvae of *C. femorata* and *C. mali* can be found in trunks and branches, at various heights. *C. femorata* is sometimes found in the same host as *C. mali* (Burke, 1929), as well as other *Chrysobothris* species.

C. femorata eggs may be oviposited on, and larvae develop in, trunks or branches (Eaton, 2011; Fenton, 1942; MacRae & Basham, 2013). *C. femorata* is more likely to attack the main trunk of nursery trees and has not been found attacking canopy branches in small or larger nursery trees; however, it has also been recovered by rearing from the branches of larger forest trees (J. Oliver, pers. comm.). In nursery surveys in Tennessee, trunk damage was mostly within 30 cm above the ground (Oliver *et al.*, 2019a). In experiments with *Acer* nursery trees, emergence holes were on the trunk, mostly within 1 m above the ground (Potter *et al.*, 1988) and Seagraves et al. (2013) reported emergence holes mostly below 10 cm and all below 40 cm above the ground. Trees may be attacked higher on the trunk or on sides other than the southern and southwestern sides when other vegetation is present at the tree base, which indicates modification of female egg-laying behaviour or larval survival (Addesso *et al.*, 2020). Ames (2018, for apple) mentions that females lay their eggs «a little higher on the trunk» than *Saperda candida* (Cerambycidae), which usually lays eggs near the ground.

C. mali may «bore from the root to the top most branch, but usually in the main trunk, especially for small trees. In weeping trees, it bores in parts exposed to sunlight by the bending down of the weeping branches» (Burke, 1929). On walnut in California, damage was found on trees of different ages, and was distributed randomly throughout the trees (incl. twigs, branches and trunks) (Rijal & Seybold, 2019a). On hazelnut in Oregon, although the main economic concern is attacks to stems of new plantings, attacks by *C. mali* can be found throughout the canopy of diseased orchards (infested by the fungus *Anisogramma anomala*) (N. Wiman, pers. comm.)

Location in the environment

Wild hosts growing near nursery borders can harbour infestations of *C. femorata*, which then attack neighbouring nursery or landscaping trees when those are vulnerable (Hansen *et al.*, 2015). Sites adjacent to woodlands or old declining orchards are reported as especially prone to infestation and damage (Ames, 2018 for organic apple; Oliver *et al.*, 2019a; Potter *et al.*, 1988 for nursery trees; Solomon, 1995; Steed & Burton, 2015). For *C. mali* in Oregon, the severity of attacks is related to the proximity of an orchard to natural areas with forest (N. Wiman, pers. comm.).

***C. femorata* is a common species.** In a compilation of surveys for Buprestidae from ten states in the eastern USA, *C. femorata* was the third most common species (Barringer, 2020). *C. femorata* constituted 6.5% of the 33 047 specimens trapped. There were however large variations between states, e.g. in Missouri 291 out of 810, and in Ohio 5 out of 5162.

2.7 Detection and identification

C. femorata and *C. mali* cause similar symptoms, which may resemble those by other boring insects. See photos in ANNEX 3.

- Sap oozing from under the bark of fresh wounds (Beddes & Caron, 2014; Hansen *et al.*, n.d.).
- Broad and sinuous larval galleries (Beddes & Caron, 2014; Steed & Burton, 2015), under the bark at the points of oozing (Krischik & Davidson, 2013). Spiral girdling of young hazelnut trees is sometimes observed for *C. mali* (N. Wiman, pers. comm.). Galleries may be circular (Brooks, 1919).
- Sawdust-like frass at bark cracks, under flaking bark and in galleries (Beddes & Caron, 2014). However, little to no boring dust is ejected (except at bark cracks) (Steed & Burton, 2015).
- Wounds or sunken/depressed areas of the bark where the cambial wood is dead (Beddes & Caron, 2014). The bark may gradually take a darkened, wet and greasy appearance (Steed & Burton, 2015). The bark may present lumpy, splitting, peeling, flaking, raised, spiralling or blistered areas (Beddes & Caron, 2014; Frank *et al.*, 2013; Steed & Burton, 2015). On old/large trees, loss of large patches of bark on trunks (Krischik & Davidson, 2013; van Driesche *et al.*, 2012).
- D-shaped to oval exit holes on the bark (typical of Buprestidae) (Beddes & Caron, 2014). The exit holes for *C. femorata* are 5-7 mm wide and those of *C. mali* are 3-5 mm wide (based on the width of the adults see Table 2). To confirm adult emergence, frass sometimes needs to be removed as the exit holes may be covered with frass (Frank *et al.*, 2013).
- Infested trees look weak (unthrifty), with less foliage, branch dieback or dead branches (Rebek, n.d.). Dead nursery/newly-planted trees (J. Oliver, pers. comm.).
- Early fall colour change has been observed on red maple nursery trees (J. Oliver, pers. comm.).
- Canopy chlorosis and dieback (hazelnut – N. Wiman, pers. comm.).

- Basal shoots forming on the trunk in response to girdling damage (generally below the girdle area and at the base of the tree) (at least on maple and dogwood) (J. Oliver, pers. comm.).
- Fungi growing through the bark on nursery trees (most likely saprophytic fungi growing on the dead tissues) (J. Oliver, pers. comm.).

Additional considerations

Infestations are usually not apparent until larvae are large enough to produce visible injury on the trunk surface or branch dieback occurs (Oliver *et al.,* 2010), which takes several months after egg-laying. Attacks are normally not detected until the autumn, and are even more visible the following spring (Oliver *et al.*, 2019a). First emergence, and therefore the appearance of D-shaped/oval exit holes, can only be observed at the earliest one year after the first infestation.

Some of the symptoms are useful for narrowing down the potential causal factor to, for example, Buprestidae for trees with D-shaped/oval exit holes, but most symptoms are the same as for many other causal factors (e.g. canker causing sap oozing). Oliver et al. (2019b) notes that borer damage is often misattributed by nursery personnel to other causes like freeze damage, canker or mechanical injury. Similarly, Rijal & Seybold (2019) note that *C. mali* attacks on walnut are often misdiagnosed due to lack of information on the borer.

Detection methods

Detection in the field relies mostly on visual examination of vulnerable trees for symptoms (Beddes & Caron, 2014), but is difficult.

There is no specific attractant available, notably no known pheromone or lure. Trapping is possible, but traps also capture other Buprestidae and identification is required. Trapping should be conducted during the expected flight period (see section 2.2, emergence times). As is the case with many buprestids, *C. femorata* is attracted to purple sticky traps (also used for *Agrilus planipennis*) (Hansen *et al.*, 2015 citing others). In Michigan, *C. femorata* was attracted to purple traps, and enlarged purple silhouettes of an *Agrilus planipennis* adult also improved attractiveness of traps for *Chrysobothris* (Petrice *et al.,* 2013). In Eastern USA (i.e. not *C. mali*), *Chrysobothris* showed a strong preference for purple prism traps over green multi-funnel traps (Rutledge, 2020). Another *Chrysobothris*, *C. sexsignata* was more attracted to purple traps than to green traps (Petrice & Haack, 2015). Purple traps have been shown to be more effective when used in open sunny spaces and near forest borders, while green traps seem to be more effective for trapping in the canopy of trees (J. Oliver, pers. comm.). For *Chrysobothris* species, purple panel traps were more effective at collecting adults than Lindgren funnel traps, and traps baited with ethanol ultra-high release or benzaldehyde, or without lure, were more effective than traps with benzyl alcohol or hexanol lures, which were possibly repellent (J. Oliver, unpublished data). Other trap colors in the violet range of the electromagnetic spectrum (e.g., light to dark pink, magenta, as well as purple) were also more attractive for *C. femorata,* other species in the *C. femorata* species complex, and other *Chrysobothris* species (J. Oliver, unpublished data). Other plant oils that are known to increase trap capture rates of other buprestids like *Agrilus planipennis* like manuka and phoebe oil (Crook *et al.*, 2012; Poland *et al.,* 2019) were not more attractive than an unbaited purple trap for *C. femorata* or several other complex species (Youssef *et al.*, 2010; N. Youssef and J. Oliver, pers. comm.). In surveys in California, where both species occur, *C. femorata* was captured in purple traps, while *C. mali* adults were more attracted to green traps (Rijal & Seybold, 2019a).

Wellso & Manley (2007) mention other collecting techniques for targeting adults such as: beating, sweeping with a net, placing a clear ca. 13 cm long plastic or glass tube slowly over an adult resting on the bark of a tree, and placing ethylene glycol in a fluorescent yellow cup near cut trees (adults are attracted to the cup and drown; citing Ed Riley, Texas A&M). Fenton (1942) also indicated that early morning shaking of trees could dislodge large numbers of adults that were still chilled from the previous evening. Walking slowly near forest edges and looking for adults resting on branches and trunks on sunny days, or on freshly cut stumps, can be effective. It has been used as a method to collect adults in the USA, but may not be as effective at new introduction sites with low populations. The collector needs to move stealthily (due to good visual acuity of the beetles) and is observant for buprestid movement on branches (i.e. adults are often spotted when they move to oviposit or to relocate on the opposite side of the branch in response to the person who is approaching) (J. Oliver, pers. comm.).

Cerceris fumipennis (Hymenoptera: Crabronidae), a parasitic wasp that provisions its nests only with buprestid prey, has been successfully used in North American detection surveys for invasive buprestids even when population levels are low (Careless *et al.*, 2009; Johnson *et al.*, 2015, Looney *et al.*, 2014, Wellso & Manley, 2007). *C. fumipennis* has been documented to collect a *C. femorata* species complex member (*C. caddo*, Wellso & Manley, 2007) and this wasp species might have potential for use in detection surveys.

None of the methods mentioned above are reliable on their own for detecting low levels of infestation.

<u>Identification</u>
C. femorata and *C. mali* belong to a large genus (ca. 690 species worldwide), with over 140 species in North America (Paiero *et al.*, 2012) and many species in the Palaearctic, including in the EPPO region (Löbl & Smetana, 2006).

Morphological identification
Morphological identification of *Chrysobothris* species should be done by a specialist of *Chrysobothris*. *C. mali* can be distinguished morphologically from species in the *C. femorata* complex. Burke (1929) details differences between adults, larvae and pupae. For a reliable identification, adults should be available.

Within the *femorata* complex, the geographical distribution and host range of species overlap and cannot be used to identify to species. Identification keys within the *femorata* complex rely on adult characters such as integument colour, elytra pattern and, especially, form of the male genitalia (Hansen *et al.*, 2011; Klingeman *et al.*, 2015 citing Fisher 1942; MacRae, 1991; Wellso & Manley, 2007).

The morphological characters used in the existing keys are not easy to observe, and intermediate character forms and intraspecific variations complicate identification (especially of females), as well as possible hybridization (see section 1 Taxonomy) (Klingeman *et al.*, 2015).

Identification of the female in some taxa/species within the *C. femorata* complex requires specimens in a good condition, and a very good reference collection consisting of specimens from across the species range. Genitalia removal is required to identify males of some taxa in the *C. femorata* complex. Therefore, regulatory interceptions, especially of female specimens, may be a challenge for positive identification of species in the *femorata* complex (J. Basham, pers. comm.).

Molecular methods
C. mali can be identified using DNA barcoding (Acheampong *et al.*, 2017). To date, no reliable nuclear markers are available to distinguish the species of the *femorata* complex (Hansen *et al.*, 2015). There currently appears to be insufficient data (sequences) in BOLD (Barcode of Life Data System) to distinguish *C. femorata s.s.* from some other species in the *femorata* complex. It is possible that other genetic targets could improve the separation of species in the *femorata* complex, however these data are not yet available. (R. Gottsberger, EU Reference Laboratory for Insects and Mites, Vienna, Austria, pers. comm.). Within the *femorata* complex, issues related to possible synonymy, or allocation of reference specimen using morphological methods may complicate the application of molecular methods.

3. Is the pest a vector?

Yes	☐	**No**	✓

There is no known vector association with a fungus for *C. femorata*, *C. mali* or species in the *femorata* complex, and *C. femorata* and *C. mali* are not considered vectors in this PRA.

It is worth noting that fungi, including plant pathogens, may be transported on the exterior of beetles (by phoresy), but none are presently known to be vectored or necessary for beetle establishment. A preliminary study recovered several plant pathogens from *C. quadriimpressa* and *C. viridiceps* (Klingeman *et al.*, 2019).

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

Yes	☐	**No**	✓

5. Regulatory status of the pest

Chrysobothris femorata and *C. mali* are not listed as a quarantine pest by any EPPO country (EPPO, 2020a). *C. femorata* was added to the EPPO Alert List in 2019 (EPPO, 2019a).

Both *C. femorata* and *C. mali* are regulated pests for the following countries (from IPPC, 2020, except if another reference is given): Korea (2016 list), Chile (2018 list, as '*Chrysobotris* spp. except *Chrysobothris bothrideres*'), Indonesia (2015 list), New Zealand (Biosecurity New Zealand website, 2020). *C. femorata* is a quarantine pest for Japan (2016 list). The information consulted is not exhaustive, and *C. femorata* and *C. mali* may be regulated in more countries.

6. Pest distribution

C. femorata and *C. mali* are native to the USA and Canada and have not been found established elsewhere to date. Table 3 provides details on their distribution. Other records in the literature are considered doubtful or invalid (see notes below Table 3).

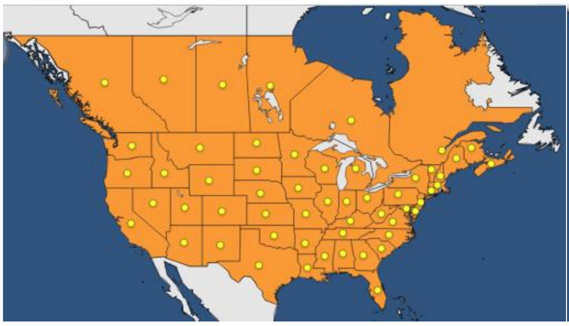
No evidence was found of range expansion of *C. mali* within North America. It is not known whether the records of *C. mali* East of the Rocky Mountains correspond to range expansion. For example, although there has been a large trade of nursery plants from Western USA to North Carolina and Tennessee, *C. mali* has never been detected there (J. Oliver, pers. comm.). There are records of movement within the USA for two members of the *femorata* complex considered as potential synonyms of *C. femorata* by some authors: a specimen of *C. quadriimpressa* reared from *J. nigra* in Idaho may represent an introduction (via nursery plants or wood) (Westcott, 2005). *C. rugosiceps* has recently been found in Washington State (trapped, not known if established or not) and may have been introduced with wood (Westcott *et al.*, 2018).

Table 3. Distribution of *C. femorata* and *C. mali*

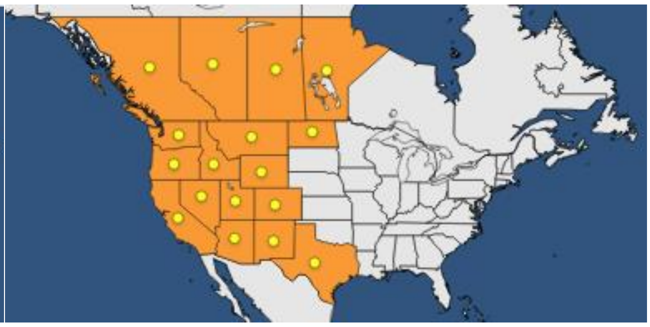
From EPPO Global Database (EPPO, 2020), except when a reference is given. The original references for records in EPPO GD can be found in the database. The distribution may be adjusted in EPPO GD in the future as needed.

C. femorata	**Distribution**	**Additional details**
EPPO region	Absent	
North America	Canada	Alberta**,** British Columbia, Manitoba, New Brunswick, Nova Scotia, Ontario, Québec, Saskatchewan. In all southern provinces except Prince Edward Island. No precise data on the northern limit. However, Bright (1987) indicates localities up to 46°N in New Brunswick (E. Canada) and 52°N in Saskatchewan (W Canada), and the northernmost latitude for georeferenced specimens in GBIF is 54°N in Alberta (W. Canada). (GBIF, 2020b).
	USA	Alabama, Arizona, Arkansas, California, Colorado, Connecticut, Delaware, Florida, Georgia, Idaho, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, Montana, Nebraska, Nevada, New Hampshire, New Jersey, New Mexico, New York, North Carolina, North Dakota, Ohio, Oklahoma, Oregon, Pennsylvania, South Carolina, South Dakota, Tennessee, Texas, Utah, Vermont, Virginia, Washington, West Virginia, Wisconsin, Wyoming. Rhode Island (specimens collected during biosurveillance surveys for emerald ash borer; L. Tewksbury, pers. comm.). In all continental states, except Alaska. *C. femorata* appears to be more common east of the Continental Divide (Bright, 1987; Wellso & Manley, 2007). *C. femorata s.s.* is the most widespread species in the *femorata* complex, followed by *C. quadriimpressa*. Others are more limited in distribution (Wellso & Manley, 2007).
*C. mal*i	**Distribution**	**Additional details**
EPPO region	Absent	
North America	Canada	Alberta, British Columbia, Manitoba, Saskatchewan. Note: this brings the distribution East of the Rocky Mountains. No precise data on the northern limit is available. However, the northernmost latitude for georeferenced specimens in GBIF (GBIF, 2020a) is 50°N in Alberta (W. Canada). Although *C. mali* was previously recorded to only be present west of the Continental Divide, there are also records east of it, in Canada (to Manitoba) and in the USA (at least North Dakota).
	USA	Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, North Dakota, Oregon, Utah, Texas, Washington State, Wyoming. Note: a few records are east of the Rocky Mountains. The records for Texas and New Mexico (from Burke *et al.*, 1929) are not repeated in later publications, but at least the New Mexico record is supported by recent collection specimens (T. MacRae, pers. comm.).

Map of provinces/states of Canada and the USA for records in Table 3 (note that the overview does not reflect the distribution within provinces/states, in particular the northern and southern limits in Canada and the USA for both species, and eastern limit for *C. mali*)



C. femorata (from EPPO Global Database)



C. mali (from EPPO Global Database)

Doubtful and invalid records

C. femorata

- **Mexico, doubtful record**. Presence in Mexico is repeated in a few publications (e.g. Bright, 1987; Nelson *et al.*, 2008; Steed and Burton, 2015), but may relate to other species in the *femorata* complex, such as *C. adelpha* or *C. wintu* (both in Mexico according to Wellso & Manley 2007). Other sources do not refer to Mexico.
- **Ecuador, doubtful record**. Flores Velasteguí et al. (2010) reported *C. femorata* in plantation of *Tectona grandis* in Ecuador. The association of *C. femorata* with *T. grandis* has later been repeated (Arguedas Gamboa & Rodríguez Solís, 2016; Arguedas *et al.*, 2013), but no other record was found. (Since the record is doubtful, the host is not added to the host list).
- **Costa Rica, invalid record**. Arguedas Gamboa & Rodríguez Solís (2016) mention *C. femorata* in a list of *T. grandis* pests in Costa Rica, but they cite Arguedas et al. (2013), which provides a list of *T. grandis* pests that is not specific to Costa Rica and, for *C. femorata*, refers only to an article for Ecuador (Flores Velasteguí *et al.*, 2010). No other record was found.
- **India, doubtful record**. Thakur (1999) and Ahmad & Faisal (2012) cite references mentioning *C. femorata* Oliver as a pest of poplar in India. The original references were not found. *C. femorata* is not mentioned amongst species of *Chrysobothris* of North India (Barries, 2008) nor amongst pests of poplar found during surveys in Northwestern India (Singh *et al.*, 2004). W. Barries, who has extensively published on Asian *Chrysobothris*, noted that identification of *Chrysobothris* species is difficult, and had no knowledge of the presence of *C. femorata* in Asia (pers. comm.).
- **Thailand, doubtful record.** Several sources cite De Foliart (2002) in relation to *C. femorata* Oliver used as an edible insect in Thailand. A list of edible insects of the world (Jongema, 2017) marks this record as needing check. No other record was found of *C. femorata* in Thailand.

C. mali

- **Minnesota, invalid record**. Minnesota is mentioned in Nelson *et al*. (2008) and Paiero *et al*. (2012). However, based on recent data, it should be considered as unreliable (M. Hallinen, under publication and pers. comm.; T. MacRae, pers. comm.).
- **Indiana, doubtful record**. Indiana is mentioned in Addesso (2019). This record is not confirmed. *C. mali* is not considered established in Indiana (pers. comm. from several experts in Indiana to J. Oliver, pers. comm.).
- **Mexico, doubtful record**. US Government (1942) includes an interception of *C. mali* from Mexico on *Echeveria*. No other evidence of the presence of the pest in Mexico was found. *Echeveria* are not woody plants.

7. Host plants and their distribution in the PRA area

C. femorata and *C. mali* are polyphagous and attack a wide range of deciduous trees and shrubs in various families. Such a wide host range is unusual among buprestids (which are typically limited to a single host plant family or genus) (Hansen, 2010). Both species have many native hosts (cultivated or wild) in North America. Many host species are also exotic to North America, especially fruit and ornamental plants. Most host genera and species of *C. femorata* and *C. mali* occur in the EPPO region, where they are planted as fruit, forest and ornamental trees and shrubs, or are native and grow in the wild.

For *C. mali*, it is often repeated that the known host range covers over 70 host species, based on the list in Burke (1929). Only a few other host records were found in subsequent literature. For *C. femorata*, new hosts are still being documented (e.g. *Cornus kousa* -Hansen *et al.*, 2012; *Vaccinium darrowii* - Ashman & Liburd, 2019), which suggests the pest is able to pass onto new hosts. The US National Plant Diagnostic Database damage reports for *Chrysobothris* species (2005-2019) mention *C. femorata* (*femorata* complex) from 22 plant genera and *C. mali* from 3 genera (Addesso, 2019). Within the *femorata* complex, *C. femorata* has the widest host range (Wellso & Manley, 2007), followed by *C. quadriimpressa* (**Erreur ! Source du renvoi introuvable.**).

ANNEX 4 provides a complete host list with references (with details of uncertainty – see explanations below), and outlines the presence and use of host species in the PRA area. Table 4 below provides a summary of genera and number of species. Further details on host species and genera in the EPPO region are given in section 9.2 (summary of hosts by use in the EPPO region) and ANNEX 5 (details for some hosts).

Based on the above, it is considered in this PRA that* C. femorata *and* C. mali *are likely able to attack other deciduous trees and shrubs currently not recorded as hosts (including species not native to North America). Conifers are not attacked.

C. femorata

Acer and apple are often mentioned as being preferred, and the pest can also attack many *Populus* species (Fulcher, 2012; Steed & Burton, 2015). Recent literature often relates to *C. femorata s.s.* as a pest of *Acer*, especially *A. rubrum*, an important ornamental tree in the USA (Oliver *et al.*, 2010). In surveys in nurseries [covering several species of flatheaded borers in Eastern USA], *Acer* had some of the highest attack rates, followed by dogwood (*Cornus*), crabapple (*Malus*) and redbud (*Cercis*); *Prunus* and *Carpinus* are also especially attacked (Oliver *et al.*, 2019b). When referring to the possibility of *C. femorata* (*s.s.*) being split into more species in the future, Wellso & Manley (2007) state: «it appears that some individuals may be reproducing on hard woods (maple, apple, etc.) and others on soft woods (poplar, birch, etc.)».

The susceptibility of host species and cultivars can vary. For *Acer*, in field trials (Seagraves *et al.*, 2013), *A. rubrum* appeared to be more susceptible than *A. saccharum* and *A.* × *freemanii* but with considerable variation among cultivars. However, environmental conditions and cultivar suitability are likely to influence tree susceptibility differently in different regions.

In this PRA, only some of the hosts recorded in the literature could be classified as confirmed true hosts for *C. femorata* due to the following uncertainties:

- Whether the plant supports the whole life cycle of the pest. Some publications mention that larvae or pupae were found, or that extensive damage occurred (implying the presence of larvae). Those plant species were classified as confirmed true hosts. Others only mention feeding of adults on a plant, or adults observed on a plant, or captured in traps on/close to the plant, or do not give details. Those plant species were classified as more uncertain records.
- Past taxonomic confusion for *C. femorata* prior to Wellso and Manley (2007) (see section 1 and 2.7) means that some host records may be in question. Hosts recorded for *C. femorata* or the 'flatheaded apple borer' may relate to *femorata* complex (records pre-dating the separation of species, or pooling of records under *C. femorata*). For example, Wellso & Manley (2007) mention: "Since *C. quadriimpressa* and some of the other species described in this paper were included by Fischer (1942) under *C. femorata*, some host records reported previously for *C. femorata* may be incorrect.". This creates uncertainty for some host genera, most importantly *Quercus* (see note in ANNEX 4).

Hosts were categorised according to the level of uncertainty attached to the host status, as follows:

1A. **Confirmed hosts.** Records confirm that the plants are true hosts of *C. femorata s.s.* (in the sense of Wellso & Manley, 2007) and shown to support the development of the pest (larvae, pupae, emerging adults reported, or extensive damage/tree mortality, implying larvae feeding in the tree).

1B. **Uncertain hosts.** Records confirm the presence of larvae, pupae or emerging adults, but there is some uncertainty on whether the record relates to other species in the *femorata* complex (publication pre-dates Wellso & Manley, 2007).

2. **Very uncertain hosts.** Records relate only to the presence of adults, or the life stages are not indicated. In some cases, there is also an uncertainty on whether the record relates to other species in the *femorata* complex (publication pre-dates Wellso & Manley, 2007).

A summary of genera in the different categories is presented in Table 4.

C. mali

Burke (1929) records "at least 70 host species belonging to 40 genera in 21 different plant families, with malaceous and rosaceous species being attacked more often than others. The heaviest infestations were noted on mountain mahogany [*Cercocarpus*] and California sycamore [*Platanus racemosa*]". Steed & Burton (2015) states that "*Populus* species are not preferred and quaking aspen [*P. tremuloides*] not commonly used". The host list (including confirmed and uncertain hosts) contains most *Prunus* species grown for fruit.

Hosts were categorised according to the level of uncertainty attached to the host status, as follows:

1. **Confirmed hosts.** Records confirm that the plants are true hosts of *C. mali*, and shown to support the development of the pest (larvae, pupae, emerging adults reported, or extensive damage/tree mortality, implying larvae). Note: this category corresponds to the category 1A for *C. femorata*.
2. **Very uncertain hosts.** Record relates only to the presence of adults, or the life stages are not indicated.

Table 4. Summary of genera in the different host categories, and number of species reported (see ANNEX 4 for details of host species)

	Number of host species attributed to each genus				
	C. femorata s.s.			*C. mali*	
Genus	Category 1A Confirmed	Category 1B Uncertain	Category 2 Very uncertain	Category 1 Confirmed	Category 2 Very uncertain
Acer	6	1		5	1
Aesculus		1		1	1
Alnus		1			1
Amelanchier		1			
Arbutus				1	
Arctostaphylos					2
Betula	3		1		1
Carpinus	3				
Carya	1				
Castanea		1			
Ceanothus				1	1
Celtis		1	as genus*		
Cercis	1		2		
Cercocarpus				1	
Cornus	2				
Corylus				2	
Cotoneaster			as genus*		1 & as genus*
Crataegus	2	1 & as genus*			1
Cydonia		1			1
Diospyros		1			
Eriobotrya				1	
Eucalyptus		1 & as genus*		1	as genus*
Fagus			1 & as genus*	1	
Ficus				1	
Frangula				1	
Fraxinus		1			1
Gleditsia			1		
Heteromeles				1	
Juglans	1	1		1	
Liquidambar		1			
Liriodendron			1	1	
Malus	2 #	as genus*		2	
Osmaronia					1
Ostrya	1				
Persea					1
Photinia					1
Pickeringia				1	
Platanus	1			2	
Populus	3	2		1	2
Prunus	1	4		10	2
Pyracantha					1
Pyrus	1		1 & as genus*	1	
Quercus		7 & as genus*#	4	1	3
Raphiolepis					1
Rhamnus					1
Ribes			as genus*	1	1
Rosa		as genus*		as genus*	
Rubus					1
Salix	1	2	1 & as genus*	1	3
Sorbus		1	1 & as genus*	1	
Tilia	1		1& as genus*		
Ulmus	2	1	as genus*	3	
Vaccinium	1			1	
Wisteria					1

* species are not specified in the host record
# see notes in ANNEX 4

Genera in bold contain at least one confirmed record for *C. femorata* or *C. mali*

8. Pathways for entry

The EWG reviewed the EPPO Secretariat's tree of pathways (in preparation) to determine which pathways were relevant. The following pathways for entry of *C. femorata* and *C. mali* are discussed in this PRA. Pathways in bold are described and evaluated in section 8.1; other pathways were considered very unlikely for reasons stated in section 8.2.

- **Host plants for planting (except seeds, tissue culture, pollen) (Table 5)**
- **Round wood and sawn wood of hosts (Table 6)**
- **Deciduous wood chips, hogwood, processing wood residues (except sawdust and shavings) (Table 7)**
- **Cut branches of hosts (Table 8)**
- **Furniture and other objects made of wood of host plants (Table 9)**

- Bark of hosts
- Wood packaging material (including dunnage) that comply with ISPM 15
- Contaminating pest on other commodities or vehicles
- Natural spread
- Sawdust and shavings, processed wood material, post-consumer scrap wood
- Sawn wood of hosts, < 6 mm of thickness
- Cut roses
- Seeds, pollen, fruits (including nuts), tissue culture of hosts
- Movement of individuals, shipping of live Buprestidae, e.g. traded by collectors

Definitions of wood commodities from the *EPPO Study on wood commodities* (EPPO, 2015c - '*EPPO Study*' below) are provided in ANNEX 6.

When reviewing the EPPO Secretariat's tree of pathways, the EWG noted that the following pathways had no relevance for *C. femorata* and *C. mali* (not relevant for woody hosts, and no life stages associated) and did not need to be mentioned in this PRA: bulbs, corms, rhizomes and tubers (for planting); cut foliage (non-woody); leaf vegetables (incl. herbs); stored plant products/dried plant parts (incl. grain); underground plant parts; soil and growing medium; animals; manufactured/processed commodities (other than wood); packaging (other than WPM); Conveyances, vehicles and equipment.

8.1 Pathways studied

The pathways are considered for all hosts in Category 1 and 2, but more information was sought for hosts in Category 1. Where several species are in Category 1, the whole genus was considered. It was not possible to cover all possible hosts in this express PRA.

Examples of prohibition and inspection are given for some EPPO countries (in this express PRA the regulations of all EPPO countries were not analysed). Similarly, the current phytosanitary requirements in place in EPPO countries for 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 to prevent the introduction of the pest.

8.1.1 Host plants for planting (except seeds, tissue culture, pollen)

Table 5. Host plants for planting (except seeds, tissue culture, pollen)

Pathway	**Host plants for planting (except seeds, tissue culture, pollen)**
Coverage	• Plants for planting in pots or similar (including bonsais), plants with bare roots, cuttings, scions. • Seeds, tissue culture, pollen are excluded because the pest is not associated with these commodities (see section 8.2) This pathway covers commercial trade, including Internet trade. Plants for planting, incl. bonsais, of various species can be bought on the Internet. Although this trade is subject to phytosanitary measures, small non-registered producers may not be aware of this. The pathway also covers the movements of plants for planting by individuals (e.g. traveller's luggage, international mail items). Although subject to phytosanitary requirements, at least in some EPPO countries, such material may escape import controls, and individuals may not be aware of the rules. There is no specific information indicating that transport in travellers' luggage is especially of concern for the host plants from North America, and no data is available. Similarly data is not available to assess Internet trade or international mail items. They are therefore not assessed separately.
Plants considered	Confirmed, uncertain and very uncertain hosts (section 7 and ANNEX 4).
Pathway prohibited in the PRA area?	Partly, some hosts in some EPPO countries. In the EU: - plants of *Betula* (other than fruit and seeds) should originate from a country known to be free of *A. anxius*, and as a consequence plants for planting of *Betula* from the USA and Canada are prohibited. - plants for planting of some hosts are prohibited unless they are in a specific state (e.g. dormant and free from leaves, flowers and fruits for *Populus*, *Quercus*, *Crataegus*, *Cydonia*, *Photinia*, *Prunus*, *Pyrus*, *Rosa*). This is not effective to prevent entry, because larvae of *C. femorata* and *C. mali* can be associated (i.e. located internally in the plant tissues) with dormant plants. - plants for planting (other than seeds, in vitro material and bonsais) in the following host genera are 'high risk plants', and import are prohibited pending a risk assessment (EU, 2019): *Acer*, *Alnus*, *Betula*, *Castanea*, *Cornus*, *Corylus*, *Crataegus*, *Diospyros*, *Fagus*, *Ficus carica*, *Fraxinus*, *Juglans*, *Malus*, *Persea*, *Populus*, *Prunus*, *Quercus*, *Salix*, *Sorbus*, *Tilia*, *Ulmus*.
Pathway subject to a plant health inspection at import? Current phytosanitary requirements on the pathway?	Partly. In many EPPO countries, consignments of plants for planting must be inspected at import. In addition, specific phytosanitary requirements may apply (for certain host species). In the EU, the following phytosanitary requirements apply for plants for planting originating in the USA and Canada (and other non-EU countries): - All consignments of plants for planting other than seeds are subject to a Phytosanitary Certificate (PC) (Regulation (EU) 2016/2031 article 72 & 73) and must be inspected at import. The PC requirement also applies to plants for planting transported by travellers (travellers' luggage). - General requirements apply to (deciduous) trees and shrubs, and to bonsais (Commission Implementing Regulation (EU) 2019/2072, details below this table). - After import, physical checks should be performed on plants for planting other than seeds that have been introduced at a dormant stage (Commission Implementing Regulation (EU) 2020/887, article 1 point 4). - Specific requirements apply for some hosts in relation to specific EU quarantine pests and specific EU regulated non-quarantine pests; (see below the table).
Pest already intercepted?	No interception of the species nor of Buprestidae reported for the EU on plants for planting. Not known for other countries. Nursery plants (and possibly firewood) were likely pathways for specimens of *C. quadriimpressa* reared from *J. nigra* in Idaho (Westcott, 2005).
Most likely stages that may be associated	Eggs, larvae, pupae and callow adults of *C. femorata* or *C. mali* can be present on/in trees and shrubs. Eggs would not be present in dormant plants. Adults, other than callow adults in stems and trunks, are not likely to remain on the plants during harvesting and packing, and may be associated with consignments only if they emerge in storage or during transport.

Pathway	Host plants for planting (except seeds, tissue culture, pollen)
Important factors for association with the pathway	Current phytosanitary requirements that may affect the probability of association with the pathway are discussed above. Life stages can be present in stems and branches of any diameter. *C. mali* has been shown to be able to use very small diameter stems (0.3-0.4 cm). The minimum size of branches or stems for *C. femorata* is not known, but it has been observed in diameters down to 1.6 cm. *C. femorata* has an association with commercial ornamental nurseries, at least in southeastern USA, and especially with *Acer*, including *A. rubrum* and *A. saccharum* (Oliver *et al.*, 2019b, 2010). In northern states, based on conversations with nursery growers in Ohio and Minnesota, *Chrysobothris* does not seem to be a problem in tree nurseries (J. Oliver, pers. comm.). *C. mali* is also mentioned as being associated with ornamental nurseries as well as production nut orchard crops like English walnut and hazelnut (Rijal, 2019; Rosetta, 2019; Wiman *et al.*, 2019). There is evidence of possible *Chrysobothris* movement with plants from Western to Eastern North America. This is based on flatheaded borer damage on spring-transplanted maple liners being too significant to have resulted at the destination site after transplanting, including adult exit holes and callous tissue indicating previous wound healing (A. LeBude, pers. comm.). In areas where *C. femorata* is a problem in nurseries in the USA, control methods are commonly applied, including treatments (section 12), and infested trees may be detected (when damage becomes visible). However, not all nurseries may apply treatments, and infestations may be missed. No information was found on whether nursery trees are subject to intensive levels of control against *C. mali* or other Buprestidae in Western North America. For both pests, no information was found on the situation in Canadian nurseries. In the context of inspection of consignments, some infested plants may be detected, but low levels of infestation may not be detected, and symptoms may not be visible.
Survival during transport and storage	It is expected that all life stages present on the plant can survive during transport and storage. If adults emerge, they may need to feed (at least maturation feeding for females), and tender bark would be available. .
Trade	There is no updated detailed data at genus or species level for import of plants for planting in the EPPO region. However, between 2000 and 2012, the following amounts of host plants for planting were imported from the USA and Canada (database used from Eschen et al. (2017) to 14 EPPO countries. Species/genera in Category 1A (femorata, confirmed hosts) and 1 (mali, confirmed hosts) are marked with yellow for C. femorata only, blue for C. mali only, and green for both species. Species/genera without colour correspond to Categories 1B (C. femorata, uncertain) or 2 (for both species, very uncertain). Considering that this data covers a period of 13 years, the imported quantities are generally small, and larger from the USA than from Canada. The highest imports were Betula (however, specific requirements are now in place in many EPPO countries, which do not allow for import of Betula plants, other than seeds and fruit, from the USA and Canada because of the presence of Agrilus anxius). Since 14 December 2019, the EU (temporarily) bans import of Acer, Alnus, Betula, Castanea, Cornus, Corylus, Crataegus, Diospyros, Fagus, Ficus carica, Fraxinus, Juglans, Malus, Persea, Populus, Prunus, Quercus, Salix, Sorbus, Tilia, Ulmus.

	number of pieces			number of pieces			number of pieces	
	USA	Canada		USA	Canada		USA	Canada
Acer	4577*	62	*Cornus kousa*	133		*Persea*	4	
Acer platanoides	290		*Corylus*	2000		*Populus*	32	
Acer rubrum	1910		*Cotoneaster*	600		*Prunus*	6	
Acer saccharum	204	10	*Diospyros*	47		*Pyrus*	7	17
Aesculus	450		*Fagus grandifolia*	276		*Quercus*	34132	50
Alnus	2000		*Fagus*		770	*Rhamnus*	32	
Amelanchier	14650	5400	*Ficus*	27332	1500	*Ribes*	10001	20
Arbutus	10600		*Gleditsia*		696	*Rosa*	62328,	2323

Pathway	Host plants for planting (except seeds, tissue culture, pollen)

Betula	6916433	678100	*Juglans regia*		55	*Sorbus*	10	50
Carpinus	5975	200	*Juglans*	57	61	*Tilia*	430	150
Carya	57		*Liquidambar*	2540	2	*Ulmus*	1237	
Ceanothus	125		*Liriodendron*	19		*Vaccinium*	266570**	
Celtis occidentalis	150		*Malus*	17031	1331	*Vaccinium corymbosum*	36773	
Cornus	57100	300	*Ostrya*	11		*Wisteria*	8601	50

* Some lots comprised quantities of pieces with comma (which did not appear to correspond to thousands separators), and the number of pieces was presumably obtained by converting quantities from another unit. The total has been rounded to the closest unit.
**except *V. corymbosum* (separate row)

Transfer

Emerging adults would already be on a suitable host, or could fly to other host plants. Eggs, larvae and pupae would continue their development once at destination.

Ratings of the likelihood of entry

The EWG noted that the likelihood of association of *C. femorata* and *C. mali* with category 1 and category 2 plants differs, and ratings were defined for these two categories separately. *C. femorata* and *C. mali* are very polyphagous, and are considered likely to be able to attack other woody plants than those currently confirmed as hosts. Category 2 plants may well be true hosts of *C. femorata* and *C. mali*, especially those species that belong to genera that contain confirmed hosts, such as *Populus*, *Prunus* and *Salix*. However, even if Category 2 plants are true hosts, they are likely to be much less frequently/severely infested than some species in Category 1, otherwise they would likely have been identified as confirmed hosts already.

Main elements for the likelihood ratings:
Common to both species:
- The limited data available shows that at least some host plants have been imported from the USA and Canada.
- Suspected movement of *Chrysobothris* with plants for planting between nurseries is reported from the USA (see further above).
- Plants for planting have been imported for decades from North America, and there is no evidence that these pests have entered (in particular, no interception on plants for planting)
- For category 2, even if the plants are hosts, the association would be weaker, which lowered the likelihood for both pests.

Specific to *C. mali*, and justifying a lower rating:
- more limited distribution in North America
- *C. mali* has apparently not been detected in nurseries in Eastern USA despite exchange of nursery material between the West and the East.

Uncertainties. For both species: trade volumes to EPPO (from infested nurseries), the situation and pest status in Canada, whether category 2 plants are hosts. For *C. mali*: less information is available on the situation in nurseries. The same uncertainty rating was given to both species.

		Likelihood	Uncertainty
Plants for planting (except seeds, tissue culture, pollen) of hosts in Category 1 (incl. 1A+1B)	***C. femorata***	Moderate	Moderate
	C. mali	Low	Moderate
Plants for planting (except seeds, tissue culture, pollen) of hosts in Category 2	***C. femorata***	Low	Moderate
	C. mali	Very low/Low	Moderate

Excerpt of EU requirements for plants for planting of hosts
General requirements for trees and shrubs intended for planting (other than seeds and plants in tissue culture) (Commission Implementing Regulation (EU) 2019/2072) • trees and shrubs intended for planting (other than seeds and plants in tissue culture) (a) free from plant debris, flowers and fruits, (b) grown in nurseries, (c) inspected at appropriate times and prior to export and found free or treated [harmful organisms]. • deciduous trees and shrubs intended for planting (other than seeds and plants in tissue culture): dormant and free from leaves. bonsais: grown for at least 2 years prior to dispatch in officially registered nurseries with detailed requirements regarding growing medium, official inspections (at least six times a year at appropriate intervals for the presence of Union quarantine pests of concern, also in the immediate vicinity of the nurseries), and packed in closed containers
There are specific requirements in relation to quarantine pests from North America, for plants for planting of *Castanea*, *Crataegus, Vaccinium*, *Corylus*, *Fraxinus*, *Juglans*, *Betula*, *Platanus*, *Populus*, *Cydonia*, *Malus*, *Prunus*, *Pyrus*, *Quercus*, *Ribes*, *Rubus*, and other than cuttings of *Amelanchier, Aronia*, *Cotoneaster*, *Pyracantha*, *Sorbus*; as well as for regulated non-quarantine pests e.g. for *Ficus*, *Amelanchier*, *Cotoneaster* (Commission Implementing Regulation (EU) 2019/2072)
In addition, certain emergency measures make specific requirements relevant for some hosts of *C. femorata* or *C. mali* from the USA and Canada: • *A. glabripennis* (Commission Implementing Decision 2015/893): Plants for planting of a diameter of 1 cm or more at their thickest point; incl. hosts *Acer*, *Aesculus*, *Alnus*, *Betula*, *Carpinus*, *Celtis*, *Corylus*, *Fagus*, *Fraxinus*, *Malus*, *Platanus*, *Populus*, *Prunus*, *Pyrus*, *Quercus rubra*, *Salix*, *Tilia*, *Ulmus*. • *Rose rosette virus* (EU 2019/1739): Plants for planting of *Rosa*. • *Phytophthora ramorum* (EU 2002/757). Plants for planting (except fruit and seeds) incl. of: *Acer macrophyllum*, *Acer pseudoplatanus*, *Aesculus californica*, *Aesculus hippocastanum*, *Arbutus menziesii*, *Arctostaphylos*, *Fagus sylvatica*, *Frangula californica*, *Heteromeles arbutifolia*, *Parrotia persica*, *Quercus* • *Xylella fastidiosa* (Commission Implementing Regulation (EU) 2020/1201): plants for planting incl. *Acer*, *Prunus*, *Pyrus*, *Quercus* and many other hardwood species.

8.1.2 Round wood and sawn wood of hosts

Table 6. Round wood and sawn wood of hosts

Pathway	**Round wood and sawn wood of hosts**
Coverage	This pathway covers all types of round wood and sawn wood, including with or without bark. Sawn wood is defined as "*wood sawn longitudinally, with or without its natural rounded surface with or without bark*" (FAO, 2018). Round wood includes logs, but also other types of material. Whole trees including branches, twigs, possibly stumps, may be harvested (e.g. as fuel wood). In addition, part of the commodity described in the EPPO Study as '*harvesting residues*' is a type of round wood (when in the form of tops of trees, branches, twigs etc.). - *composition*: Consignments of round wood (as logs) and sawn wood would generally be from one species. Harvesting residues (in the form of round wood) arise from the harvest of logs and may initially be from one species, but it is not known if they would be mixed with other tree species from other origins when traded (e.g. as fuel wood). Round wood intended for other purposes (e.g. fuel wood, production of chips) may contain a mixture of species. - *presence of bark*: round wood (as logs) and sawn wood may be traded with or without bark. Other types of round wood may also have bark attached. - *size*. Logs would normally be of a large size. For harvesting residues (in the form of round wood) and any material sold as fuel wood, the material may be of variable size (including branches, tops 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.). **Sawn wood of hosts of less than 6 mm** of thickness is considered to pose a minimal risk because larvae and pupae will likely be damaged during the sawing processing. (note that although *C. mali* can be on material of smaller diameter, 6 mm was kept here as it corresponds to the threshold for commodity codes). The likelihood of entry on this pathway for both *C. femorata* and *C. mali* is therefore not studied in this pathway (added to section 8.2).
Plants considered	Confirmed, uncertain and very uncertain hosts (section 7 and ANNEX 4).
Pathway prohibited in the PRA area?	No
Pathway subject to a plant health inspection at import?	Partly, in some EPPO countries. In the EU, a number of specific requirements made against other pests apply to round and sawn wood of some host genera and would imply a phytosanitary certificate and inspection at import [see below the table].
Pest already intercepted?	In the EU, several interceptions of *Chrysobothris* at species or genus level from the USA on "wood and bark" have been reported (Europhyt, 2021 – data up to June 2020): - *C. femorata:* 1 in 2017 (also reported in JKI, 2017) and 1 in 2019, on *J. nigra* - *C. quadriimpressa* (*femorata* complex): 1 interception in 2019 on *J. nigra* - *C. sexsignata*: 1 interception in 2019 on *J. nigra* - *Chrysobothris*: 2 interceptions in 2019 on *Juglans* and *J. nigra*.. Also interceptions of Buprestidae in the EU from the USA on "wood and bark": in 2017, 1 on *Juglans* and 1 on *Ulmus rubra*; in 2019: 1 on *J. nigra;* in 2020, 1 on *J. nigra* (Europhyt, 2021). *Chrysobothris* have been intercepted on wood (in the broad sense, including wood packaging material) in the USA. In 1985-2000, *Chrysobothris* were amongst the top four Buprestidae genera intercepted from Africa, Asia, Europe, Central and South America in association with wood (Haack, 2006). In 2000-2008, *Chrysobothris* specimens were intercepted each year at US ports of entry, and represented 10 to 30% of all Buprestidae that were intercepted on wood packaging material in any given year (noting also that some intercepted buprestid specimens were identified only at the family level, and would therefore not be accounted for as *Chrysobothris*) (underlying data in Haack *et al.*, 2014).

Pathway	Round wood and sawn wood of hosts
	In Washington State, wood is hypothesized as a possible pathway of *C. rugosiceps*, trapped close to facilities importing and using host wood from the Eastern USA (Westcott *et al.*, 2018).
Most likely stages that may be associated	Eggs and young larvae would be restricted to wood with bark. Mature larvae, pupae and callow adults may be associated with wood that is with or without bark. Adults, other than callow adults, may be associated with consignments of wood only if they emerge during transport or storage. (If females were attracted to recently cut material, they may lay eggs but it is unlikely that females would remain associated with such material through handling, storage etc.).
Important factors for association with the pathway	*C. femorata* and *C. mali* are present in forests in North America, although there was no information regarding their prevalence in forests (van Driesche *et al.*, 2012; Burke, 1929; Coyle *et al.*, 2005 – details in section 12). Both species are reported to invade nurseries or orchards from woodlands (section 2). There can be several larvae, pupae or callow adults in one tree (see section 2). The concentration of *C. femorata* or *C. mali* is expected to be higher in wood for bio-energy use, as wood of poor quality is usually used for this purpose and no treatment is applied afterwards. Females may lay eggs on freshly-cut wood [details in section 2.6]. Low levels of infestation may not be detected. The pest would probably be more easily detected in sawn wood than in round wood because galleries may be seen after sawing (e.g. galleries leading to pupal chambers in the sawn wood), or in round wood without bark because larval galleries could be seen directly on the sapwood surface. Processing into sawn wood is likely to eliminate the exterior portion of the logs, which are most likely to be infested by larvae. In addition, sawn wood will dry faster than round wood, which makes development of immature stages and survival of the pest less likely in sawn wood than in round wood. Debarking will destroy or remove most eggs and young larvae, and may expose other life stages to desiccation (as they are under the bark and not deep in the outer sapwood). The presence of bark on the wood would favour survival of larvae. Heat treatment, and irradiation are common pest management options to prevent entry of regulated pests with imported wood in EPPO countries. Heat treatment and irradiation applied against other pests would also eliminate *C. femorata* and *C. mali*. Removal of the outer sapwood is also an option used against certain pests (e.g. removal of bark and at least 2.5 cm of the outer sapwood for *Betula* in the EU against *A. anxius*); this would remove eggs and young larvae of *Chrysobothris* species and may expose other life stages to desiccation, thus reducing infestation. However, the treatment options or removal of outer sapwood do not apply to all host trees, nor to all EPPO countries, and in some cases the option of a pest free area (PFA) can be chosen against regulated pests, which has no effect on *C. femorata* or *C. mali*. Therefore, the EWG did not take pest management options against other pests into account for the likelihood rating.
Survival during transport and storage	Larvae are expected to survive during transport and storage if the wood remains suitable for feeding/boring galleries. Larval survival is assumed possible, as *C. femorata* is reported to emerge from cut trees. It is not known for how long the conditions would be adequate. Delayed emergence is known for Buprestidae, and emergence of *C. femorata* (complex) from cut wood after 3 years following felling is reported in Fenton (1942) [details in section 2.6]. Adults emerged from sealed logs after 3 months in Potter et al. (1988). At least, older larvae are expected to survive, as well as pupae and callow adults. Complete development is assessed to be more likely in round wood than in sawn wood because sawn wood may dry out more rapidly depending its thickness. If adults emerge during transport or storage, they may be able to survive eating bark, but it is not known if this would be sufficient to allow mating and egg laying as they normally feed on tender bark. Under normal circumstances, their life span is 3-5 weeks, but may be longer in cooler conditions. Eggs may be able to hatch, but young larvae are less likely to survive than mature larvae as the wood would dry and provide less suitable conditions to complete development (section 2.6). For sawn wood, this is considered to be very unlikely because the wood is expected to dry and become unsuitable before individuals can develop into adults. Only late stage larvae and pupae are expected to be able to complete their development after arrival. At several occasions, live larvae of *C. femorata* have been intercepted, proving that the pest had survived transport.
Trade	Many known hosts are in the Working List of Commercial Timber Tree Species (Mark *et al.*, 2014), incl. hosts not mentioned in the data below, such as *Ostrya virginiana*, *Carpinus betulus*, *C. caroliniana* etc.

Pathway	Round wood and sawn wood of hosts
	FAOSTAT provides data for most EPPO countries for general categories (tree species and commodities concerned are not known). Data were extracted for 2015-2017. - *'industrial roundwood, non-coniferous non-tropical'* (ANNEX 7, Table 1). Substantial US exports, decreasing from ca. 128,000 m^3 to ca. 95,000 m^3 in 2015-2017. For 2017, exports to 33 EPPO countries, with ca. 70% to Italy, Germany, Portugal and Turkey. Smaller Canadian exports and apparently considerable decrease in 2015-2017 (from 45,000 to 3,600 m^3): in 2017, only 7 EPPO countries, ca. 60% to Germany. - '*non-coniferous sawnwood'* (ANNEX 7, Table 2). Major US exports, increasing from 385,000 m^3 to 439,000 m^3 in 2015-2017. In 2017, exports to 43 EPPO countries with ca 70% traded to the UK, Germany, Italy and Spain (between 48,000 and 145,000 m^3 depending on the country). Smaller Canadian exports (40,000-50,000 m^3 each year in 2015-2017), traded to many EPPO countries (34 in 2017); in 2017, the UK and Germany were major importers (19,000 m^3 between them). Data available in Eurostat (i.e. into the EU) were extracted for years 2015 and 2017-2019 for '*fuel wood as logs, billets, twigs, faggots or similar forms*' (ANNEX 7 Table 3) as well as for round wood and sawn wood of birch and poplar, sawn wood of *Acer* and *Prunus*, and general categories for round wood and sawn wood covering deciduous wood not detailed in other categories (therefore including known hosts such as *Acer* roundwood and all *Juglans*). Data for *Castanea* and *Quercus* is available in Eurostat, but was not extracted (mostly uncertain hosts). <u>- Round wood</u> • *Fuel wood as logs, billets, twigs, faggots or similar forms* (ANNEX 7 Table 3). From Canada, only 2 imports (1.6 tons to Germany in 2019; 28 t to the UK in 2015). From the USA, about 116 t in total in 2019 mostly to Latvia (about 82 t). Total of 210 t in 2018; 126 t in 2017). • *Birch* (ANNEX 7 Table 4). Minor imports from Canada (only ca. 5 t to Ireland in 2018) and none in 2017-2019 from the US (against 220 t in 2015 to 4 countries). • *Poplar* (ANNEX 7 Table 5). No imports from Canada. Minor irregular imports from the USA to 4 countries over 2017-2019 (18-46 t), with 88 t in total in 2019 (decreased volumes compared to 1037 t in 2015). • *Other deciduous round wood* (ANNEX 7 Table 6). Small and irregular imports from Canada (only Germany and France had regular imports in 2017-2019), with a total of 180-190 t over the period (but decreased from 930 t in 2015). Substantial imports from the USA, decreasing or fluctuating (ca. 56,100 t in 2017, 83,900 in 2018 and 43,150 in 2019). In 2019, Italy was by far the main country importing from the USA (24,096 t), and Germany, Portugal, Czech Rep., Spain and Denmark had imports over 1000 t. • In the EPPO PRA for thousand cankers disease (EPPO, 2015b), it was noted that roundwood of walnut was commonly imported from the USA into the EPPO region in 1998-2013 (based on data from USDA-FAS), the main importing countries being Italy, Germany, Portugal and Turkey. <u>- Sawn wood</u> • *Acer* (ANNEX 7 Table 7, 8, 9). Regular imports. For the category with highest volume (Table 7; 'excluding planed, end-jointed and sanded wood'), in 2019 4,500 t from Canada and 2,700 t from the USA. The UK imported ca. 50% of the volume from Canada (2,182 t) and the US (1,590 t), and Germany imported mostly from Canada (1,230 t). 14 other countries imported smaller quantities. Maple wood is commonly used in particular for flooring. • *Prunus* (ANNEX 7 Tables 10, 11, 12). Regular imports, small volumes. For the category with highest volume (Table 7; 'excluding planed, end-jointed and sanded wood') in 2019 240 t from Canada and 660 t from the USA, mostly to the UK and Germany. The Eurostat category of *Prunus* mentions 'cherry', which in trade covers *Prunus serotina* (host), a valuable timber grown in the USA and used in particular for furniture. • *Birch* (ANNEX 7 Table 13, 14). Regular imports from the USA, only to Italy and the UK (217 t in 2019). Otherwise small irregular volumes. • *Poplar* (ANNEX 7 Table 15, 16, 17). Stable imports from the USA and Canada. In 2019, 16,700 t from the USA, mostly to the UK (ca. 12,900 t), also Ireland (1,046 t). Ca. 150 t from Canada in 2019.

<table>
<tr><th>Pathway</th><th>Round wood and sawn wood of hosts</th></tr>
<tr><td></td><td>• Other deciduous sawn wood (ANNEX 7 Table 18). Significant and relatively stable imports from Canada (2,515 t to 16 EPPO countries in 2019) and the USA (51,048 t to 20 EPPO countries in 2019). In 2019, Italy and Germany imported over 50% of the total volume from the USA, with also significant quantities to the UK (8,840 t) and Belgium (6,420 t). From Canada, main importers were the UK (990 t) and Germany (790 t). Note that Juglans would be covered in this category.</td></tr>
<tr><td>Transfer to a host</td><td>Wood is often stored outdoors. If mature larvae or pupae are present in the wood, adults could emerge. Wood is often stored close to forests or trees, so transfer is considered possible. Adults present in the consignment or emerging adults would need to find a suitable host tree species, but both pests utilise a very wide host range of forest, ornamental and fruit trees.
The survival of young larvae would depend on their developmental stage and the availability of enough wood volume with suitable moisture. However, the conditions in drying wood will become less favourable over time [see section 2.6].</td></tr>
<tr><td>Likelihood of entry and uncertainty</td><td>The EWG decided to rate round wood and sawn wood with bark, which present the higher risk. As in the case of plants for planting, separate ratings were given to hosts in Category 1 (1A & 1B) and Category 2.
Regarding wood without bark, the EWG did not develop ratings but noted that bark favours the association (more life stages may be associated, and they may survive better). Consequently, the likelihood of entry on wood without bark is considered to be lower.

Main elements for the likelihood ratings:
- known interceptions of C. femorata, Chrysobothris and Buprestidae in trade;
- both species are found in forest environments at origin. Many forest genera are hosts, including major species used for their wood;
- C. femorata is known to emerge from cut hosts;
- large trade volume of some host genera, at least to the EU.
The narrower distribution of C. mali in North America did not justify a lower rating for this species because the species is still present in a large area.
For sawn wood, the entry is likely to be lower than for round wood due to less favourable conditions for development and survival in sawn wood and although still hard to detect, galleries are expected to be more likely to be detected in sawn wood than in round wood.
For category 2: the plant species may not be a host, and even those that are hosts are not expected to frequently be attacked because if they were, it is expected that there would be sufficient information in the literature to classify them as known hosts. Both these factors lowers the likelihood of entry on hosts in category 2. It is noted that category 2 includes some species with high trade volumes.

Uncertainties: transfer capabilities, pest situation in Canada, for C. mali whether deciduous wood is imported from Western USA (major coniferous wood production area), whether category 2 plants are hosts.
<table>
<tr><th></th><th></th><th>likelihood</th><th>uncertainty</th></tr>
<tr><td rowspan="2">Round wood with bark of hosts in Category 1 (incl. 1A+1B)</td><td>C. femorata</td><td>High</td><td>Moderate</td></tr>
<tr><td>C. mali</td><td>High</td><td>Moderate</td></tr>
<tr><td rowspan="2">Round wood with bark of hosts in Category 2</td><td>C. femorata</td><td>Low</td><td>Moderate</td></tr>
<tr><td>C. mali</td><td>Low</td><td>Moderate</td></tr>
<tr><td rowspan="2">Sawn wood with bark (>6 mm) of hosts in Category 1 (incl. 1A & 1B)</td><td>C. femorata</td><td>Moderate</td><td>Moderate</td></tr>
<tr><td>C. mali</td><td>Moderate</td><td>Moderate</td></tr>
<tr><td rowspan="2">Sawn wood with bark (>6 mm) of hosts in Category 2</td><td>C. femorata</td><td>Low</td><td>Moderate</td></tr>
<tr><td>C. mali</td><td>Low</td><td>Moderate</td></tr>
</table></td></tr>
</table>

Excerpt of EU requirements for round wood and sawn wood of various host genera
Commission Implementing Regulation (EU) 2019/2072: from the USA, *Juglans* (PFA for *Pityophthorus juglandis* and *Geosmithia morbida*, heat treatment or squared to entirely remove the wood surface), *Quercus* (squared to remove entirely the rounded surface, or bark-free and the water content is less than 20 %, or bark-free and disinfected by an appropriate hot-air or hot water treatment, or if sawn, with or without residual bark attached, kiln-dried to below 20% moisture content), *Platanus* (PFA for *Ceratocystis platani* or kiln-drying to 20%). From the USA and Canada: *Acer saccharum* (kiln-dried to 20% moisture content), *Fraxinus* (PFA for *A. planipennis* or bark and at least 2.5 cm of the outer sapwood removed or ionizing irradiation), *Betula* (bark and at least 2.5 cm of the outer sapwood removed or ionizing irradiation), *Populus* (bark free or kiln-drying to 20%), *Amelanchier*, *Cotoneaster*, *Crataegus*, *Cydonia*, *Malus*, *Prunus*, *Pyracantha*, *Pyrus*, *Sorbus* (PFA for *Saperda candida*, heat treatment or ionizing radiation).
In addition, certain emergency measures make specific requirements relevant for some hosts of *C. femorata* or *C. mali* from the USA and Canada: • *A. glabripennis* (Commission Implementing Decision 2015/893): *Acer*, *Aesculus*, *Alnus*, *Betula*, *Carpinus*, *Celtis*, *Corylus*, *Fagus*, *Fraxinus*, *Malus*, *Platanus*, *Populus*, *Prunus*, *Pyrus*, *Quercus rubra*, *Salix*, *Sorbus*, *Tilia*, *Ulmus* imported from an *A. glabripennis*-infested country (PFA or heat treatment). • *P. ramorum* (EU 2002/757). *Acer macrophyllum*, *Aesculus californica*, *Quercus* (PFA, stripped of its bark (+ squared or below 20% water content or disinfected by an appropriate hot-air or hot-water treatment) or for sawn wood with or without bark kiln-dried to below 20%)

8.1.3 Deciduous wood chips, hogwood, processing wood residues (except sawdust and shavings)

Table 7. Deciduous wood chips, hogwood, processing wood residues (except sawdust and shavings)

Pathway	**Deciduous wood chips, hogwood, processing wood residues (except sawdust and shavings)**
Coverage	*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 round wood (e.g. residues from squaring), the EPPO study considers that they would either be left on-site or be transformed on-site, in which case they become another commodity (e.g. wood chips, hogwood). - *composition:* depending on the intended use, wood chips are produced from one or a mixture of species. This is not known for the other commodities but would presumably be the same. - *presence of bark:* wood chips or hogwood may be produced from different types of initial material (e.g. wood with or without bark, post-consumer scrap wood etc.). Processing wood residues are residues from round and sawn wood, e.g. made from off-cuts, and may have bark attached. As a consequence, at least part of these commodities may include some bark. - *size:* wood chips are produced through a shredder using a round-hole sieve that defines the dimension of chips (e.g. <2.5 cm) on two dimensions (not the third). The European Standard on solid fuel (CEN, 2014) identifies ten classes of wood chips [cut with sharp tools; typical particle size 5-100 mm] and hog fuel [crushed with blunt tools; varying size] according to the dimensions of the particles. In the class with the largest predefined size of particles, a minimum of 60 weight-percentage (w-%) should consist of particles with a height and a width in the range of 3.15-200 mm and a max length of ≤ 400 mm, and a coarse fraction (≤ 10 w-%) can have a height or width of > 250mm and a max length of particles of 400 mm. There is also one larger size class (60 w-% with a height and a width in the range of 3.15 – 300 mm) where the criteria for the coarse fraction and the max length are not predefined but "to be specified". In the class that most closely relate to the typical wood chips size (5-100 cm), 60% of wood chips should be comprised in the range 3.15–100 mm, and 10% can measure 150-350 mm. As a consequence, both wood chips and hogwood can be quite large. - *intended use*: All these commodities may be used for different purposes, such as pulp, fibreboard production, energy purposes, mulch.
Plants considered	Confirmed, uncertain and very uncertain hosts (section 7 and ANNEX 4).
Pathway prohibited in the PRA area?	Partly, in some EPPO countries. In the EU, 'Wood chips, particles, sawdust, shavings, wood waste and scrap obtained in whole or in part from *Betula*' should be accompanied with an 'Official statement that the wood originates in a country known to be free of *Agrilus anxius*. In practice, this prohibits deciduous wood chips containing *Betula* from the USA and Canada.
Pathway subject to a plant health inspection at import?	Partly, in some EPPO countries. In the EU, a number of specific requirements made against other pests apply to such wood and would imply a phytosanitary certificate and inspection at import [see below the table].
Pest already intercepted?	No interceptions of *C. femorata* or *C. mali* reported to EPPO and/or to the EU on this pathway (EUROPHYT, 2021; EPPO Reporting Service), not known for other regions. However, the EWG considered there were likely to be substantial practical difficulties in inspecting consignments and this may contribute to the lack of recorded interceptions.
Most likely stages that may be associated	Given the size of larvae and pupae, both may be associated with this pathway. Some life stages would be destroyed at processing. Similar considerations for adults as for wood. Adults are attracted to cut material like stumps or damaged branches (see section 2), and there is a possibility that they would be attracted to wood chip consignments possibly creating a risk for hitchhiking of adults.

Pathway	Deciduous wood chips, hogwood, processing wood residues (except sawdust and shavings)
Important factors for association with the pathway	Similar considerations apply as for wood. In addition, as heavily infested trees cannot be used as round wood or sawn wood, they may be processed (e.g. into wood chips). Trees of all diameters may be used for chips. VKM (2013) considered wood chips and bark as possible pathways for *C. femorata*. VKM indicated wood chip sizes were highly variable and sometimes included larger fragments (>2.5 cm) and pieces of branches. Chips also were from a diversity of deciduous tree hosts that could serve as potential hosts for polyphagous species like *C. femorata* and *C. mali*. Although not discussed by the authors, certain times of the year for chip origin and harvest (e.g., spring) might pose a greater risk of importation of the non-feeding stages (like late instar larvae, pupae and callow adults) of *C. femorata* and *C. mali* that would not be impacted by chip suitability for food like the larval stage. Existing requirements (e.g. in the EU) are based on size, i.e. that chips should be less than 2.5 × 2.5 cm in two dimensions, and the third dimension can be of any size. These requirements would reduce the likelihood of association but applies only to certain hosts and is maybe not applied in all EPPO countries. The higher risk of introduction would arise from the presence of mature larvae or pupae, i.e. close to emergence. If they are alive following processing, they would not need to feed in order to develop to the adult stage, and would not require inner bark (phloem), cambium or sapwood tissues to continue their development. Older larvae and pupae of *C. femorata* [larvae 18-25 mm; pupae 7-19 mm] and *C. mali* [larvae 15-18 mm; pupae 6-11 mm] are of comparable size to *A. bilineatus* [larvae 18-24 mm, pupae 6-10 mm] and *A. planipennis* [larvae 26-32 mm; pupae 10-14 mm] (EPPO, 2013a & 2019b). Consequently, the EWG assessed that the association of *C. femorata* and *C. mali* in wood chips would be similar to that assessed in the PRA for *A. bilineatus*: "Chipping of infested wood greatly reduces survivorship of *A. bilineatus* (Dunbar & Stephens, 1974) and similarly for other agrilids such as *A. auroguttatus* (Jones *et al.*, 2013) and *A. planipennis* (McCullough *et al.*, 2007).". The chipping process would cause high larval mortality. "This was demonstrated for *A. planipennis* prepupae using a horizontal grinder with a 2.5 cm × 2.5 cm screen: no evidence of survival was observed (McCullough *et al.*, 2007). Chipping below 2.5 cm x 2.5 cm is considered effective *against A. planipennis* [and therefore against *A. bilineatus* which has a similar size]. However, it cannot be excluded that surviving J-larvae or prepupae could have been found if a larger volume of wood chips would have been used in the experiment (Økland *et al.*, 2012)."
Survival during transport and storage	As for association (above), the EWG assessed that the likelihood of survival of *C. femorata* and *C. mali* in wood chips would be similar to that assessed in the PRA for *A. bilineatus* : [Quote from here onwards] "Because young larvae are mostly feeding on the inner bark (phloem), and cambial tissue, any of this tissue that is present on wood chips would soon dry and not support larval growth. Survival rates of late instars may be higher than for early instars." "Further, mortality of any insects that would survive chipping is presumed to be high since the chips are usually dry and because of possible other treatments (Dunbar & Stephens, 1974; McCullough *et al.*, 2007)." In addition, young larvae would not be able to survive and complete their development since the amount of wood in individual pieces would not be sufficient. Mature larvae and pupae can survive in 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. 55° C or greater) due to composting effect, which will affect the pest (McCullough *et al.*, 2007). This is an occasional phenomenon according to VKM (2013). However, if it occurs, temperatures in the periphery of the pile are still expected to be much lower and seldom lethal (VKM, citing others). If adults have been attracted to the wood chips, they may already have fed, which may increase their ability to survive. If adults emerge during transport or storage, they may be able to survive eating bark, but it is not known if this would be sufficient to allow mating and egg-laying as they normally feed on tender bark. Under normal circumstances, their life span is 3-5 weeks, but may be longer in cooler conditions.
Trade	FAOSTAT provides data for most EPPO countries, but groups coniferous and non-coniferous wood chips. For 2015-2017 (ANNEX 7 Table 19), Canada and the USA were major exporters of wood chips to the EPPO region (decreasing for Canada from 460,000 to 240,000 m^3; increasing for the USA from 1.8 M to 2.5 M m^3). Turkey was by far the largest importer of wood chips, importing in 2017 ca. 98% of the total from Canada, and 85% of the total from the USA. In 2017, non-negligible exports of wood chips from the USA occurred to Germany (76,000 m^3), France (85,000 m^3), and Italy (193,000 m^3). 23 other EPPO countries also imported wood chips. Non-EU EPPO-countries only have incidental imports.

Pathway	Deciduous wood chips, hogwood, processing wood residues (except sawdust and shavings)
	Eurostat (i.e. import into the EU) provides data for deciduous wood chips and waste wood (‘*Wood in chips or particles (excl. those of a kind used principally for dying or tanning purposes, and coniferous wood)*’, 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 described in the EPPO Study. -Eurostat ‘wood chips’ likely covers EPPO hogwood; -Eurostat ‘wood waste and scrap’ would cover both deciduous and coniferous wood. It would cover part of EPPO processing residues, possibly of harvesting residues, as well as other commodities that do not present a risk. - wood chips (ANNEX 7 Table 20) * decreasing imports from the USA over 2017-2019 (1,200 t to 600 t), to 17 EU countries, with volumes over 100 t only to France and Spain. * Overall minor and irregular imports from Canada to most EU countries (2 years over 20 t for 2 countries in 2017-2019, otherwise smaller quantities). The only exception is a large volume to Denmark in 2019 (ca. 31,500 t). - Waste wood. (ANNEX 7 Table 21) Minor imports from Canada (highest volume 79 t to UK in 2019), and from USA for most countries (to 28 t per year) except to Germany (about 1,600 t in 2018-2019) and France (from 14,600 t in 2017 to 53,900 in 2018 and 153,950 in 2019). It is noted that the EU requires that ‘wood chips, particles, sawdust, shavings, wood waste and scrap obtained in whole or in part from *Betula’* should be accompanied with a statement that the wood originates in a country known to be free of *Agrilus anxius*. Thus, wood chips and wood waste from the USA and Canada should not contain *Betula*.
Transfer to a host	As for wood. In addition, transfer would be facilitated if the commodities are used outdoors (e.g. ground cover, mulch) or stored outdoors for enough time prior to processing, allowing emergence (e.g. chips for energy). Use of the wood commodities as mulch presents the highest risk (as facilitating transfer of pests to nearby trees), but this is a minor use of such commodities.
Likelihood of entry and uncertainty	*Likelihood of entry*. A lower survival likelihood (during processing, desiccation, and heating within consignments in transport) was the main reason to rate this pathway lower than round wood and sawn wood (although such consignments may comprise large wood pieces, including from wood of a lower quality than round wood). In addition, transfer may be difficult, but wood chips are sometimes stored outdoors in big piles. There are large trade volumes. No known interceptions (but inspection and recognition of the pest in the product is recognized to be difficult). *Uncertainties*: transfer capabilities, pest situation in Canada, for *C. mali* whether deciduous wood is imported from Western USA (major coniferous wood production area), whether category 2 plants are hosts.

	likelihood	uncertainty
C. femorata	Low-Moderate	Moderate
C. mali	Low-moderate	Moderate

Excerpt of EU requirements applying to ‘chips, particles, sawdust, shavings, wood waste and scrap obtained in whole or part from these plants‘:
Commission Implementing Regulation (EU) 2019/2072: from the USA, *Juglans* (PFA for *P. juglandis* and *G. morbida* or heat treatment), *Quercus* (kiln dried to 20% or appropriate fumigation or heat treatment), *Platanus* (PFA for *C. platani* or kiln-drying to 20%); from the USA and Canada: *Fraxinus* (PFA for *A. planipennis*), *Acer saccharum* & *Populus* (produced from debarked round wood or kiln dried below 20% moisture content or fumigation or heat treatment), *Amelanchier*, *Cotoneaster*, *Crataegus*, *Cydonia*, *Malus*, *Prunus*, *Pyracantha*, *Pyrus* & *Sorbus* (PFA for *S. candida*, or pieces of not more than 2,5 cm thickness and width, or heat treatment 56 C for 30 min).

In addition, certain emergency measures make specific requirements relevant for some hosts of *C. femorata* or *C. mali* from the USA and Canada for *A. glabripennis* and *P. ramorum* (EU 2002/757) [as for wood]

8.1.4 Cut branches of hosts

Table 8. Cut branches of hosts

Pathway	**Cut branches of hosts**
Coverage	Branches traded for decoration purposes. It is unlikely that such material includes fresh leaves.
Plants considered	Cut branches of some confirmed, uncertain or very uncertain hosts may be traded and used (e.g. for decoration). Cut branches of birch are harvested and sold in North America as decorations around Christmas time, without leaves, but no evidence of export/import was found (EPPO PRA on *Agrilus anxius*) (prohibited in the EU, see above). Cut branches of *Prunus dulcis* and *P. avium* are harvested and sold in North America as decoration (N. Wiman, pers. comm.). No more data were sought.
Pathway prohibited in the PRA area?	Partly, some hosts in some EPPO countries. In the EU: • plants of *Betula* other than fruit and seeds should originate from a country known to be free of *A. anxius*. 'Plants' covers cut branches, and this therefore amounts to a prohibition of cut branches of *Betula* from the USA and Canada. • Plants of *Populus* and *Quercus* other than dormant and free from leaves are prohibited.
Pathway subject to a plant health inspection at import?	Partly. Some hosts in some EPPO countries. - In the EU, all plants for cut branches are subject to a phytosanitary certificate (PC) from non-EU countries (EU Directive 2016/2031 article 72 & 73). This requirement covers all hosts, and would ensure some inspection at import. There are no specific requirements made in relation to other pests, which would imply targeted inspections.
Pest already intercepted?	For the EU, no interceptions on this pathway reported in EUROPHYT (2021).
Most likely stages that may be associated	Eggs may be associated with the bark surface before larvae enter the bark. Larvae, pupae and callow adults may be in the branches.
Important factors for association with the pathway	*C. mali* has been shown to use very small diameter stems (3-4 mm). The minimum size of branches or stems for *C. femorata* is not known, but it has been observed in diameters down to 1.6 cm. On cut branches, the minimum diameter for life stages to survive and complete development is probably larger because the branches will dry out after cutting. Females are not considered likely to lay eggs on cut branches, unless they are freshly cut or kept fresh by placing them in water (Fenton, 1942 – see section 2.6 *Freshly cut material*).
Survival during transport and storage	All life stages may survive in fresh branches, and development will continue for some time. However, only mature larvae, pupae and callow adults are expected to complete their development, allowing adults to emerge. Delayed emergence is known on wood, but cut branches of small diameter would degrade rapidly, and become unsuitable. Eggs and younger larvae are not expected to complete their development in cut branches because the material will desiccate over time and probably become unsuitable as a food source. If adults emerge during transport or storage, they could survive eating bark (and the bark of small branches may still be soft enough), but as branches would progressively dry, it is not known if this would be sufficient for maturation feeding.
Trade	No information was sought on the trade of cut branches of hosts into the EPPO region.

Pathway	**Cut branches of hosts**
Transfer to a host	If adults emerge, they may be able to find a host. However, cut branches are often used indoors, and will degrade rapidly. Nevertheless, adults may emerge after the material is disposed of outdoors, in which case finding a host may be easier.
Likelihood of entry and uncertainty	*Likelihood of entry*: Survival and transfer were the main reasons for rating the likelihood of entry as low, as well as this pathway was assumed to have a very low volume. There is more certainty that *C. mali* uses branches and completes its development, and uses potentially very small diameter branches/stems. *Uncertainties*: whether the cut branches of some hosts are traded from North America, its origins, and whether *C. femorata* or *C. mali* could be associated with such traded material.

	Likelihood	Uncertainty
C. femorata	Low	Moderate
C. mali	Low	Moderate

8.1.5 Furniture and other objects made of wood of host plants

Table 9. Furniture and other objects made of wood of host plants

Pathway	**Furniture and other objects made of wood of host plants**
Coverage	Articles made of wood, incl. those still carrying bark
Pathway prohibited in the PRA area?	No.
Pathway subject to a plant health inspection at import?	Partly. In the EU, there are specific requirements for 'furniture and other objects made of untreated wood' in relation to *Betula* for *Agrilus anxius* (bark and at least 2.5 cm of the outer sapwood are removed, or wood treated by ionizing irradiation) and for *Fraxinus* for *Anoplophora planipennis* (wood from a PFA, or bark and at least 2.5 cm of the outer sapwood are removed, or wood treated by ionizing irradiation).
Pest already intercepted?	For the EU, no interceptions on this pathway reported in EUROPHYT (2021).
Plants considered	The wood of many hosts may be used to fabricate furniture or wooden objects. There is little information available to study in detail the pathway for furniture and other objects made of wood of host plants. Considering a few other EPPO PRAs, this pathway was considered at least for wood of: - *Juglans nigra* (PRA on thousand cankers disease), - *Betula* (PRA on *Agrilus anxius*), - *Fraxinus* (PRA on *Agrilus planipennis*) This pathway was considered generally for *Aromia bungi*, a pest of *Prunus* spp. (EPPO, 2015a). It was expected that the wood would usually be dried before being used for such objects. Various arguments for other pests appear valid for *C. femorata* and *C. mali*: For *Pityophthorus juglandis* (Scolytinae), it was considered that life stages would be exposed to desiccation, and possibly only late stages would be able to complete their development and emerge. However, *P. juglandis* is a bark beetle, which feeds in the inner bark (phloem), and thus is also closer to the surface potentially than buprestids during some of their life-cycle. For *A. anxius*, it was considered that this pathway may present a risk if untreated/air dried/bark-covered sapwood is used. This is often the case in rustic birch furniture where whole logs with intact bark are used to construct table legs, bed frames, etc. For *A planipennis*, furniture made of low-quality wood presents a higher risk. The risk of entry from this pathway was considered as lower than that for wood with bark (as fewer life stages may be associated and the dry condition of the wood). For *Aromia bungi* (Cerambycidae), it was noted that larvae and pupae can be present in furniture and other objects, in particular in wooden parts that are not externally visible. Objects and furniture for outdoor use makes the transfer more likely than if they are intended to be used indoors. However, *Prunus* wood used outdoors would generally be processed e.g. dried and treated against potential wood decayers and pests.
Most likely stages that may be associated	Larvae, pupae and callow adults may be associated.
Important factors for association with the pathway	Life stages may be killed during the manufacturing process, and the wood would become less suitable for larvae as it dries. If pupae are present in the wood, adults are likely to be able to emerge even from dry wood. Larvae make a path below the outer bark for eventual adult emergence. However, these exit "galleries" may be exposed if bark is removed during fabrication. Only mature larvae and pupae would present a risk as young larvae would not be able to complete their development. Even if there was sufficient material, the further development would take several months, during which the attached bark and wood would desiccate and probably become unsuitable for larvae. For most objects, except rustic furniture and decorations, any hole would be seen as a defect.

<table>
<tr><th>Pathway</th><th>Furniture and other objects made of wood of host plants</th></tr>
<tr><td></td><td>Some traded wood objects are known to allow the movement of insects: the Cerambycidae Monochamus alternatus (vectoring Bursephalenchus xylophilus) and Trichoferus holosericeus have been found in dining chairs, Trichoferus campestris in a wooden cutlery tray, and Leptura quadrifasciata, in a railway sleeper (Hodgetts et al., 2016; Ostojá-Starzewski, 2014). Emergence of beetles from furniture has been reported for cerambycids such as Monochamus spp. (Fera, 2013), and Semanotus spp., Chlorophorus spp., Batocera spp. (Duffy 1968; Cocquempot, 2007; Cocquempot & Lindelöw; 2010; Cocquempot & Gattus, 2013). [all cited in EPPO PRAs]
Furniture and other items made of wood would not be attractive to females, and probably not accessible to them either as produced indoors. There would be no infestation of consignments of furniture or other items after fabrication.
Mature larvae, pupae or callow adults may be able to complete their development independent of moisture conditions, and the fact that the wood has been seasoned through air-drying is not sufficient to eliminate the risk. Seasoning through kiln-drying will probably eliminate the pest if associated with heat for a sufficient duration.</td></tr>
<tr><td>Survival during transport and storage</td><td>Eggs and young larvae may survive in the bark and wood for some time, but are unlikely to complete their development (see ‘important factors for association with the pathway’). Mature larvae and pupae are expected to survive and able to complete their development.
If adults emerge during transport or storage, they may be able to survive by eating bark, but it is not known if this would be sufficient to allow for mating and egg-laying. Adults also have a limited life span (3-5 weeks).</td></tr>
<tr><td>Trade</td><td>There is no information on trade.</td></tr>
<tr><td>Transfer to a host</td><td>If male and female adults emerge, they may be able to find a mate and host plant. However, this is unlikely for furniture used indoors. Other items may have a variety of uses.
Furniture would be stored before being sold to consumers, and there may be larger quantities of furniture/number of individuals originating from the same infested area, thereby increasing the chance of successful transfer.
If used outdoors, adult emergence and subsequent larval infestation of local trees may be possible. If used indoors, the chance of successful transfer is lower.</td></tr>
<tr><td>Likelihood of entry and uncertainty</td><td>Likelihood of entry. The likelihood was not rated as very low, because in some conditions, there may be large infested consignments/numbers of individuals, and a possibility for transfer, or the furniture may be for outdoor use.

Uncertainties: whether wood of hosts from infested areas would be used to produce furniture or other objects, and there is a trade to the EPPO region.
<table>
<tr><th></th><th>Likelihood</th><th>Uncertainty</th></tr>
<tr><td>C. femorata</td><td>Low</td><td>Moderate</td></tr>
<tr><td>C. mali</td><td>Low</td><td>Moderate</td></tr>
</table></td></tr>
</table>

For all pathways and at the scale of the PRA area, the EWG considered that the current phytosanitary requirements in place are not enough to prevent the introduction of *C. femorata* and *C. mali* into the EPPO region.

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

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

8.2 Unlikely pathways: very low likelihood of entry

- *Wood packaging material (including dunnage) that complies with ISPM 15*. The EWG considered that the assessment of this pathway was similar to *A. bilineatus* (EPPO, 2019b).
  Uncertainty: very low.
- *Bark of hosts traded on its own.* Eggs may be present on the bark, and larvae at the interface between the bark and the wood. The bark on smaller host material would be too thin to support larvae, pupae and callow adults and prevent exposure when bark was harvested. On other types of bark, those life stages may be associated with large pieces of bark, considering that such larger pieces may also include some sapwood. A high proportion of individuals would be damaged or killed during processing into bark pieces, including larvae exposed between the bark and the wood. Younger larvae are most likely to be associated with the bark, but they are unlikely to develop to the next stage unless sufficient inner bark (phloem), cambial, and sapwood tissues were attached (which is unlikely). Transfer to a suitable host of adults emerged at destination would require certain circumstances, i.e. that the bark is kept or used outdoors at destination at an appropriate time for adult emergence and survival (e.g. bark used as mulch). The trade volume is assumed to be low.
  Likelihood: very low-low; *Uncertainties:* moderate (whether bark of host species is traded internationally).
- *Contaminating pest on other commodities or vehicles*. Hitchhiking on the outside or inside vehicles has been shown to be a pathway for *A. planipennis* for spread of adults at relatively short distances (i.e. between neighbouring countries) (EPPO, 2013a). Hitchhiking is not mentioned in the North American literature for *C. femorata* and *C. mali*. Adults are not mentioned as being attracted to light (which may attract them to e.g. vehicles or containers). Adults have a short life span, ca. 3-5 weeks. Hitchhiking may play a role in local spread if *C. femorata* or *C. mali* are introduced in the EPPO region (see Section 11. Spread), but is not a pathway from the USA or Canada.
  Uncertainty: low.
- *Natural spread*. *C. femorata* and *C. mali* are present only in North America and entry into the EPPO region by natural spread is not possible.
  Uncertainty: low.
- *Sawdust and shavings, processed wood material, post-consumer scrap wood* (see definitions in ANNEX 6). The EPPO Study on wood commodities (EPPO, 2015c) 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 during production of these commodities, or not be able to continue development.
  Uncertainty: low.
- *Sawn wood of hosts, < 6 mm of thickness, with or without bark*. Larvae, pupae and callow adults will be damaged during the processing. If any life stages are not killed, they are very unlikely to survive in such material (see wood).
  Uncertainty: low.
- *Cut roses*. *Rosa* is an uncertain host of *C. femorata* and a confirmed host of *C. mali*. There are no indications from North America that these species are pests in rose production, nor on the *Rosa* species attacked, and there is no report of association with cut roses.
  Uncertainty: low.
- *Seeds, pollen, fruits (including nuts), tissue culture of hosts*. No life stages are associated with these.
  Uncertainty: low.
- *Movement of individuals, shipping of live Buprestidae, e.g. traded by collectors.*
  The insect will most likely be shipped dead.
  Uncertainty: low.

9. Likelihood of establishment outdoors in the PRA area

9.1 Climatic suitability

C. femorata and *C. mali* are present in North America in a wide range of climatic conditions. They normally complete their life cycle in one year, but 2-3 years are necessary in some northern areas (see section 2.2). Immature stages are mostly under the bark or in sapwood in winter and are therefore protected from sharp drops in temperature, and from desiccation. Immature stages become dormant in cold conditions. The northern distribution limit in Canada does not appear to be linked to the presence of hosts (as there is continuity of at least *Populus tremuloides* further North – even if "not commonly used" by *C. mali* (Steed & Burton, 2015)), and it may be due to climatic conditions or other factors. Therefore, the coldest conditions in Northern Scandinavia or Russia (Siberia, Far-East), may not allow establishment of *C. femorata* and *C. mali*.

Comparisons of areas where *C. femorata* or *C. mali* occur and the EPPO region:

- ***Degree-day accumulation for the EPPO region and North America.*** *C. femorata* requires 412 Celsius degree-days from 1st January base 10°C to emerge as an adult from the life stage present in the tree at the start of the year. The number of degree-days that either *C. femorata* or *C. mali* need to complete their total development are not known. However, comparing the maps of growing degree-days at base 10ºC for North America and the EPPO region, the current distribution of *C. femorata* corresponds to the whole EPPO region except its northern part (most of Ireland and northern UK in the West, through Scandinavia, to Siberia in the East) (see ANNEX 8, Fig 1). The distribution of *C. mali* is within that of *C. femorata*, and its northern limit is close to that of *C. femorata,* and so it is expected the northern limits described above for *C. femorata* may also broadly apply to *C. mali*.
- ***Plant hardiness.*** *C. femorata* and *C. mali* are present in the plant hardiness zones 3-9 (at least) (ANNEX 8 Figs. 2 & 3). Therefore, it is likely that winter temperatures would not limit their establishment in a large part of the EPPO region. However, northern Scandinavia and northeastern Russia are in hardiness zones 1-2, like the northern part of Canada where *C. femorata* or *C. mali* are not reported. There seems to be a correspondence between the northern limit of distribution in Canada and the limits for plant hardiness and/or degree day accumulation.
- ***Köppen-Geiger climate classifications*** (based on Rubel & Kottek, 2010) (ANNEX 8 Figs. 4, 5, 6). Many climate types that are present in the provinces/states of Canada and the USA where the pests are present are also present in the EPPO region (see Fig. 4, 5 & 6 in ANNEX 8). However, it is uncertain if the pests occur under all these climate types (i.e. the distribution within the provinces/states in uncertain). The information available is provided as notes in ANNEX 8.

For both species, data is lacking on air temperature and humidity levels suitable for adults. It is also not known if humidity would be sufficient in the driest areas of the EPPO region. However, both *C. mali* and *C. femorata*, in walnut orchard surveys, were trapped in the Central valley of California, which has an arid to Mediterranean climate. Some areas of the EPPO region (e.g. in part of the Near East, North Africa and Central Asia) are possibly too dry for establishment. However, it is expected that in arid areas, irrigation may make conditions suitable for establishment, and in cold areas, netting might make orchards more suitable because of the rise of temperatures.

C. mali has remained mostly associated with damage in areas of Western States that are dry, at least in summer (in parts of Oregon – N. Wiman, pers. comm., British Columbia, California). No information was available regarding its presence in wetter coastal areas (in Oregon, this is under investigation; N. Wiman, pers. comm.). Barr (1971) mentioned its presence in south-eastern British Columbia and eastern Washington, i.e. not coastal areas). There is an uncertainty on whether *C. mali* could establish in more mesic locations like the eastern US or EPPO countries with wet summers. In particular, there are no confirmed establishments of *C. mali* in southeastern USA (warm and humid) despite regular trade of nursery stock and wood from infested regions.

In conclusion, *C. femorata* and C. *mali* are present in a wide range of climatic conditions in North America. The EWG assessed that the climatic conditions are suitable for establishment in the major part of the EPPO region for both species, but there is more uncertainty for *C. mali* on the area that would be suitable for its establishment.

9.2 Host plants

Note: All elements considered relevant to the PRA are presented in this section. However, readers wishing a rapid overview can focus on the bold highlighted text.

The EWG assessed that the availability of host plants will not limit the establishment of *C. femorata* and *C. mali* in any area of the EPPO region.

***C. femorata* and *C. mali* have a wide host range amongst deciduous woody plants. Establishment may be facilitated by the conditions in which trees and shrubs are grown, such as: dense presence of hosts; conditions favouring attacks (e.g. areas of extensive new plantings, areas where trees are especially stressed); private gardens and amenity land and forests may be more favourable because of less management; urban trees are also often stressed and not closely managed, and some species (e.g. maple) are susceptible to high attack rates in these environments.**

***C. femorata* and *C. mali* have attacked many species exotic to North America, and would probably be able to find new hosts in the EPPO region. The host list in ANNEX 4 provides basic information on hosts. General aspects on the hosts in the EPPO region are provided below. Details on the presence of main hosts in the EPPO regions are provided in ANNEX 5 for the main hosts.**

Many host species are native to North America and are mostly used as ornamentals in the EPPO region. This includes *Acer rubrum* (especially attacked by *C. femorata* in Southeastern USA nurseries and urban landscapes). Some North American host species are naturalized in the PRA area. Some have been planted for forestry or ornamental purposes and are now also widely present in the EPPO region in the wild. *Acer negundo* (introduced as ornamental), *Prunus serotina* (planted as ornamental, timber production and for soil amelioration – CABI, 2021) for example are associated with oak-hornbeam forests in Europe (European Atlas of Forest Species, 2018).

Some hosts are present throughout the region (e.g. apple, *Acer*, *Populus*, *Betula*), while others have a more restricted distribution that excludes the northernmost and easternmost areas (e.g. *Castanea, Corylus, Juglans,* some *Prunus, Pyrus*).

The host range of both pest species comprises many species of importance in the PRA area in various conditions. The different uses are given for each species in ANNEX 2.

- For fruit or nut production (commercially or in gardens, and sometimes also present in the wild). In particular, the host range of *C. mali* probably covers most major fruit trees and bushes planted in the EPPO region (except *Citrus* and *Vitis*).
- In forests for wood production, including commercial plantations (natural or planted), including genera such as *Betula*, *Populus*.
- In the wild, native and naturalized hosts of both *C. femorata* and *C. mali* are components of various ecosystems, including forests, mountains etc. Many host species (or related species in the same genera) are endemic to the PRA area and grow in the wild, and may cover extensive areas (see ANNEX 5). The abundance of wild hosts would favour establishment, as the pest may not be detected before it is well established. Some of the confirmed hosts or related species in the same genera grow in the wild (e.g. *Acer*, *Aesculu*s, *Amelanchier, Betula*, *Carpinus*, *Castanea*, *Celtis*, *Cornus*, *Corylus*, *Crataegus*, *Juglans*, *Malus*, *Ostrya, Populus*, *Sorbus,* etc.). Central Asia, being the centre of origin and of diversity for many fruit and nut trees, has wild populations of walnut, apple and apricot (EPPO, 2020b).
- As ornamentals (private and public gardens, landscaping, cities). Urban trees can be found in urban forests and woodlands, public spaces, gardens, along waterways and as street trees. A wide range of ornamental tree species are planted in these settings, including many non-indigenous tree species (even more in botanical gardens). Urban trees are sometimes considered as being at the frontline of invasions because they are close to points of entry, such as harbours, airports or companies receiving commodities. Among host genera, the following are mentioned as suitable or planted as urban trees in cities across the EPPO region (considering only a few cities: Bologna, Moscow, 5 Nordic cities, Central Asian cities): *Acer*, *Aesculus*, *Betula, Carpinus*, *Cercis*, *Crataegus*, *Diospyros*, *Fraxinus*, *Juglans*, *Malus*, *Platanus*, *Populus*, *Prunus*, *Quercus*, *Salix, Sorbus*, *Tilia*, *Ulmus* (EPPO, 2020b).

Even in areas dominated by conifers in the EPPO region, deciduous bushes or trees may be present and used as hosts. In the boreal part of Europe and in northern Russia, *Betula pubescens* is widely present and associated with pine or spruce (Beck *et al.*, 2016; Pividori *et al.*, 2016). In Far-East Russia, 75% of the total forest area is occupied by conifers, but the main non-coniferous trees (12 species in the genera *Acer*, *Alnus*, *Betula*, *Fraxinus*, *Populus*, *Quercus*, *Salix*, *Tilia* and *Ulmus*) cover ca. 28,000 million ha; an analysis of the vegetation zones of

Far-East Russia names ca. 40 non-coniferous trees, 30 bushes and 10 vines (EPPO, 2020b citing Krestov, 2013).

9.3 Biological considerations
For the potential establishment of a population, there should be simultaneous entry of individuals of both sexes (or a single mated female). Adults live for about 3-5 weeks, and may need to feed, find a mate and a host for maturation feeding and oviposition. If mating occurs during transport, mated females may escape the consignment at destination, find a host and lay eggs. Females may lay 60-100 eggs.

C. femorata and *C. mali* probably share some host genera with some native *Chrysobothris* spp. in the EPPO region (given the high number of endemic *Chrysobothris* species). There is no information indicating that establishment could be prevented by competition from existing *Chrysobothris* species in the PRA area. In the USA, several species can also be found developing in the same tree. Finally, it was considered unlikely that natural enemies would prevent establishment.

9.4 Conclusion on establishment
The EWG rated the likelihood of establishment outdoors as high for both species (not very high because the pests are not known to have established in other areas to date). However, there is a moderate uncertainty for *C. mali* (related to the area that would be suitable for establishment).

C. femorata

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

C. mali

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

10. Likelihood of establishment in protected conditions in the PRA area
C. femorata and *C. mali* are pests of woody plants, which are not normally grown under protected conditions in the PRA area. Both species can complete their life cycle on young plants, including nursery plants. Nursery plants are small and managed, and damage may be detected early and the pest eliminated before adults emerge. *C. femorata* and *C. mali* are not likely to maintain indoor populations in the long term if the facility is managed and control measures are taken. If introduced in an area where they cannot establish outdoors, they could be eradicated from the protected conditions.

The EWG chose to not rate this question, as it is not considered relevant for these pests (not known as pests in protected conditions).

11. Spread in the PRA area
Natural spread. No specific data were found on the flight capacity of *C. femorata* and *C. mali*, and current observations relate to flight at short distances (up to 110 m observed) (see section 2.4). The EWG did not exclude that *C. femorata* and *C. mali* may be able to fly over long distances (more than 1 km), as known for other Buprestidae. As with other Buprestidae, it is expected that when host trees are abundant, the spread is minimal (see Section 2.4). Both *C. femorata* and *C. mali* are polyphagous, which would favour finding hosts in the vicinity of the tree or shrub from which they emerged. Many known hosts are native and widespread in the EPPO region. Spread would also be facilitated by attacks on woody plants currently not known as hosts, and such attacks are considered likely.

Trees planted along roads, in cities or elsewhere may be in a condition favouring attacks (e.g. due to water and heat stress, salt in winter, reduced growth, etc.) and may constitute biological corridors for the spread of the pest in the EPPO region. Large areas of new plantings may also favour the rapid build-up of populations and further spread. Unlike monophagous species like *A. planipennis*, polyphagous species like *C. femorata* and *C. mali* will have more potential corridors for spread.

Human-assisted spread. C. femorata and *C. mali* could also spread over longer distances via transportation of plants for planting, wood, wood products, and wood packaging material (if not treated according to ISPM 15). There is a large trade of deciduous woody plants for planting and wood within the EPPO region. Within the EU, an EU plant passport is required for all plants for planting (excluding seeds) according to EU regulation 2016/2031, implying inspection of the place of production. However, infestation by young larvae may not be detected for several months until significant symptoms appear (damage is more apparent in winter, and most apparent the following spring. Spring is the optimal time to survey for larval damage).

Transport of the pest as contaminant on vehicles or non-host commodities may also play a role locally, particularly if trees in car parks are attacked, although no specific record was found in North America.

There are many buprestids in the EPPO region, which might affect how early the pest is detected. In addition, regional droughts or other environmental conditions could affect vegetation appearance and mask damage symptoms, leading to delayed detection.

C. femorata

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

C. mali

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

Summary of uncertainties (for both species): data lacking about natural spread; how rapidly it will spread with trade; *C. femorata* and *C. mali* are more polyphagous, i.e. higher uncertainty for movement in trade; whether other pathways would contribute to spread (e.g. firewood between countries); host preferences which may alter spread rates, as well as favour population development.

12. Impact in the current area of distribution

Nature of the damage: See details in section 2.5.

Impact in Canada. No mention was found of environmental and social impact, and very little on economic impact, only for *C. mali*. Historically *C. mali* was considered one of the worst enemies of newly planted trees and shrubs in the Pacific coast states and in British Columbia (Capizzi *et al.*, 1982). It was recently reported as a pest of apple (attacking apple saplings) in one area of British Columbia with unique climatic conditions for Western Canada (low rainfall) (Acheampong *et al.*, 2017), and this was only the second record as a pest in that province (Acheampong *et al.*, 2017). Most of Canada probably has suboptimal climatic conditions for both species.

Impact in the USA. Historically, *C. femorata* and *C. mali* were considered as serious pests of fruit and shade trees, *C. mali* being, according to Burke (1919), "far more common and injurious in the Pacific states than *femorata*". Amongst *Chrysobothris*, *C. femorata* and *C. mali* have been the two species causing greatest damage in nursery, nut and fruit production systems (Addesso, 2019).The impact by *C. femorata* and *C. mali* in the USA is economic. Changes in cropping practices and climate change may be the cause of the recent re-emergence of flatheaded borers (referring to *C. mali* and *C. femorata*) as pests (Rijal & Seybold, 2019a). For both species, damage has been reported mostly from more southern areas (e.g. California for *C. mali* and Southeastern states for *C. femorata*), and also in some conditions in northern areas (e.g. *C. mali* on hazelnut in Oregon – N. Wiman, pers. comm.). Recent significant damage by *C. mali* has been reported mostly in areas with dry summers (see section 9.1), and damage by *C. femorata* is higher in warm and humid climates. In other areas, although the pests are present in the environment, attacks to nurseries or fruit orchards may generally not reach economic levels, but the pest may emerge when suitable conditions occur (e.g. extensive planting of trees at a sensitive stage - see examples of hazelnut, pecan and sugar maple (*Acer saccharinum)* below - or plantings of trees that are not suited to a particular area such as the wrong plant hardiness zone). For endemic widespread species like *C. femorata* and *C. mali*, damage may be less reported than in the case of invasive species such as *A. planipennis*. In addition, damage on trees in the environment, such as landscape trees, may not be reported to the same extent as in commercial production (nursery and fruit). Finally, damage in nurseries may be under-reported. It was noted that significant damage by *C. mali* is reported in dry areas, which may be linked to the fact that plants are stressed in such conditions.

C. femorata

Currently, *C. femorata* has impact especially on commercial nurseries and landscapes trees (including urban trees), due to mortality of young newly transplanted or weakened trees, or loss of value/unmarketability of trees attacked (Hansen *et al.*, n.d.; Oliver *et al.*, 2019a, 2019b, 2010; Vanek *et al.*, 2012). *C. femorata* can cause rapid decline of economically important hosts (Hansen *et al.*, n.d.). It attacks vulnerable nursery tree species (e.g. *Acer*) during the entire production cycle (~5 years) with about 5% loss during each year of production (Oliver *et al.,* 2019b). A single larva can girdle a young tree within one season (Hansen *et al.*, n.d.).

Damage by *C. femorata* is more often reported from southeastern USA, and few publications mention damage in other areas.

- Significant losses have been observed in Tennessee and North Carolina when growers purchased red maple tree liners (diameter ca. 2.5 to 3.75 cm) from west coast suppliers, which were subsequently transplanted without irrigation and often root pruned to facilitate mechanical transplanting (Oliver pers. comm.). *C. femorata* has also caused damage on nursery-grown and landscape trees in Oklahoma, Georgia, Kentucky, Tennessee, numerous western states (Burke, 1919; Fenton, 1942; Potter *et al.*, 1988, Oliver *et al.*, 2010), and Alabama (J. Oliver, pers. comm.).
- In Missouri, *C. femorata* is recorded as being especially common in nurseries and urban landscapes, attacking young trees suffering from various stress factors (MacRae, 1991).
- In Oklahoma, *C. femorata* causes substantial damage to ornamental plantings, nursery stock and a wide variety of fruit and shade trees, killing many recently transplanted shade, pecan and fruit trees. It sometimes attacks and kills large, well-established trees if under drought or other stress (Rebek, n.d.).
- In Tennessee, *C. femorata* damage levels vary among different nurseries, which may relate to issues like proximity to forest sources, vulnerability of trees, species planted, borer populations from previous infestations, and management efforts (J. Oliver pers. comm.). Research field surveys regularly find maples, dogwood (*Cornus*), crabapple (*Malus*), redbud (*Cercis*), and some cherry (*Prunus*) with flatheaded borer issues, while growers also indicated flatheaded borer issues with hornbeams (*Carpinus*). It is noted that the pest is currently under control in nurseries (relying on wide use of imidacloprid soil drenches), and that serious damage is avoided for most hosts (Oliver *et al.*, 2019b).
- In Georgia, *C. femorata* has been a sporadic and minor pest in pecan, ornamental and tree fruit systems (Acebes-Doria *et al.,* 2019).
- In the North Central USA, substantial mortality of *Acer saccharinum* was observed during trials on intensively managed hardwood forest systems (grown using conventional agricultural as well as forestry methods, as an alternative to natural forest production) (Coyle *et al.*, 2005, see below).
- Even where there is no significant damage reported by nursery growers (such as Ohio or Minnesota), trees have been found damaged in other settings (e.g. landscape trees) (J. Oliver, pers. comm.).

It is not known if extension publications cited above refer to the whole *femorata* complex. Some very recent publications differentiate between *C. femorata s.s.* and other species (e.g. Ashman & Liburd, 2019, Oliver *et al.*, 2019a). There is not a complete overview of which other species of the *femorata* complex may damage nursery stock. To date, three species in the *femorata* complex (other than *C. femorata – i.e. C. rugosiceps, C. viridis, C. adelpha*) have been found associated to nursery trees in a research collection in Tennessee, though less frequently than *C. femorata* (J. Oliver, pers. comm.). Other *Chrysobothris* species (*C. azurea, C. chlorocephala,* and *C. sexsignata*) have also been reared from Tennessee nursery stock (J. Oliver, pers. comm.).

Most damage quantified in the literature relates to young *Acer* trees (Hansen, 2010), but literature on quantitative impacts are generally quite scarce. It is possible that other hosts are damaged to a similar extent, but that information on the damage is either not available or could not be located in the time available for this PRA.

- *Acer* have been particularly susceptible in Kentucky and Tennessee, especially *A. rubrum*, which is a popular ornamental tree widely grown by the US nursery industry (Potter *et al.*, 1988; Seagraves *et al.*, 2013; Oliver *et al.*, 2010). In insecticide tests performed in Tennessee nurseries during 2005, non-insecticide-treated *A. rubrum* (control treatment) had levels of damage by *C. femorata* in 2005 that ranged from 2.3-41%. Untreated plants or plants receiving ineffective treatments continued to sustain damage every year. *Acer* crops in middle Tennessee nurseries commonly sustain 25-40% losses by the 3rd to 4th production year (Oliver *et al.*, 2010). During a period of intermittent drought from 1979 to 1983, nurseries in Kentucky and neighbouring states suffered severe economic losses due to infestation of young maple trees, particularly *A. rubrum*, with infestation rates reaching 30% or more in nurseries, accompanied by tree mortality or unmarketable trees. *A. rubrum* recently transplanted to urban landscapes also suffered damage (Potter *et al.*, 1988).
- In intensively managed hardwood forest systems using *A. saccharinum* in the north-central United States, *C. femorata* caused over 40% mortality of first-year trees (Coyle *et al.*, 2005, citing others).
- *Acer* species and cultivars have been shown to differ in susceptibility to *C. femorata* attack (Seagraves *et al.*, 2013).

Few data were found on impact on fruit hosts.
- Pest in apple orchards (Ames, 2018; Eaton, 2011; Fenton, 1942). *C. femorata* occasionally becomes a problem on trees of pre-bearing age and in organic orchards, and management is needed in higher-risk orchards. In conventional orchards, insecticides applied against other pests control *C. femorata*, except in trees of pre-bearing age because they are usually sprayed less frequently (Eaton, 2011). In North Carolina, *C. femorata* is of relatively minor importance in commercial apple orchards because broad-spectrum insecticides are applied (IPM info, 2004).
- Recorded as a pest of pecan, *Carya illinoiensis* (Thompson & Conner, 2012), with more damage on nursery trees, newly set trees or old weakened trees, especially on the sunny side (Mulder *et al.*, n.d.) (Oklahoma).
- Potential new pest of Southern highbush blueberries (*Vaccinium darrowii*) in Florida (Ashman & Liburd, 2019) (*C.* femorata *s.s.*). About 8% of the bushes sampled had injury that appeared to be associated with *Chrysobothris* species or wood boring beetles. *C. femorata* (*s.s.)* and *C. crysoela* were found in branches, and several other *Chrysobothris* species were also associated with the plants (trapped), including, for the *femorata* complex, *C. viridiceps* and *C. shawnee*.

C. mali

Historically, *C. mali* was considered one of the worst enemies of newly planted trees and shrubs in the continental Pacific coast states to British Columbia (Capizzi *et al.*, 1982), and has long been recognized as a problematic pest for new orchards, shade trees and certain forest species (Wiman *et al.*, 2019). In the 1920s, *C. mali* was known to attack nursery trees, orchards, newly planted street trees, as well as trees in parks and cemeteries. In some localities of California, attacks in orchards were common (for example on apple, currant, prune, plum, sweet and sour cherry, peach, apricot). Losses could range from a few trees per orchard to 95%. Damage was apparently greater in mountains, probably because of the proximity of many native hosts (Burke, 1929). Such damage is particularly detrimental to fruit growers since it potentially involves the death of young trees during their first three years, while trees have not yet produced fruits.

Wiman et al. (2019) note that there has been little recent research in orchards, while at the end of the 1960s, it was a major pest for some orchards in California's Central Valley. Rijal (2019 citing Davis *et al.*, 1968) mentions that *C. mali* has been reported as an occasional pest in orchards (walnuts, almonds, cherries, and plums) on trees with compromised health. Currently, it is still considered a pest problem in US Pacific Northwest nurseries (N. Wiman, pers. comm.).
A number of publications from the end of the 1990s by the IPM Centers for various fruit trees mention *C. mali*. In California on apple, *C. mali* was an occasional pest and a serious problem in newly planted orchards; it was not uncommon for 25% of trees in a young orchard to be killed unless preventive measures were taken (IPM Centers Crop Profile, 1999). Similar issues are reported on pear in Oregon (1999) (https://ipmdata.ipmcenters.org/source_report.cfm?sectionid=40&sourceid=244), prune and almond in California (https://ipmdata.ipmcenters.org/source_report.cfm?view=yes&sourceid=5).

Recent mentions of damage relate to nurseries and fruit crops:
- *C. mali* can be an issue in shade tree production blocks, particularly grafted species, and where stress occurs. Growers typically burn infested trees (Rosetta, 2019 citing others).
- In 2018-2019, *C. mali* has become a widespread issue in English walnut (*Juglans regia*) of Central California, from young to mature and healthy trees (flagged branches, dead twigs, 'canker-like' symptoms

on tree trunks). Windbreak following attacks is also mentioned (Rijal & Seybold, 2019a). High incidence was observed in 2019. Two orchards (1- and 2- year old) had over 90% trees infested (trunk). In a 3rd orchard (6-year-old), the pest attacked various parts of the tree (twigs, branches, limbs, and trunk). Infestations were found in young (1-5 years) to mature (6-20 years) orchards, irrespective of the variety. Damage on apparently healthy trees was found, and the pest was not limited to wounded and sunburn-damaged branches. The damage was random within orchards and within trees (Rijal, 2019). The new infestation "appeared to be much more severe and widespread with reports throughout the walnut growing regions of California". The damage observed did not occur in other places or on other tree species (Rijal & Seybold, 2019b).

- In Oregon, *C. mali* has caused serious problems for establishment of hazelnut orchards in recent years with up to 35% loss in some orchards (Oregon produces 99% of US hazelnuts), and it also attacks apples and cherries (Wiman *et al.*, 2019). In hazelnut, the main economic issue is the loss of young hazelnut trees in new plantings due to girdling of the main stem/trunk. Attacks by *C. mali* also occur in branches throughout the canopy in diseased orchards, especially in hazelnuts attacked by the fungus *Anisogramma anomala.* However, the disease is the main issue in these orchards, and attacks by *C. mali* are not considered an economic issue (N. Wiman, pers. comm.). Recent dry, hot summers, suboptimal planting sites, rapid rise in new acreage, and poor management are mentioned as possible factors favouring the recent increased attacks in hazelnut crops (Keyes *et al.,* 2020; Mugica *et al.,* 2020).
- Some damage to blueberry (*V. corymbosum* hybrids) has been reported from California (serious damage in some years in the Central valley) and to a lesser extent Oregon (Cahill, 2020). In the San Joaquin valley (California) damage to blueberries is occasional (Haviland, n.d.). In the Pacific Northwest pest management handbooks (https://pnwhandbooks.org/), *C. mali* is dealt with in relation to apple, plum and cherries. In California, UC IPM (2020) provide guidance in relation to apple, apricot, blueberry, cherry, prune, plum and peach. Almonds are also attacked (stressed trees) (Strand & Ohlendorf, 2002).

Environmental and social impact of *C. femorata* and *C. mali*

No reports of environmental or social impacts were found. In Michigan, the *femorata* complex is part of the forest environment, especially associated with oaks (Redilla & McCullough, 2017), but trap captures were used in the study and did not confirm oak as the origin of the beetles (Redilla & McCullough, 2017). Burke (1929) mentions that in native forests attacked by *C. mali,* generally only part of the tree is killed (bark on one side of the trunk, or entire branch) and that the entire trunk is rarely killed. At that time, in Oregon and California, damage in forests was greatest on alder, hazel, and mountain mahogany. Van Driesche et al. (2012) include *C. femorata* (but not *C. mali*) in a compilation on forest pests with similar damage as in other contexts, i.e. especially to newly planted or stressed trees; young trees may be girdled and killed; larger trees may show injuries through loss of large patches of bark on trunks.

Existing control measures against *C. femorata* and *C. mali*

Management is complicated by the wide host range (Hansen, 2010) and the fact that infestations are usually not apparent until the larvae are large enough to produce visible injury on the trunk surface or branch dieback occurs (see section 2.7). Management measures seem to be applied mostly to newly planted trees and young trees. The methods described in the literature apply to both pests, although chemical control is apparently more commonly applied against *C. femorata* in ornamental nurseries, probably linked to the availability of labelled insecticides that are more limited for fruit or nut bearing crops commonly attacked by *C. mali*. Although recommendations appear to differ slightly for nurseries, landscape trees, orchards and gardens, they are based on the same methods. It is worth stressing that extensive research is continuing in the USA to develop control methods, and provide alternatives to insecticides (e.g. Addesso *et al.,* 2018; Dawadi *et al.,* 2019; Oliver *et al.,* 2019a). The current section focuses on control options that are still recommended in recent literature.

Chemical control

- *Soil drenches targeting larvae in the trees*. Systemic imidacloprid-based soil drenches are currently the most effective control method available (Addesso *et al.,* 2019 citing Oliver *et al.,* 2014). Systemic neonicotinoid drenches are the main control method used in nurseries where *C. femorata* damage is prevalent (Oliver *et al.,* 2019b), providing 2-4 years (imidacloprid) or 1 year (dinotefuran, clothianidin) of protection in trials with young *Acer* trees (Oliver et al. 2010). For landscape trees, Baker (2019) notes that imidacloprid soil drenches can be combined with insecticide sprays on trunks and larger branches. A recent study (Addesso *et al.,* 2020) deals with optimizing imidacloprid soil drenches and how presence or absence of weeds affects treatment effectiveness.

- *Trunk sprays*. Chlorpyrifos, bifenthrin and permethrin trunk sprays are commonly used (Addesso *et al.*, 2018 citing Oliver *et al.*, 2014). Krischik & Davidson (2013) also mentions imidacloprid, and Beddes & Caron (2014) carbaryl. Clothianadin is authorized against *C. mali* on hazelnut, and lambda-cyalothrin is also used (N. Wiman, pers. comm.). Prophylactic calendar sprays with broad-spectrum insecticides have been used (Oliver *et al.*, 2010; Potter *et al.*, 1988). Such sprays at appropriate intervals are still part of control recommendations especially for young trees (Baker, 2019; Krischik & Davidson, 2013; Rebek, n.d.). LeBude (2019) noted that sprays on trunks are required multiple times per year, and that missed or poorly timed applications increase the likelihood of attack during the 24 to 60 month production cycle of shade trees in eastern USA.

The life stage targeted by trunk sprays is not clear (i.e. targeting adults, or eggs before or when they have been laid, larvae when they hatch, or all these stages) (Oliver *et al.*, 2019a). In addition, monitoring to time insecticide sprays is difficult. Monitoring for damage is not appropriate, because when damage is sufficient to be detected, the value of the tree is usually already compromised (Oliver *et al.*, 2019a). Similarly monitoring for the presence of adults gives only partial information as the trees may not be susceptible to attacks (Oliver *et al.*, 2019a).

It is not clear if the methods recommended in the literature for timing insecticide applications are used in practice. One such method is monitoring for injury in late winter and flagging trees for monitoring for adult emergence in the spring to time applications (through regular monitoring for D-shaped holes after removing frass, or cutting infested sections from several infested trees and holding them in a cage outside) (Frank *et al.*, 2013). The use of purple panel traps covered with sticky material is also mentioned, but these traps catch other buprestids too, and species should be identified (Frank *et al.*, 2013).

Alternative insecticide strategies (e.g., anthranilic diamides like chlorantriniliprole or cyclaniliprole) are being investigated in the USA to avoid heavy reliance on a single active ingredient like imidacloprid and reduce the potential for insecticide resistance development. Insecticide research also is focused on other *Chrysobothris* species including complex members involved in tree attacks (Oliver *et al.*, 2019a).

Cultural control methods

Various control methods aim at maintaining tree health and controlling existing *C. femorata* populations. In walnut orchards in California, cultural methods are critical as there are no insecticide registered against *C. mali* (Rijal & Seybold, 2019a).

- *Proper planting practices*:

- Choosing appropriate planting site (including soil) (Beddes & Caron, 2014; Oliver *et al.*, 2019b), and species and cultivars that are well-suited to the growing site (Beddes & Caron, 2014).
- Planting non-infested material (Capizzi *et al.*, 1982).
- For *Acer*, using less-susceptible species and cultivars (Seagraves *et al.*, 2013).
- Avoiding planting too deep (Krischik & Davidson, 2013; Beddes & Caron, 2014; Oliver *et al.*, 2019b).
- Planting trees with the graft union facing north decreases the probability of infestation by as much as 40% (LeBude, 2019). However, nursery growers considered this impractical because many trees (2000-3000) are planted at the same time, at a rapid rate, and are often covered with soil from holding barns making location of the graft union challenging (if the tree has a graft union as opposed to cuttings) (Oliver, 2019b).

– *Proper plant management*

- Adequate water, mulch, and fertilization (Baker, 2019; Hansen *et al.*, n. d.; Rebek, n.d., Ames, 2018; MSU, n.d.; Krischik & Davidson, 2013; Beddes & Caron, 2014).
- The use of cover crops sown within the tree rows in nurseries was recently found to be a viable alternative to insecticides (possibly by changing the microclimate at preferred oviposition sites, or acting as trunk camouflage or interfering with adult access to oviposition sites) (Addesso *et al.*, 2019; Dawadi *et al.*, 2019). Poor weed control in nurseries has a similar effect (Addesso *et al.*, 2020). Neither cover crops nor weedy nursery fields are presently used in commercial nurseries deliberately for *C. femorata* control (the presence of weeds affects tree growth), but rather cover crops are used in row middles for other purposes, like erosion prevention or nutrient addition, or weeds are allowed to grow due to poor herbicide management (J. Oliver pers. comm.).
- For walnut orchards, removal of weakened, injured, dead, and flagged branches (Rijal & Seybold, 2019a).

- *Preventing emergence of adults from infested material*

- Inspection of host tree trunks for borers once or twice during the growing season (Ames, 2018 for apple).
- Removal and destruction of infested, dead and dying material, and pruned branches (Rebek, n.d.; Solomon & Payne, 1986; Capizzi *et al.*, 1982; Solomon, 1995; Beddes & Caron, 2014).
- Not piling firewood near susceptible host productions (e.g. apple orchard) as adults may emerge in the summer after it was cut down (Eaton, 2011).

Physical control methods

- Proper support so that trees grow straight (Eaton, 2011) (see section 2.6).
- Avoiding injuries e.g. by equipment, wind breakage, frost, fire, sunscald, drought, winter injury (Solomon & Payne, 1986; Capizzi *et al.*, 1982). Fresh wounds can be painted with pruning compound (Solomon & Payne, 1986).
- To prevent winter sunscald (occurs in late winter when sun-exposed bark is heated during the day and frozen at night), the trunks of susceptible trees can be wrapped with white tree wrap in late fall, from the base of the tree to the lowest limbs (remove the wrap in early spring) (Beddes & Caron, 2014). Trunks may be painted with a mixture of white latex paint and water (Beddes & Caron, 2014, Solomon, 1995).
- Protecting young trees from sunburn (Rijal & Seybold, 2019a). Shading the trunks of young trees by pruning to head the trees low or by wide stakes, flat board or post (Brooks, 1919; Capizzi *et al.*, 1982).
- Wrapping trunks is also recommended by some authors to create a barrier to oviposition. Various materials are recommended such as newspapers, wrapping paper, burlap, crepe paper (Capizzi *et al.*, 1982; Solomon & Payne, 1986, Rebek, no date); for apple trees, window screen from the ground to about 18” high (Ames, 2018 for apple). Tree wraps are mentioned as a possible method on landscape trees (Baker, 2019). In a nursery growers’ meeting in Tennessee tree wraps were considered impractical (time and cost) given the high number of trees produced in nurseries (Oliver *et al.*, 2019b). Evaluation of various commercial tree wrapping devices including Tree Pro Tree Protector, Tree Wrap Crinkled Paper, Vendura® Biodegradable Tree Spiral, and Tubex TreeShelter®, also did not prevent Chrysobothris attacks (which apparently crawled under the wrap), and the high moisture beneath the wrapping material increased nectria trunk canker damage (Fare *et al.*, 2018).

Biological control

Predators and parasitoids can reduce borer populations under natural conditions but their role in ornamental nurseries and landscapes is unknown (Frank *et al.*, 2013). However, many of the parasitic wasps that are reared from flatheaded borer infested materials in the spring emerge after the borer damage has become extensive and the tree quality is ruined (Oliver, pers. comm.). There are no commercial biological control agents available for *C. femorata* or *C. mali*. Species mentioned in the literature as attacking *C. femorata* or *C. mali* are listed in ANNEX 9.

For *C. femorata*, the magnitude of impact was rated as moderate. *C. femorata* has only caused significant damage in some regions, only in some environments and conditions, and only on some tree species. The impact has mostly been associated with plant stress. In addition, where measures are applied in nurseries (relying on imidacloprid soil drenches), they are effective in controlling the pest.

For *C. mali*, the magnitude of impact was also rated as moderate. There are limited treatment options available for fruit and nut crops. Severe damage has been reported on fruit and nut crops, but only in some areas. Impact has also mostly been associated with plant stress.

C. femorata

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

Summary of uncertainties: whether the damage reported is due to *C. femorata s.s.*; damage relevance in northern areas (although impact in such areas is probably limited); whether nurseries report damage; current impact in other environments.

C. mali

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

Summary of uncertainties: current impact in hazelnut and walnut (is it limited to very specific situations) and on other fruit crops; current impact in other environments.

13. Potential impact in the PRA area

Will impacts be largely the same as in the current area of distribution?
C. femorata : Yes/No
C. mali: Yes/No

Similarities between the potential impact in the EPPO region and the situation in North America

- The pests are expected to cause the same type of damage, i.e. mortality or damage to trees in nurseries, nut and fruit orchards and landscapes.
- Both species will find many hosts in the EPPO region. In North America, many known hosts are native to the EPPO region and can be affected (including forest and ornamental species, as well as fruit and nut species). Both pests have emerged as new pests on various host plants in North America, for example hazelnut and walnut for *C. mali*, or blueberry for *C. femorata*.
- Some areas are likely to be more conducive to damage than others.
  C. femorata damage is reported mostly in nurseries and landscape trees in the southeastern USA (warm and humid climate), where conditions are similar to those in parts of Northern Italy, as well as those in the Balkans, and the Black Sea coast. There are also occasional reports of damage in north-central USA. Historically, *C. femorata* was also recorded as damaging in Mediterranean- and temperate-type climates (California to British Columbia). It may be that conditions are less suitable for damage in the rest of *C. femorata* distribution (but this could also be due to other factors such as host plants, management, etc.). It is not clear if *C. femorata* is able to cause damage in colder areas.
  C. mali damage is now reported from Oregon to California, and in British Columbia, where conditions are closer to Mediterranean and temperate oceanic areas of the EPPO region. However, more damage is reported from areas with dry climate or dry summers. Historically, there were many records of damage in California (but it may also have been due to the wide presence of commercial fruit orchards there, and not to the climate).
- Both species would likely affect primarily newly planted trees and weakened/stressed trees, especially in the landscape, nurseries, orchards and forest plantations. Young trees in the EPPO region can be subject to similar levels of stress as in North America, especially during the post-transplant establishment phase. Amenity trees are largely unmanaged. Trees in urban environments are often stressed by greater incidence of impervious surfaces, heat stress, soil compaction, reduced water access, ozone and other pollutant emissions, etc., and therefore would be at greater risk of attack. New plantings undergoing post-transplant shock/stress would always be at risk as the establishment period is a sensitive stage for young trees. Fewer pesticides are used in organic orchards, private gardens and amenity land. Abandoned orchards are also not managed. *C. mali* may pose a greater risk for older trees, based on current issues with branch attacks in larger walnut trees in California (Rijal & Seybold, 2019).
- The absence of specific monitoring would complicate control, but purple panel sticky traps placed in open areas near the forest or nursery/ orchard have been effective at capturing flatheaded borers in the genus *Chrysobothris* (see section 2.7).
- The presence of other *Chrysobothris* species would complicate detection, identification, and control.
- The concentration of hosts, reduction of pesticide use and climate change or related weather anomalies (drought, flooding) may influence the pest situation. These may be factors that have influenced the current situation of *C. mali* and *C. femorata* in the USA (e.g. hazelnut plantings in Oregon for *C. mali*; *Acer* in nurseries in southeastern USA for *C. femorata;* walnut orchards in *California*). Young organic fruit orchards may experience greater attack rates (i.e. young trees, no chemical treatments). For both pests, substantial damage may occur in areas of high concentration of suitable hosts, once the pest has built up populations. For example, mortality of 40% was noted in trials of intensively managed hardwood forest systems using *A. saccharinum* (Section 12). Susceptible crops are often concentrated in certain areas (e.g. Emilia-Romagna represents more than 60% of the area under pear trees in Italy (EPPO, 2011b). There are also probably areas with intensive plantings of young deciduous trees for reforestation, environmental reasons or other.
- Once established in the EPPO region, the pest is likely to have a similar elongated emergence period, as it currently has in the USA, which would also complicate control.

Differences in favour of more damage in the EPPO region than in North America:

- There may be damaging outbreaks of *C. femorata* and *C. mali* in orchards, amenity trees or nurseries until appropriate control programmes are in place. Control measures may not be immediately available in the EPPO region (active ingredients not authorized or with restricted use). For example, in the EU, systemic neonicotinoids that are effective on *C. femorata* larvae as soil drenches (e.g., imidacloprid, dinotefuran, clothianidin, thiamethoxam) are not authorised. Use of imidacloprid is only possible (in some countries) in permanent greenhouses (as well as treatment of seeds to be used in permanent greenhouses). Other potentially effective insecticides used in the USA are not authorised in the EU (such as chlorpyrifos, bifenthrin and permethrin applied as trunk sprays in the USA). The EWG noted that pre-authorisation of trunk injections may be under consideration in the EU to prepare for the possible arrival of *Agrilus planipennis*. Some new insecticides like the anthranilic diamides under evaluation in the USA may already be authorised for some uses in EPPO countries. For example chlorantriniprole and cyantraniliprole (but not cyclaniliprole) are authorised in the EU for use in certain vegetable crops.

- Many fruit trees are produced under integrated production management systems in the EPPO region, which may need to be adapted to the presence of *C. femorata*. Management programmes are applied in the EPPO region in nurseries against various pests (EPPO, 2011b), but they may not completely be effective against *C. femorata*. Interventions for *C. femorata* or *C. mali* also may disrupt current IPM programs and lead to new secondary pest outbreaks.

Differences in favour of less damage in the EPPO region than in North America:

- Some hosts mentioned as preferred by *C. femorata* are North American species and are only present to a limited extend in the EPPO region (e.g. *Acer rubrum* for *C. femorata*).
- Currently research is being conducted in the USA, especially in relation to nursery trees and nut orchards. The results will benefit the faster implementation of control measures in the EPPO region, should outbreaks be detected.

Finally, the export of plants or wood of *C. femorata* and *C. mali* hosts from EPPO countries where the pest is introduced may be affected by quarantine requirements or closure of export markets within and outside the EPPO region (the same restrictions would apply for export from North American countries where the pests are currently present).

Uncertain factors: whether and how they will affect impact

- It is not clear if *C. femorata* and *C. mali* would have natural enemies in the EPPO region that could limit their populations, in particular species that attack native *Chrysobothris*. The natural enemies mentioned in Annex 9 are not listed in Fauna Europaea. However, there may be generalist parasitoids.
- There may be a large number of tree and shrub species not yet known as hosts. There is a risk that the pests may be able to overcome the defences of woody plants with which they have not co-evolved and the potential impact of *C. femorata* and *C. mali* may be significantly higher if plant species or cultivars that are common within the EPPO-region are highly susceptible. In the US, there is evidence that some tree species or cultivars are more susceptible to *C. femorata* attack than others (Seagraves *et al.*, 2013).
- Some host species or species in the same genera play an important ecological role in the EPPO region, and attacks may lead to environmental impact. Such a situation is currently happening in China for the Buprestidae *Agrilus mali*, which has passed from *Malus domestica* to the wild *M. sieversii* forests in Xinjiang, causing extensive damage to native forests (EPPO RS, 2020). In addition, hosts that are ornamental plants in the USA (such as *Carpinus betulus*) are common trees in EPPO environments and forests, and this may have ecological implications if impacted by introduced *C. femorata* or *C. mali*.
- The species diversity within the *C. femorata* complex is still not entirely understood, which complicates risk assessment. Similarities among complex species could also complicate identification or recognition of new infestations. Since there also is evidence that some complex members may still be sharing genetic material via possible hybrids, there could also be a risk for intermating with existing closely-related *Chrysobothris* species in the EPPO region with unknown consequences.

For both species, the magnitude of impact was rated as moderate-high, i.e. higher than in North America. For both species, one main argument was that the treatments that are effective in the USA are not available in at least part of the EPPO region. For *C. mali*, the range of treatments that can be applied to fruit trees and bushes is limited. For *C. mali*, it was noted that many of the known hosts are fruit crops with a high economic importance in the EPPO region. However, the EWG decided that this did not warrant a higher rating than for *C. femorata*.

Uncertainties are similar for both species: host susceptibility, uncertainty on impact where it occurs, the role of uncertain factors identified above.

C. femorata			
Rating of the magnitude of impact in the PRA area			*Moderate-High* X
Rating of uncertainty	*Low* ☐	*Moderate* ☐	*High* X

C. mali			
Rating of the magnitude of impact in the PRA area			*Moderate-High* X
Rating of uncertainty	*Low* ☐	*Moderate* ☐	*High* X

14. Identification of the endangered area

Potential area of establishment

Numerous hosts of *C. femorata* and *C. mali* are available throughout the EPPO region, such as endemic and imported/naturalized forest, cultivated, ornamental, and urban trees. Climatic conditions are suitable for establishment in a large part of the EPPO region. Based on the known northern limits of these species in North America, areas that appear unsuitable for establishment are the coldest continental areas (north of a line from southern Scandinavia to Central Siberia). There is an uncertainty if the climatic conditions are suitable for establishment in the aridest areas in North Africa, Near East and Central Asia. For *C. mali*, there is a higher uncertainty about its potential distribution in EPPO countries, but in its North American distribution it may favour dryer areas (in particular areas with dry summers).

Endangered area

The endangered area for *C. femorata* and *C. mali* is assessed to include areas where the climate is similar to where the pests are known to have caused economic damage in their current areas of distribution. In addition, some human alterations to the environment (irrigation, increased temperatures by growing trees under screens during part of the year) may expand the potential endangered area.

For both species, the areas in the EPPO region conducive to impact would include at least the southern part of the region, from the Mediterranean Basin to Central Asia. Economic damage is also expected in part of the temperate areas from Europe to Central Asia. For *C. femorata* the highest impact is expected in areas that climatically corresponds to the southeastern USA (i.e. parts of Northern Italy as well as the Mediterranean and Black Sea Coast). The northern limit for both species is uncertain, but there may be occasional outbreaks in more northern areas when conditions are most appropriate (e.g. during warm dry summers).

15. Overall assessment of risk

Summary of ratings:

	C. femorata		***C. mali***	
	likelihood	**uncertainty**	**likelihood**	**uncertainty**
Entry (overall)				
Plants for planting (except seeds, tissue culture, pollen) of hosts in Category 1 (incl. 1A+1B)	Moderate	Moderate	Low	Moderate
Plants for planting (except seeds, tissue culture, pollen) of hosts in Category 2	Low	Moderate	Very low/Low	Moderate
Round wood with bark of hosts in Category 1 (incl. 1A+1B)*	High	Moderate	High	Moderate
Round wood with bark of hosts in Category 2*	Low	Moderate	Low	Moderate
Sawn wood with bark (>6 mm) of hosts in Category 1(incl. 1A & 1B)*	Moderate	Moderate	Moderate	Moderate
Sawn wood with bark (>6 mm) of hosts in Category 2*	Low	Moderate	Low	Moderate
Deciduous wood chips, hogwood, processing wood residues (except sawdust and shavings	Low-moderate	Moderate	Low-Moderate	Moderate
Cut branches of hosts	Low	Moderate	Low	Moderate
Furniture and other objects made of wood of host plants	Low	Moderate	Low	Moderate
Establishment outdoors	High	Low	High	Moderate

	C. femorata		*C. mali*	
	likelihood	**uncertainty**	**likelihood**	**uncertainty**
Establishment in protected conditions	Not rated	Not rated	Not rated	Not rated
Spread	Moderate	Moderate	Moderate	Moderate
Magnitude of impact in the current area of distribution	Moderate	Moderate	Moderate	Moderate
Magnitude of potential impact in the PRA area	Moderate-high	Moderate	Moderate-high	Moderate

* No specific rating was given for the pathways round wood and sawn wood without bark (see note in section 8.1.2).

The likelihood of entry for both pests was rated high and round wood with bark was the pathway with the highest rating. Entry on plants for planting and sawn wood with bark (>6 mm) were rated with a moderate likelihood, while other pathways presented a lower likelihood rating (see table above).

Confirmed hosts are widespread in the endangered area, and both species may pass onto new hosts. Suitable climatic conditions exist. There is a high likelihood of establishment outdoors for both species, with a moderate uncertainty for *C. mali* due to more uncertainty about environmental conditions needed for establishment. A wide endangered area was determined (see section 14 above), based on comparable regions in North America experiencing damage from *C. femorata* and *C. mali*.

The magnitude of spread was rated as moderate with a moderate uncertainty. The flight capability of adults is unknown. Spread over long distance would be mostly human-assisted, especially with wood and plants. Impact in North America was assessed as moderate, with large differences between areas. The potential impact in the EPPO region was assessed to be higher due to more limited availability of control options (insecticides), and was rated as moderate to high.

Stage 3. Pest risk management

16. Phytosanitary measures

16.1 Measures on individual pathways

The EWG recommended measures for *C. femorata sensu stricto* and *C. mali*. Measures were studied in detail for the pathways host plants for planting, round wood and sawn wood (>6 mm) of hosts, as well as for wood chips, hogwood and processing wood residues. ISPM 15 should be applied for wood packaging material. Cut branches are considered a potentially more important pathway than furniture (the likelihood of entry was rated low for both, but this rating also took into account that the trade volume of cut branches is currently assumed to be very low). The EWG suggested measures for cut branches in the table below based on measures for plants for planting. The EWG did not recommend measures on bark of hosts or furniture and other objects but, measures could be extrapolated from the measures discussed respectively for wood chips and for sawn wood, if countries determine a higher level of protection is warranted.

For plants for planting, round wood and sawn wood (>6mm), measures are recommended for at least host plants in Category 1A (*C. femorata*) and Category 1 (*C. mali*). It is noted that both *C. femorata* and *C. mali* are likely to have a wider host range than currently reported. Both species are polyphagous and known to attack more than one species within different genera, and the EWG recommended that risk managers consider applying measures at the genus level for some genera. For example, both pests have a number of hosts in the genera *Acer, Populus*, *Prunus*, *Malus, Ulmus*, and for *C. femorata* also *Betula* and *Carpinus*.

For host plants in Category 1B and 2 (*C. femorata*) and 2 (*C. mali*), it is recommended that plants for planting, round wood and sawn wood (>6mm) should be accompanied by a phytosanitary certificate, and if further measures are considered necessary, they can be based on the measures for Category 1. As evidence becomes available that plants are hosts, they can be added to the Category 1. For wood chips, hogwood and processing wood residues, considering the polyphagy of the pests, measures are recommended for deciduous wood chips independently of the host species involved.

Measures as proposed below would also cover most genera that are known hosts of other species in the *femorata* complex.

Possible pathways (in order of importance)	**Measures identified (see ANNEX 1 for details)**
Plants for planting of hosts in Category 1A (*C. femorata*) and Category 1 (*C. mali*) (except seeds, tissue cultures and pollen)	PFA (see requirements below) + Stored and transported in conditions preventing infestation, i.e. outside of the flight period of *C. femorata* and *C. mali*, or not in/through areas infested with the pests, or closed. or Pest-free production site established according to PM 5/8 Guidelines on the phytosanitary measure 'Plants grown under complete physical isolation' + Stored and transported in conditions preventing infestation (i.e. outside of the flight period of *C. femorata* and *C. mali*, or not in/through areas infested with the pests, or closed). Or Systems approach (in the framework of a bilateral agreement) combining treatment of the crop (soil drenches with systemic insecticides at optimal timing) with options appropriate to the situation, amongst: • plants with diameter below a certain size* • growing vegetation of a sufficient height (30-45 cm) at the base of the plants (e.g. cover crop established during spring and present during the flight season of the pest) • visual examination of the plants • visual inspection of the consignment (in the framework of a bilateral agreement) Or Post-entry quarantine for 2 years (in the framework of a bilateral agreement)
Round wood of hosts in Category 1A (*C. femorata*) and Category 1 (*C. mali*)	Stored and transported in conditions preventing infestation (i.e. outside of the flight period of *C. femorata* and *C. mali*, or not in/through areas infested with the pests, or closed). AND PFA (see requirements below) 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 or PT 23 (FAO, 2017b, 2017c))
Sawn wood (>6mm) of hosts in Category 1A (*C. femorata*) and Category 1 (*C. mali*)	PFA (see requirements below) 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 or PT 23 (FAO, 2017b, 2017c))

Possible pathways (in order of importance)	Measures identified (see ANNEX 1 for details)
Deciduous wood chips, hogwood, processing wood residues	PFA (see requirements below) + stored and transported in conditions preventing infestation (i.e. outside of the flight period of *C. femorata* and *C. mali*, or not in areas infested with the pests, or closed).
Wood packaging material	ISPM 15
Cut branches of hosts in Category 1A (*C. femorata*) and Category 1 (*C. mali*)	PFA (see requirements below) + stored and transported in conditions preventing infestation (i.e. outside of the flight period of *C. femorata* and *C. mali*, or not in/through areas infested with the pests, or closed). or Pest-free production site established according to EPPO Standard PM 5/8 Guidelines on the phytosanitary measure 'Plants grown under complete physical isolation') + Stored and transported in conditions preventing infestation (i.e. outside of the flight period of *C. femorata* and *C. mali*, or not in areas infested with the pests, or closed).
Plants for planting (except seeds, tissue cultures and pollen), round wood, sawn wood >6 mm, cut branches of hosts in Category 1B and 2 (*C. femorata*) and Category 2 (*C. mali*) (except seeds, tissue cultures and pollen)	Phytosanitary certificate

* This size can determined based on information provided by the exporting country, depending on the host species and any data available (see also section 2.6, *Size of material attacked*).

Measures considered by the EWG but not retained at later stages of the PRA development:
Plants for planting of hosts in category 1 (except seeds, tissue cultures and pollen)
Two combinations proposed by the EWG were not retained by the PPM, and an alternative wording was used in the table of measures above. See also Annex 1 (below the table).

Requirements for establishing a PFA:
A pest-free area would be possible in some circumstances.
Considering the current distribution of the pest:
For *C. femorata*, it is not considered possible to establish a PFA in Southern Canada and in continental USA (except Alaska).
For *C. mali*, a PFA is considered possible in Eastern USA and part of Canada, with the condition that the absence of the pest should be fully demonstrated, including trapping for Buprestidae in various environments, sampling of Buprestidae damage on a wide range of deciduous plants, including in the wild and in ornamental nurseries, identification to the level sufficient to exclude the possibility that the specimens are *C. mali* (this requires a *Chrysobothris* specialist).
Measures could be similar to the requirements proposed for *A. planipennis* (EPPO, 2013b):

- For *A. planipennis, A. bilineatus* and *A. fleischeri*, a minimum distance of 100 km between the PFA and the closest known area where the pest is known to be present has been recommended. However, as for other Buprestidae, *C. femorata* and *C. mali* are expected to fly long distances only in the absence of host plants. Because of the wide host range of *C. femorata* and *C. mali*, they are less likely to fly long distances, and therefore a distance of less than 100 km may be sufficient.
- To establish and maintain the PFA, detailed monitoring should be conducted in the area in the three years prior to establishment of the PFA and continued every year. Specific surveys should be performed in the zone between the PFA and known infestation to demonstrate pest freedom. The surveys should be targeted for the pest and should be based on an appropriate combination of trapping, sampling and visual examination of host trees.
- Surveys should include high risk locations, such as places where potentially infested material may have been imported.

- There should be restrictions on the movement of host material (originating from areas where the pest is known to be present) into the PFA, and into the area surrounding the PFA, especially the area between the PFA and the closest area of known infestation.

16.2 Eradication and containment

Eradication

Maximum flight distances are not known but *C. femorata* and *C. mali* may be able to fly over long distances that have been observed with other buprestid species (more than 1 km). However, they are unlikely to do so if hosts are present in the immediate surroundings. The pests would be difficult to eradicate, especially because of the expected long time between introduction and detection. Eradication may be possible in case of limited presence and early detection. Eradication measures should be applied before adults emerge as they can easily spread to other host plants. *C. femorata* and *C. mali* have a very wide host range, which would complicate eradication. Eradication may require the removal of all woody deciduous plants around the location where the pest has been detected.

Containment

Containment will be difficult because host plants are widespread and infestations can be difficult to detect. Information on the flight capability, as well as likely flight distance, is lacking for both of these borers. That may complicate determining the size of the quarantine area. A strategy to contain the pest should involve:

- Trapping using purple traps should be used when delimiting the infested area and potentially remove some adults that are present in the area, and should be combined with visual examination of potential host plants. Other monitoring methods should be combined to improve detection (see section 2.7).
- Public education and outreach campaigns (support of residents and land owners) may help an earlier reporting of findings and a better implementation of measures (PRA on *Agrilus bilineatus*). In this case however, this may lead to a lot of false alerts as there are many hosts, as well as other *Chrysobothris* and Buprestidae in the EPPO region.
- Removal of infested trees and shrubs. At heavily infested locations all woody deciduous plants should be removed but it is recommended that some preferred hosts remain in the introduction/containment area (e.g. red maple) in a stressed condition (e.g. ring-barked) to serve as attractive host/trap trees to reduce adult beetle movement. These host/trap trees should be destroyed by burning or deep burying at the end of the adult flight season.
- Insecticide treatments could suppress populations in the localized introduction area. The current insecticides found effective in the USA are mostly not authorized in the EU (see details in section 13). In addition, application of insecticides outside commercial plantations may be restricted or even forbidden in EPPO countries. The EWG noted that, in the USA, trunk injections with emamectin benzoate have demonstrated three years of control against *Agrilus* larvae and leaf-feeding *Agrilus* adults (EPPO, 2019b, citing sources). Emamectin benzoate is authorized in some EPPO countries for trunk injections (e.g. against *Camereria ohridiella* and *Rhynchophorus ferrugineus* in the EU), and may be an option against *Chrysobothris*. However, emamectin benzoate has not been tested against *Chrysobothris* in the USA, and in particular the EWG did not have information on whether it may have a repellent effect on feeding adults (which might induce further spread of the pest to other non-treated trees and reduce containment efficacy).
- There should be regulatory measures to prevent spread by human assistance such as restrictions on the movement of any potential host material (i.e. all deciduous woody plants) from demarcated areas.

17. Uncertainty

The uncertainties apply to both species, unless mentioned:

- host range,
- whether some data on *C. femorata* relates to other species in the complex,
- whether the distribution of *C. mali* is wider than currently reported,
- minimum diameter of stems and branches in which *C. femorata* can develop,
- whether dead plant tissues are suitable for larval development,
- conditions under which the pests would have a longer life cycle and delayed emergence,
- natural spread rates,
- effect of environmental conditions on establishment potential and potential impact of the pests,
- whether some natural enemies would be effective against the pests in the EPPO region,
- data on trade for all pathways (depending on pathways, whether host commodities are traded from infested areas and/or trade volumes).

18. Remarks

Many knowledge gaps regarding both *C. femorata* and *C. mali*, and areas of current research, are provided in the Proceedings of the flatheaded borer (2019). A multidisplinary project on flatheaded borers has started in the USA and will increase the knowledge of these pests in the coming years. The EWG noted that the results of this project should be followed to determine if the new information obtained will change any of the assessments in the current PRA.

The EWG noted that studies on the following topics would help solve some uncertainties raised in the PRA:

- Host range studies, especially ascertaining whether category 1B and category 2 plants are hosts.
- Studies on host suitability of some major potential hosts in EPPO (e.g. *Acer campestre*) would be helpful for determining potential ecological impact in the EPPO region.
- Host preferences.
- Other insecticide treatments that could be used for eradication or control (e.g. emamectin benzoate, anthanilic diamides).
- Alternative damage detection (especially in early stages of infestation) and larval and adult identification.
- Improving molecular methods for identification, including for *C. femorata* s.s. and to discriminate with other species in the complex.
- Species-specific trapping, such as based on drumming behaviour, or improved lures.
- Mark and recapture for studying flight capacity and behaviour (such as have been done for e.g. *Agrilus planipennis*).
- Economic and social impacts in the current distribution, and how that may extend to an EPPO introduction.

19. References (including for Annexes)

All websites mentioned were accessed in September 2020

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ANNEX 1. Consideration of pest risk management options

The table below summarizes the consideration of possible measures for the pathways '*plants for planting*',' *round wood and sawn wood*', and '*wood chips, hogwood, processing wood residues (except sawdust and shavings)*' (based on EPPO Standard PM 5/3).
When a measure is considered appropriate, it is noted "yes", or "yes, in combination" if it should be combined with other measures in a systems approach. "No" indicate 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	No, see section 8.	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. Infestation is difficult to detect without destructive sampling (signs and symptoms may be restricted to galleries under the bark and adult exit holes. Young and small larvae may not produce externally visible signs). The best time for inspection is from late fall to spring, and damage is more visible in late spring; at other times, symptoms may not be visible.** There is no specific trapping method that would ensure detection at the place of production, but trapping using preferably purple traps (see section 2.7) can be used, followed by identification (by a *Chrysobothris* specialist). Traps would not be sufficient to demonstrate the absence of the pest.	Yes in combination*. **Trapping using purple traps may be used (see section 2.7). Regarding detection by visual inspection of trees, there may be few holes per tree. The emergence holes are small and could be difficult to detect if in a bark crevice. Detection would be more difficult in forest or plantation environments than in a plant nursery.** [note: this was considered relevant in a system approach for *Agrilus bilineatus* and *A. fleischeri*, but no combined measures were considered to achieve a suitable level of protection]	Yes, in combination*. This may only be feasible for high value wood chips. As for wood.
Testing at place of production	No. **Not relevant**	No. Not relevant	No. Not relevant
Treatment of crop	Yes, in combination*. Soil drenches with systemic insecticides (particularly imidacloprid or dinotefuran) are reported as very effective preventive measures on nursery trees in the USA. However, they are effective only on feeding life stages. Treatment should be performed the season preceding dispatch. To allow for translocation of the active ingredient, optimal timing for application is early spring, usually March. Other active ingredients with proven efficacy may also be used. The treatment procedure should be described and take	Not relevant in forest.	Not relevant in forest.

Option	Host plants for planting	Round wood and sawn wood of hosts	Wood chips, hogwood, processing wood residues (except sawdust and shavings)
	account of the characteristics of the treatment (long duration of uptake, not by dormant trees, effective only if *Chrysobothris* is at the active feeding stage). Treatment with soil drenches is not considered sufficiently effective on its own because of the limitations stated above, but may be combined with other measures. Repeated trunk sprays applied during the flight season are not as effective but may provide some benefit. However, surface-applied insecticide trunk sprays are unlikely to completely eliminate the pest when life stages are inside the tree (hidden larval, pupal, or callow adult). Trunk sprays may also be used in combination with systemic insecticides, but this combination is not sufficient as a stand-alone measure. Note that research is ongoing on control methods in the USA, which may lead to improvements on control in the near future.		
Resistant cultivars	**Not available.** Some *Acer* cultivars are reported as being less susceptible, but they are not resistant.	Not available	Not available
Growing the crop in glasshouses/ screenhouses	Yes. Plants for planting could be grown under protected conditions with sufficient measures to exclude the pest (following EPPO Standard PM5/8(1) Guidelines on the phytosanitary measure 'Plants grown under complete physical isolation' (EPPO, 2016)). However, this is not common practice 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	Size of plant: Yes, in combination. There is not sufficient information available for *C. femorata* to identify a minimum diameter that would prevent infestation. The minimum diameter for *C. mali* would be 3-4 mm. The EWG considered that it was so small that it does not make sense to take it into consideration (Section 2). However, limiting the commodity to small plants (for example 0.5 cm diameter at the thickest part) would reduce the risk. Growth stage/time of the year: Yes in combination. Larvae may be present in trunks or branches	Age/size of plant: No, trees need to be large enough before being cut for wood. The size of the tree will determine whether larvae are present deep in the sapwood or at the interface with the bark. However, larval depth depends on the period of the year and also may be affected by other factors like wood hardness. This cannot be generalized to all potential hosts. On large diameter material, larvae, pupae and callow adults are not likely to be in the heartwood, while they may be in small diameter material (see section 2.2). Growth stage/time of the year: No. As for plants for planting.	Size of plant: No. As for wood Growth stage/time of the year: 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)
	throughout the year. In particular, dormant plants may contain overwintering larvae. However, the plants could be maintained in the nursery until spring to make sure damage visibility is maximized. This may not be feasible for all types of plants for planting. In the EPPO countries that require that imported plants should be dormant (such as the EU), this measure would not be possible.		
Produced in a certification scheme	**Not relevant**	Not relevant	Not relevant
Pest freedom of the crop	Yes, in combination* It may be possible to ensure pest freedom of the crop by applying a combination of measures in the crop and consignment (subject to a bilateral agreement) (treatment and size of plants). See below this table. In addition, growing vegetation of a sufficient height (30-45 cm height) at the base of the plants (weed or cover crop established during spring and present during the flight season of the pest) reduces the risk of infestation by the borer, with the same efficacy as imidacloprid. The part of the plant above that height should be inspected. This could be part of a systems approach combined with soil drenches, and visual inspection of consignments.	Not relevant	Not relevant
Pest free production site	Yes, grown under complete physical isolation (see Growing the crop in glasshouses/screenhouses). Not outdoors, unlikely to be feasible. The pest would be difficult to detect in the buffer zone. The pests are also very polyphagous, which makes it difficult to ensure a host-free buffer zone. They can fly to find hosts. Finally, the size of the buffer zone cannot be specified. In any case, the EWG considered that it is not possible to establish a suitable buffer zone around a production site in an area where the pests are present.	Not possible	Not possible
Pest free place of production	Yes, grown under complete physical isolation. Each site should be pest free (grown under physical isolation). Consequently only pest-free production site is mentioned in the table of section 16.	Not possible	Not possible

Option	Host plants for planting	Round wood and sawn wood of hosts	Wood chips, hogwood, processing wood residues (except sawdust and shavings)
	Not outdoors. It is not possible to have pest-free place of production with a buffer zone (same reasoning as for pest free production site).		
Pest free area	A pest-free area would be possible in some circumstances. **Considering the current distribution of the pest:** **- For *C. femorata*, it is not considered possible to establish a PFA in Southern Canada and in continental USA (except Alaska)**. **- For *C. mali*: a PFA is possible in Eastern USA and part of Canada, with the condition that the absence of the pest should be fully demonstrated, including trapping for Buprestidae in various environments, sampling of Buprestidae damage on a wide range of deciduous plants, including in the wild and in ornamental nurseries, identification to the level sufficient to exclude the possibility that the specimens are *C. mali*** (this requires a *Chrysobothris* specialist, see section 2.7)**.** Measures could be similar to the requirements proposed for *A. planipennis* (EPPO, 2013b): • For *A. planipennis*, *A. bilineatus* and *A. fleischeri*, a minimum distance of 100 km between the PFA and the closest known area where the pest is known to be present has been recommended. However, as for other Buprestidae, *C. femorata* and *C. mali* are expected to fly long distances only in the absence of host plants. Because of the wide host range of *C. femorata* and *C. mali*, they are less likely to fly long distances, and therefore a distance of less than 100 km may be sufficient. • To establish and maintain the PFA, detailed surveys and monitoring (using trapping and other methods) should be conducted in the area in the three years prior to establishment of the PFA and continued every year. Specific surveys also should be performed in the zone between the PFA and known infestation to demonstrate pest freedom. The surveys should be targeted for the pest and should be based on an appropriate combination of trapping, sampling and visual examination of host trees.	Same as plants for planting, with an additional requirement: - storage and transport should be done in conditions preventing entry of adults (see packing and handling below).	Same as plants for planting, with an additional requirement: For *A. bilineatus*, as recommended in the past for *A. planipennis*, the Panel on Phytosanitary Measures considered that storage and transport in the period after chipping should be done in conditions preventing entry of adults. This is because the chipping process releases strong concentrations of host volatiles, and adults may be attracted to consignments of wood chips soon after chipping. The EWG recommended that this was also necessary for *C. femorata* and *C. mali*.

Option	Host plants for planting	Round wood and sawn wood of hosts	Wood chips, hogwood, processing wood residues (except sawdust and shavings)
	• Surveys should include high risk locations, such as places where potentially infested material may have been imported. There should be restrictions on the movement of host material (originating from areas where the pest is known to be present) into the PFA, and into the area surrounding the PFA, especially the area between the PFA and the closest area of known infestation.		
Options after harvest, at pre-clearance or during transport			
Visual inspection of consignment	Yes, in combination*. Visual inspection may detect some infested plants. However, the pest would be difficult to detect in large consignments. Plants are generally traded during the dormant season, when the larvae would be overwintering inside the plants. The best time for inspection is from late fall to spring, and damage is more visible in late spring. At other times, symptoms may not be visible. Destructive sampling should be used but may not detect low levels of infestation.	Yes, in combination*. Inspection may detect some galleries but will not guarantee detection. Visual inspection of wood consignments is generally difficult, but even more with consignments mixing several tree species (such as firewood). An infestation on wood without bark may be easier to detect. Adult *Chrysobothris* should be identified to species. *Chrysobothris* larvae and pupae should be identified using molecular methods (the constraints of identification are described in section 2.7). Low levels of infestation may not be detected.	No Inspection of consignments of wood chips and other such commodities is difficult. It is unlikely to detect *C. femorata* or *C. mali* as consignments may contain several tree species, and signs of presence of the pest would not be easy to observe. In a study on *A. anxius*, when simulating the process from logging in North America to sampling the wood chips upon arrival in Europe, the probability of pest detection for current sampling protocols used by port inspectors was very low (<0.00005), while a 90% chance of detection may require sampling 27 million litres of wood chips per shipload (Økland *et al.*, 2012). Remark: there is still a value in inspecting wood chip consignments at the point of entry in that it will contribute to a better understanding of the risks (e.g. categories of material that are traded, size of the chips, tree species). It is therefore not proposed for *C. femorata* and *C. mali*.
Testing of commodity/inspection methods other than visual inspection	No **There is no information about the practical use of a scanner or sniffer dogs for this pest.**	No, as for plants for planting	No, as for plants for planting
Treatment of the consignment	No. The treatments available would not be effective at removing the pest in the consignment. Late larval instars, pupae would not feed and would not be destroyed. Consignments would mostly be assembled at the dormant stage. Soil drenches (e.g. imidacloprid or dinotefuran) would not be effective on dormant plants, nor before the	Yes. *Heat treatment of debarked wood.* According to EPPO Standard PM 10/6(1) *Heat treatment of wood to control insects and wood-borne nematodes* (EPPO, 2009), Buprestidae are killed in round wood and sawn wood, which have been debarked and heat-treated until the core temperature reaches at least 56 °C for at least 30 min.	No. Chipping down to a certain size (2.5 cm × 2.5 cm) (Section 8) was considered by the EWG as a standalone measure. However, in the past, when this measure was discussed for *A. planipennis* and *A. anxius*, the Panel on Phytosanitary Measures considered that further research should be performed to determine

Option	Host plants for planting	Round wood and sawn wood of hosts	Wood chips, hogwood, processing wood residues (except sawdust and shavings)
	stage when larvae would be susceptible.	Yes. *Irradiation*. According to EPPO Standard PM 10/8(1) Disinfestation of wood with ionizing radiation (EPPO, 2009), Buprestidae infesting wood are killed after an irradiation of 1kGy. Such treatments might be applied to quality logs but will be too expensive for low-value products such as firewood. Yes. *Fumigation with sulfuryl fluoride* could be applied. ISPM 28 PT 22 and PT 23 (FAO, 2017b, 2017c) only applies to debarked wood below 20 cm in cross-section. Note: methyl bromide has been phased-out and MBr fumigation is not considered here. Yes. *Processing*. Conversion of the wood into sawn timber of less than 6 mm. The efficacy and feasibility of ultra-cold freezing could be investigated. Coverage of logs with insecticide-impregnated netting to kill any emerging adults could also be investigated. It would have to be applied for a sufficient period to kill all adults.	the safe size for wood chips and how such size can be consistently obtained in commercial production of chips. This measure, when combined with debarking, was not considered realistic due to the cost of debarking compared to the value of the chips. The Panel on Quarantine Pests for Forestry also commented that the chipping process was applied repetitively, in the study by McCullough et al. (2007) on the same material, which is not representative of a classical industrial process. In coherence with the measures recommended for *A. planipennis* and *A. anxius*, this measure was not proposed by the Panel on Phytosanitary Measures for *A. bilineatus* and *A. fleischeri*. It is therefore not proposed for *C. femorata* and *C. mali*. Treatments (heat treatment, fumigation, irradiation) were suggested for round wood and sawn wood. However, for *A. bilineatus*, the Panel on Phytosanitary Measures decided that the treatment of woodchips and bark should not be proposed as a measure before analysing specifically whether the measures detailed in PM 10/6(1) *Heat treatment of wood to control insects and wood-borne nematodes*, in PM 10/8(1) *Disinfestation of wood with ionizing radiation* as well as in ISPM 28 PT 22 or PT 23 on fumigation could be applicable for other wood commodities including woodchips and bark. It is therefore not proposed for *C. femorata* and *C. mali*.
Pest only on certain parts of plant/plant product, which can be removed	No. **Life stages are on/in the trunk or branches.**	No. As for plants for planting. Debarking may remove some individuals, and make conditions less favourable to survival. However, it would not remove late larval stages and pupae that are in the wood. Removal of bark and at least 5 cm of the wood would remove most individuals in most situations, but larvae may tunnel deeper into soft woods. This measure may not be feasible because of wood loss.	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)
		In summer and fall, it is less likely that mature larvae or pupae are present (deep in the wood), and removing a smaller quantity of wood would be sufficient to remove younger larvae. However, in a multi-year life cycle (such as colder climates), there may be mature larvae and pupae also in summer and fall.	
Prevention of infestation by packing/handling method	**Yes, associated with certain measures. Plants should be** stored and transported in conditions preventing infestation (i.e. outside of the flight period of *C. femorata* and *C. mali*, or not in/through areas infested with the pests, or closed).	**For round wood: Yes, associated with certain measures** If *C. femorata* and *C. mali* females did lay eggs on such material in transport or in storage, there is an uncertainty on whether eggs could develop and larvae complete their development. Round wood should be stored and transported in conditions preventing infestation (i.e. outside of the flight period of *C. femorata* and *C. mali*, or not in/through areas infested with the pests, or closed). For sawn wood. No. If *C. femorata* and *C. mali* females did lay eggs on such material in transport or in storage, the young larvae are unlikely to complete their development as the material would become less suitable with drying. It may be possible to use insecticide-impregnated netting to prevent infestation. This method needs further investigation before it can be recommended for *C. femorata* and *C. mali*.	**Yes, associated with certain measures** Adults may be attracted to recently cut wood chips (see section 2.x). The chips should be stored and transported in conditions preventing infestation, (i.e. outside of the flight period of *C. femorata* and *C. mali*, or not in/through areas infested with the pest, or closed). The EWG on *A. bilineatus* and *A. fleischeri* suggested that a specific packing should be required if wood chips were imported to be directly burned/transformed (i.e. as a stand-alone measures preventing adults to escape from the consignment which is for direct transformation). However, the Panel on Phytosanitary Measures suggested that this measure should only be accepted by derogation, in a bilateral agreement between the exporting and the importing country.
Options that can be implemented after entry of consignments			
Post-entry quarantine	Yes. The EWG suggested that plants may be kept in post-entry quarantine for a sufficient time in optimal conditions for the pest in order to detect the symptoms of larval activity or adult emergence (2 years* to provide that the pest is detected if there were only eggs on the plants, taking into account that the material may not be in the stressed conditions that would ensure that symptoms are visible in the 1 year). [*2 years covers the possibility for delayed development and sufficient time for damage evidence to be visible]. This measure is likely to be applicable only for small scale imports of high value plants, but it may pose practical difficulties for large trees. The Panel on Phytosanitary Measures considers that this measure should only be proposed in the	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)
	framework of a bilateral agreement.		
Limited distribution of consignments in time and/or space or limited use	No. Plants for planting are destined to be planted, and if adults emerged, they could fly and may find hosts in the vicinity. Limiting the distribution to areas where the pest is not likely to establish is not feasible (and this area cannot be precisely defined).	No. **Not possible/practical to restrict import to periods of the year outside of the emergence and flight period of *C. femorata* and *C. mali* (these are also not clearly known), and to process the material before the next such period (with appropriate conditions in storage).**	No. As for wood.
Only surveillance and eradication in the importing country	No. **Detection is difficult, and the pest may be detected only years after establishment. Moreover, signs and symptoms may be already caused on the same host plants by other Buprestidae in the EPPO region of a similar size. Adults may be confused with adults of other *Chrysobothris* spp. Surveillance and eradication are difficult.**	As for plants for planting.	As for plants for planting.

*The EWG considered whether the measures identified above as 'Yes in combination' (listed below) could be combined to achieve a suitable level of protection. There were no such combinations for wood pathways.
For host plants for planting, two possible combinations were proposed:
- Pest freedom of the crop, guaranteed by treatment of the crop (soil drenches with systemic insecticides (imidacloprid, dinotefuran or other active ingredient with proven efficacy) at optimal timing for translocation of the active ingredient) + Plants with diameter below a certain size (for example 0.5 cm diameter at the thickest part)
However it is not known if there is any trade for such plants.
- Pest freedom of the crop guaranteed by growing vegetation of a sufficient height (30-45 cm) at the base of the plants (e.g. cover crop established during spring and present during the flight season of the pest) + visual examination of the plants + soil drenches + visual inspection of the consignment (in the framework of a bilateral agreement).

When reviewing the pest risk management options, the EWG noted that there is evidence that treatment with soil drenches would have efficacy if correctly applied, and they should be part of any systems approach that could be developed. However, the combinations of measures that could be used in association with this treatment (system approach) may vary depending on the situation (e.g. setting, type of plants, host species), and should be considered by the NPPO in the framework of a bilateral agreement. The combinations proposed above were not retained. and an alternative wording was used in the table of measures in section 16.

Host plants for planting	Round wood and sawn wood	Wood chips, hogwood etc.
Visual inspection at the place of production (incl. trapping)	Visual inspection at the place of production (incl. trapping)	Visual inspection at the place of production (incl. trapping)
Treatment of the crop (soil drenches with systemic insecticides (imidacloprid, dinotefuran or other active ingredient with proven efficacy))	Visual inspection of consignments	Storage and transport requirements (to be associated to appropriate measures)
Growing vegetation of a sufficient height (30-45 cm) at the base of the plants (e.g. cover crop established during spring and present during the flight season of the pest)		
Maintaining the plants in the nursery until spring to make sure damage visibility is maximized		
Visual inspection of the consignment		

Plants packed in conditions preventing infestation		
Plants with diameter below a certain size (for example 0.5 cm diameter at the thickest part)		

ANNEX 2. Other species in the* C. femorata *complex

This Annex is an outline based only on the publications used to compile information on *C. femorata* (and not a complete search of the literature).

"…very little information is available about the other species in this species group [other than *C. femorata s.s.*], except for their distribution, abundance, and hosts. Most species in this species group are considered to be secondary attackers of trees that have been stressed by age, fire, and water (lack thereof, excess or both) and are often collected on recently cut or injured plants…." Wellso & Manley (2007).

Name	Distribution	Hosts	Comments
C. adelpha Harold, 1869	USA: probably all states east of those from Texas to Minnesota. Mexico, Canada (W & M, 2007).	Reared from: *Amelanchier arborea*, *Carya illinoinensis*, *C. ovata*, *C. tomentosa, Prosopis grandulosa* (W & M, 2007). Larvae recorded on *Amelanchier arborea*, *Carya alba*, *C. floridana*, *C. glabra*, *C. illinoinensis*, *C. laciniosa*, *C. ovata, Prosopis glandulosa*. Adults observed on *Acer platanoides*, *Fraxinus pennsylvanica*, *Quercus* (Paiero *et al.,* 2012).	Common in Tennessee (J. Oliver, pers. comm.). Reared from nursery trees in Tennessee, although not as frequently as *C. femorata* (J. Oliver, pers. comm.).
C. caddo Wellso & Manley, 2007	Texas, Arizona, Florida, Kansas, Louisiana, Missouri, Nebraska, New Mexico, Oklahoma, Texas (W & M, 2007).	Emerged/reared from *Celtis laevigata, C reticulata, Cercis canadensis, Pithecellobium ebano* (W & M, 2007).	
C. comanche Wellso & Manley, 2007	Texas, New Mexico, Utah (W & M, 2007).	Associated with *Juglans* (*major*) *microcarpa*, presumably its host (W & M, 2007).	
C. mescalero Wellso & Manley, 2007	Texas, New Mexico (W & M, 2007).	Emerged from *Quercus mohriana*. Adults collected on *Q. mohriana* and *Q. havardii* (W & M, 2007).	
C. quadriimpressa Gory & Laporte, 1837 = *C. misella* LeConte 1860	Probably all states east of the Continental Divide. Alabama, Arizona, Connecticut, Delaware, Florida, Idaho, Illinois, Indiana, Iowa, Massachusetts, Maryland, Maine, Michigan, North Carolina, New Jersey, New York, Ohio, Oregon, Pennsylvania, Rhode Island, Tennessee, Texas, Virginia, Wisconsin (W & M, 2007).	Emerged from *Juglans nigra*, *Liquidambar styraciflua*, *Quercus alba*, *Q. coccinea, Q. emoryi*, *Q. rubra*, *Sapindus saponaria* var. *drummondii.* (W & M, 2007) Uncertain: Specimens, although identified to *C. quadriimpressa*. presented some substantial variation on: *Juglans cinerea* (reared from), *Celtis laevigata* (collected on). (W & M, 2007). *C. quadriimpressa* and *C. shawnee* are associated almost exclusively with oaks (MacRae & Basham, 2013).	Common oak inhabiting species. Often present on oak branches 4" or less in diameter along with C. *rugosiceps* and C. *shawnee* that usually prefer larger branches or the trunk (W & M, 2007). Not observed infesting nursery trees in Tennessee to date and seems to be more of a forest species; however, it is readily and commonly trapped near nursery sites (J. Oliver, pers. comm.). A specimen of *C. quadriimpressa* reared from *J. nigra* in Idaho may represent an introduction (nursery plants or wood) (Westcott, 2005). One interception in the EU on 'wood and bark' of *Juglans nigra* in 2019.
C. rugosiceps Melsheimer, 1845 = *C. alabamae* Gory, 1841	"Probably all states east of the states adjacent to the Mississippi River", Kansas, Texas, and Canada. (W & M, 2007). Minnesota (Hallinen *et al.,* 2020).	Often collected on oaks with *C. quadriimpressa* and *C. shawnee*. Reported breeding in *Castanea dentata* (W & M, 2007). Larvae recorded from *Castanea dentata*, *Quercus alba*, *Q. macrocarpa, Q. velutina*. Adults observed on *Carya ovata*, *Pinus echinata*, *Q. marilandica*, *Q. palustris*, *Q. stellata* (Paiero *et al.,* 2012) Emerged /reared from *Q. rubra*, *Q. robur* (Hansen *et al.,* 2011).	Common and widespread species (W & M, 2007). Reared from nursery trees in Tennessee, although not as frequently as *C. femorata* (J. Oliver, pers. comm.). Recently been found in Washington State (trapped, not known if established or not) and may have been introduced with wood (Westcott *et al.,* 2018).

Name	Distribution	Hosts	Comments
C. seminole Wellso & Manley, 2007	Georgia, Florida (W & M, 2007).	Reared from *Chrysoma pauciflosculosa* (W & M, 2007).	Asteraceae, bushy perennial (W & M, 2007). Note: only species of the *femorata* complex that is not on deciduous trees.
C. shawnee Wellso & Manley, 2007	Texas, Arkansas, Colorado, Connecticut, District of Columbia, Florida, Georgia, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maryland, Massachusetts, Michigan, Mississippi, Missouri, New Hampshire, New Jersey, New York, North Carolina, Oklahoma, Pennsylvania, Rhode Island, South Carolina, Tennessee, Texas, Virginia, West Virginia (W & M, 2007). Minnesota (Hallinen *et al.,* 2020). Paiero et al. (2012) did not separate information on *C. shawnee* from *C. femorata*, but noted that *C. shawnee*, if valid, would be expected to occur throughout north-eastern Canada.	A few specimens collected from *Celtis laevigata* in the vicinity of cut oaks. Reared from *Castanea dentata, Quercus stellata*, *Quercus* spp. *Q. phellos*, *Q. palustris*. Collected on *Fraxinus pennsylvanica*, *Q. alba*, *Q. bicolor*, *Q. coccinea*, Q. gravesii, *Q. marilandica*, *Q. michauxi*, *Q. palustris*, *Q. rubra*, Q. *velutina* (W & M, 2007). Larvae found in naturally infested logs of *Q. rubra* and *Q. robur* (Hansen et al. 2015). *C. quadriimpressa* and *C. shawnee* are associated almost exclusively with oaks (MacRae & Basham, 2013).	Occurs on large branches and trunks of dead oak trees along with *C. rugosiceps* (W & M, 2007). Trapped in *Vaccinium darrowii* crops in Florida (but immature stages not detected in the plants) (Ashman & Liburd, 2019).
C. sloicola Manley & Wellso, 1975	Endemic to Michigan (W & M, 2007).	Adults collected on *Prunus americana* (W & M, 2007).	Uncommon species (W & M, 2007).
C. viridiceps Melsheimer, 1845 =*C. lesueuri* Gory & Laporte (1837)	Probably all states east of the Continental Divide and in Canada (W & M, 2007). Minnesota (Hallinen, 2020).	Reared from *Carya illinoinensis*, *Prosopis glandulosa, Quercus alba*, *Q. grisea*, *Q. macrocarpa*, *Q. stellata*, *Ulmus crassicola* (W & M, 2007). Larvae recorded from *Acer rubrum*, *Carya illinoinensis*, *Pinus*, *Prosopis*, *Quercus alba*, *Q. grisea*, *Q. macrocarpa*, *Q. stellata*, *Ulmus crassifolia*. Adults observed on *A. saccharinum*, *Carya ovata*, *Q. bicolor*, *Q. marilandica*, *Q. velutina, U. americana*. (Paiero *et al.,* 2012).	Common species (W & M, 2007). Reared from nursery trees in Tennessee, although not as frequently as *C. femorata* (J. Oliver, pers. comm.). Trapped in *Vaccinium darrowii* crops in Florida (but immature stages not detected in the plants) (Ashman & Liburd, 2019).
C. wintu Wellso & Manley, sp. 2007	USA: California, Arizona, Oregon, Washington. Mexico: Baja California (W & M, 2007). Baja California north through Arizona, California, Oregon, and Washington (Rijal & Seybold, 2019a).	Adults usually on oak, collected on: *Quercus agrifolia, Q, chrysolepis, Q. gravesii*, *Q. garryana, Arctostaphylos viscida*, *Pyrus communis*, *Salix scouleriana*, *Betula* spp. Larval host records include *Platanus racemosa, Quercus, Q. kelloggii Q wislizenii, Q. douglasii, Q. berberidifolia, Prunus domestica, Salix lasiolepis*, *Salix nigra* (W & M, 2007). *Juglans regia* (Rijal & Seybold, 2019a, citing Westcott *et al.,* 2015).	The relative risk of this species causing economic damage in walnut orchards is lower. It was captured in trapping study, but not found in walnut branches (Rijal & Seybold, 2019a).

ANNEX 3. Pictures of life stages and damage of **C. femorata**


Adult (view from above) (J. Basham, Tennessee State University [currently USDA-APHIS]).


Female ovipositing (N. Youssef)


Larvae (J. Oliver) Exit hole (A. Murillo)

Symptoms and damage



Adult feeding damage (on *Acer rubrum*) Larval gallery below bark Deeper tunneling by larva for
pupation
(A. Murillo) (N. Youssef) (N. Youssef)

Early late-summer reddening of infested trees
(*A. rubrum*) (J. Oliver)

Basal shoots formed following girdling damage
2’’ diameter) (dogwood) (J. Oliver)

Basal shoots formed following girdling damage, with bark cracking and evidence of frass.
left: extensive damage, probably older damage
(J. Oliver)

Larval galleries in *Acer rubrum* ‘Franksred’ with the bark removed. Note the gradually enlarging galleries from start to end.
Left: 18-cm gallery (J. Oliver); right: two larval galleries on one red maple ‘Franksred’ tree (J. Oliver).
Unlike older larval damage, which is visible on the surface when the bark dies and sloughs, this damage was revealed only after removing the bark from the live and actively growing trees. It is also a more recent and active gallery.


Circular galleries. Left: with bark (J.Oliver); Right: approximately 5-y old tree, bark removed (J. Oliver)



Bark damage on the trunk of nursery trees

splitting (J. Oliver)

Splitting and older damage evidenced by some bark callusing (note d-shaped exit hole in middle) (J. Oliver)

Sunken bark and serpentine gallery visible. (J. Oliver)


Bark damage on the trunk of nursery trees revealing flatheaded borer excrement

splitting/flaking (note possible 2 adult exit holes) (J. Oliver)

Splitting/flaking (N. Youssef)

***ANNEX 4. Hosts plants of* C. femorata *and* C. mali**

Categories of uncertainties on host status (as in section 7)

C. femorata	*C. mali*
1A. **Confirmed hosts.** Records confirm that the plants are true hosts of *C. femorata s.s.* (in the sense of Wellso & Manley, 2007) and shown to support the development of the pest (larvae, pupae, emerging adults reported, or extensive damage/tree mortality, implying larvae). 1B. **Uncertain hosts.** Records confirm the presence of larvae, pupae or emerging adults, but there is some uncertainty on whether the record relates to other species in the *femorata* complex (publication pre-dates Wellso & Manley, 2007). 2. **Very uncertain hosts.** Records relate only to the presence of adults, or the life stages are not indicated. In some cases, there is also an uncertainty on whether the record relates to other species in the *femorata* complex (publication pre-dates Wellso & Manley, 2007).	1. **Confirmed hosts.** Records confirm that the plants are true hosts of *C. mali*, and shown to support the development of the pest (larvae, pupae, emerging adults reported, or extensive damage/tree mortality, implying larvae). Note: this category corresponds to the category 1A for *C. femorata*. 2. **Very uncertain hosts.** Record relates only to the presence of adults, or the life stages are not indicated.

Content of the column "main use and availability in PRA area": For host species, indicates whether native or exotic (the origin is indicated between brackets). Then provides the uses in the EPPO region. Categories are not exclusive, but aim at providing an overview of the extent of presence, management and use of the plants in the PRA area. All species may also be present in botanical gardens or collections, even if no information was found.

Wild	Presence in non-managed habitats of native or naturalized plants.
Forest	Species may be found in larger areas (forest or plantations), with different levels of management.
Wood	Species planted (forests or plantations) for its wood. The wood of other species may also be used, but with them, wood use is not the primary aim for planting.
Fruit	Species grown commercially for their fruits (including nuts), and which may also be found in gardens etc.
Ornamental	Species used for ornamental purposes as landscape trees, gardens, urban trees etc. 'Ornamental' is indicated only if a search on the Internet showed some availability in nurseries located in the EPPO region.
No information found for EPPO	Not found available in the EPPO region, not even as ornamental, through Internet searches.

The references in this table refer to the host status for *C. femorata* and *C. mali* (not to the main use and availability in EPPO).

The comments provides any useful details from the main reference, as well as other references that mention the host.

Host plant	Family	Main use & availability in EPPO	*C. femorata*	*Ref.*	*Comments*	*C. mali*	*Ref.*	*comments*
Acer macrophyllum	Sapindaceae	Exotic (native to N.Am.). Ornamental				1	Burke, 1919	Reared from
Acer negundo	Sapindaceae	Exotic (native to N.Am.). Wild, forest, ornamental. Considered invasive in many EPPO countries	1A	Wellso & Manley, 2007	Reared from (adults emerging from material collected in the field). *Other references* van Driesche *et al.*, 2012. Attacked. Burke, 1919. as 'box elder'. Mentioned as food plant. Pre-dates Wellso & Manley, 2007.	1	Burke, 1919	Reared from

Host plant	Family	Main use & availability in EPPO	*C. femorata*	*Ref.*	*Comments*	*C. mali*	*Ref.*	*comments*
Acer platanoides	Sapindaceae	Native. Wild, forest, wood, ornamental.	1A	Oliver *et al.,* 2019a	Damage to trunks, i.e. larvae, in Tennessee nurseries. MacRae, 1991. Adults emerged from trunks of dead or living trees. Publication pre-dating Wellso & Manley, 2007.			
Acer pseudoplatanus	Sapindaceae	Native. Wild, forest, wood, ornamental, bonsai.				1	Burke, 1919	Reared from
Acer rubrum	Sapindaceae	Exotic (native to N. Am.). Ornamental	1A	Fulcher, 2012;	Overwintering life stage. The publication refers to *Acer* cultivars 'Burgundy Belle', 'October Glory', 'Northwood', Sun Valley', 'Franksred' [sometimes called 'Red Sunset']. Vanek *et al.,* 2012. Girdling. MacRae, 1991. Adults collected on trunks. pre-dates Wellso & Manley, 2007.	1	Burke, 1919	Reared from
Acer saccharinum	Sapindaceae	Exotic (native to N. Am.). Ornamental	1B	MacRae, 1991	Adults emerged from trunks of dead or living trees. Pre-dates Wellso & Manley, 2007. Coyle *et al.,* 2005. Stem girdling. Publication pre-dates Wellso & Manley, 2007. Burke, 1919. As 'silver maple'. Killed. Pre-dates Wellso & Manley, 2007. van Driesche *et al.,* 2012. Attacked. Nelson *et al.,* 2008. Larvae. Not known if takes account of the separation in Wellso & Manley 2007.	1	Burke, 1919	Reared from
Acer saccharum	Sapindaceae	Exotic (native to N.Am.). Ornamental	1A	Wellso & Manley, 2007,	citing Westcott pers. comm. 'Reared from'. Fulcher 2012. As 'Acer green mountain'. MacRae, 1991. Adults emerged from trunks of dead or living. Pre-dates Wellso & Manley, 2007.	2	Burke, 1929	
Acer truncatum × *platanoides*	Sapindaceae	Artificial hybrid. Parents are exotic (native to China) and native, respectively. Ornamental (apparently rare)	1A	Vanek *et al.,* 2012	Girdling. Evaluations done in replicated field plots (Seagrave *et al.,* 2012).			
Acer × *freemanii*	Sapindaceae	Exotic (native to N.Am.). Ornamental	1A	Vanek *et al.,* 2012	Girdling. Evaluations done in replicated field plots (Seagrave *et al.,* 2012).			
Aesculus californica	Sapindaceae	Exotic (native to California, Oregon). Ornamental (apparently rare)				2	Burke, 1929	
Aesculus hippocastanum	Sapindaceae	Native. Wild, forest, ornamental	1B	Burke, 1919	Reared from. pre-dates Wellso & Manley, 2007.	1	Burke, 1919	Reared from

Host plant	Family	Main use & availability in EPPO	*C. femorata*	*Ref.*	*Comments*	*C. mali*	*Ref.*	*comments*
Alnus rhombifolia	Betulaceae	Exotic (native to W. USA). Seeds available in Europe on the internet	1B	Burke, 1919	Reared from. Pre-dates Wellso & Manley, 2007.	2	Burke, 1919	Taken 'larvae which appear to be this species'
Amelanchier arborea	Rosaceae	Exotic (native to NE. Am.). Ornamental	1B	Nelson *et al.*, 2008	Larvae. Not known if takes account of species separation in Wellso & Manley 2007.			
Arbutus menziesii	Ericaceae	Exotic, (native to N. Am.). Ornamental				1	Burke, 1919	Reared from
Arctostaphylos nummularia	Ericaceae	Exotic (native to N. Am.) No information found for EPPO				2	Burke, 1929	
Arctostaphylos tomentosa	Ericaceae	Exotic (native to California)No information found for EPPO				2	Burke, 1919	Taken 'larvae which appear to be this species'
Betula nigra	Betulaceae	Exotic (native to N. Am.). Ornamental	2	MacRae, 1991	Adults collected on trunks. Publication pre-dates Wellso & Manley, 2007.			
Betula occidentalis	Betulaceae	Exotic (native to N.Am.). No information found	1A	Westcott, 2005	Reared from. Also cited in Wellso & Manley, 2007.			
Betula papyrifera	Betulaceae	Exotic (native to N.Am.). Ornamental	1A	Wellso & Manley, 2007	citing Westcott, pers.comm. Reared from.			
Betula pubescens	Betulaceae	Native. Wild, forest, reforestation, ornamental	1A	Westcott, 2005	As *B. alba* Linnaeus. Reared from. Also cited in Wellso & Manley, 2007. Burke, 1919. As *B. alba*. Larvae which appear to be this species (i.e. no clear identification). Pre-dates Wellso & Manley, 2007.	2	Burke, 1929	As *B. alba*
Carpinus betulus	Betulaceae	Native. Wild, forest, ornamental	1A	MacRae & Basham, 2013	Larval host.			
Carpinus caroliniana	Betulaceae	Exotic (native to N.Am.). Ornamental	1A	Westcott, 2005	as *C. carolineana*. Reared from. Also cited in Wellso & Manley, 2007. Nelson *et al.,* 2008. Larvae. Not known if takes account of the separation in Wellso & Manley 2007.			
Carpinus japonica	Betulaceae	Exotic (native to Asia). Ornamental	1A	Westcott, 2005	Reared from. Also cited in Wellso & Manley, 2007. Nelson *et al.,* 2008. Larvae. Not known if takes account of the separation in Wellso & Manley 2007.			
Carya illinoinensis	Juglandaceae	Exotic (native to N Am). Fruit (limited cultivation), ornamental	1A	Wellso & Manley, 2007	citing Westcott pers. comm. Reared from. Nelson *et al.,* 2008. Larvae. Not known if takes account of the separation in Wellso & Manley 2007.			

Host plant	Family	Main use & availability in EPPO	*C. femorata*	*Ref.*	*Comments*	*C. mali*	*Ref.*	*comments*
					Burke, 1919. As pecan. Mentioned as food plant. Pre-dates Wellso & Manley, 2007.			
Castanea dentata	Fagaceae	Exotic (native to N Am). Ornamental	1B	Bright, 1987	5 species of the *femorata* complex (at the time) considered together. Mentions that some of the records may refer to other species in the complex. Publication pre-dates Wellso & Manley, 2007. Nelson *et al.,* 2008. Larvae. Not known if takes account of the separation in Wellso & Manley 2007. Burke, 1919-No life stage indicated. Pre-dates Wellso & Manley, 2007.			
Ceanothus cuneatus	Rhamnaceae	Exotic (native to W. N. Am.). No information found for EPPO				2	Burke, 1929	
Ceanothus sorediatus	Rhamnaceae	Exotic (native to endemic to California). No information found for EPPO.				1	Burke, 1919	Reared from
Celtis	Cannabaceae	Wild, ornamental, bonsai	2	van Driesche *et al.,* 2012	Attacked			
Celtis occidentalis	Cannabaceae	Exotic (native to E. N Am.). Ornamental	1B	Bright, 1987	5 species of the *femorata* complex (at the time) considered together. Mentions that some of the records may refer to other species in the complex. Publication pre-dates Wellso & Manley, 2007. Nelson *et al.,* 2008. Larvae. Not known if takes account of the separation in Wellso & Manley 2007. Burke, 1919. No life stage indicated. Pre-dates Wellso & Manley, 2007.			
Cercis canadensis	Fabaceae	Exotic (native to N Am)	1A	Wellso & Manley, 2007	Reared from. MacRae, 1991. Adults collected on trunks. Nelson *et al.,* 2008. Larvae. Not known if takes account of the separation in Wellso & Manley 2007. Burke, 1919 As redbud « food plant » and pre-dates Wellso & Manley, 2007.			
Cercis chinensis	Fabaceae	Exotic (native to China, Japan). Ornamental	2	Bright, 1987	As *C. japonica*. 5 species of the *femorata* complex (at the time) considered together. Mentions that some of the records may refer to other species in the complex. Publication pre-dates Wellso & Manley, 2007.			
Cercis reniformis	Fabaceae	Exotic (native to N. Am). Ornamental.	2	Burke, 1919	No life stage indicated. Pre-dates Wellso & Manley, 2007.			

Host plant	Family	Main use & availability in EPPO	*C. femorata*	*Ref.*	*Comments*	*C. mali*	*Ref.*	*comments*
Cercocarpus montanus	Rosaceae	Exotic (native to N. Am.). Burke (1919) mentions *C. parvifolius*, which currently seems to be synonym of *C. montanus* (Plant of the World Online, http://powo.science.kew.org/).				1	Burke, 1919	As '*C. parvifolius*'. Reared from
Cornus florida	Cornaceae	Exotic (native to Eastern N Am). Ornamental	1A	Wellso & Manley, 2007	citing Westcott pers. comm. Reared from. MacRae, 1991. Adults emerged from trunks of dead or living trees. Pre-dates Wellso & Manley, 2007.			
Cornus kousa	Cornaceae	Exotic (native to East Asia, naturalized in New York State). Ornamental	1A	Hansen *et al.*, 2012	Larvae, new host record.			
Corylus avellana	Corylaceae	Native. Wild, forest, fruit				1	Wiman *et al.*, 2019	larvae
Corylus cornuta subsp. californica	Corylaceae	Exotic (native to N. Am.). No information found for EPPO				1	Burke, 1929	As '*C. californica*' Although Burke does not provide details, it is very likely to be a host (N. Wiman, pers. comm.).
Cotoneaster	Rosaceae	Native (Palaearctic). Several species considered invasive in EPPO region.	2	Beddes & Caron, 2014	As 'cotoneaster'. No details given.	2	Burke, 1929	
Cotoneaster horizontalis	Rosaceae	Exotic (native to W China). Ornamental. Invasive alien species in some EPPO countries (CABI ISC)				2	Burke, 1929	
Crataegus	Rosaceae	Wild, forest, ornamental	1B	MacRae, 1991	Adults collected on trunks. Pre-dates Wellso & Manley, 2007. Nelson *et al.,* 2008. Larvae. Not known if takes account of the separation in Wellso & Manley 2007.			
Crataegus crus-galli	Rosaceae	Exotic (native to N Am). Ornamental	1B	MacRae, 1991	Adults emerged from trunks of dead or living trees. Publication pre-dating Wellso & Manley, 2007.			
Crataegus douglasii	Rosaceae	Exotic (native to N Am). Ornamental	1A	Wellso & Manley, 2007	citing Westcott pers. comm. Reared from.			
Crataegus viridis	Rosaceae	Exotic (native to N Am). Ornamental	1A	MacRae & Basham, 2013	Larval host.			

Host plant	Family	Main use & availability in EPPO	*C. femorata*	*Ref.*	*Comments*	*C. mali*	*Ref.*	*comments*
Crataegus × lavallei 'Carrierei'	Rosaceae	Native. Ornamental				2	Burke, 1929	As *C. carrierei*
Cydonia oblonga	Rosaceae	Native (Turkey, Central Asia). Wild?, fruit (Orhan *et al.,* 2014)	1B	Nelson *et al.,* 2008	Larvae. Not known if takes account of the separation in Wellso & Manley 2007. Burke, 1919. As quince. Mentioned as 'food plant'. Pre-dates Wellso & Manley, 2007.	2	Burke, 1929	
Diospyros virginiana	Ebenaceae	Exotic (native to SE USA). Ornamental.	1B	Nelson *et al.,* 2008	Larvae. Not known if takes account of the separation in Wellso & Manley 2007.			
Eriobotrya japonica	Rosaceae	Fruit				1	Burke, 1919	Reared from, killed
Eucalyptus	Myrtaceae	Exotic. Forest, wood, ornamental	1B	Burke, 1919	Attacked and killed (larvae assumed). Pre-dates Wellso & Manley, 2007.	2	Burke 1919	attack and kill (larvae assumed)
Eucalyptus globulus	Myrtaceae	Exotic (native to Australia). Ornamental, forest, plantations (one of the main eucalyptus in Europe) (http://www.fcba.fr/biotechnologie/fiches_essences/culiexa_eucalyptus2.pdf)	1B	Burke, 1919	Reared from. Pre-dates Wellso & Manley, 2007.	1	Burke, 1919	Reared from
Fagus	Fagaceae	Wild, forest, wood, ornamental	2	Burke, 1919	As 'beech'. Mentioned as 'food plant'. Pre-dates Wellso & Manley, 2007.			
Fagus grandifolia	Fagaceae	Exotic (native to Eastern N. Am.). Ornamental.	2	van Driesche *et al.,* 2012	Attacked			
Fagus sylvatica	Fagaceae	Native. Wild, forest, wood, ornamental				1	Burke, 1919/1929	Reared from / killed
Ficus carica	Moraceae	Native (middle East, W Asia). Wild (incl. naturalized), fruit				1	Burke, 1929	In branch
Frangula californica	Rhamnaceae	Exotic (native to Western N. Am.). No information found for EPPO region.				1	Burke, 1919	As *Rhamnus californica* Reared from.
Fraxinus pennsylvanica	Oleaceae	Exotic (native to N. Am.)	1B	Bright, 1987	5 species of the *femorata* complex (at the time) considered together. Mentions that some of the records may refer to other species in the complex. Pre-dates Wellso & Manley, 2007. Nelson *et al.,* 2008. Larvae. Not known if takes account of the separation in Wellso & Manley 2007.	2	Walker, 2014	'Associated with', no life stage indicated
Gleditsia triacanthos	Fabaceae	Exotic (native to E. and C. USA). Occasionally naturalized in C. and S. Europe. Ornamental.	2	MacRae, 1991	Adults collected on trunks. Pre-dates Wellso & Manley, 2007.			

Host plant	Family	Main use & availability in EPPO	*C. femorata*	*Ref.*	*Comments*	*C. mali*	*Ref.*	*comments*
		Planting promoted by NGO in Bulgaria as overstorey for pastures, in Australia deemed alien invasive in pastures.						
Heteromeles arbutifolia	Rosaceae	Exotic (native to W. N. Am.). Ornamental				1	Burke, 1919	Reared from
Juglans cinerea	Juglandaceae	Exotic (native to N. Am.). Wood (occasional), ornamental	1B	Nelson *et al.*, 2008.	Larvae. Not known if takes account of the separation in Wellso & Manley 2007.			
Juglans nigra	Juglandaceae	Exotic (native to N. Am). Wild (naturalized), wood, ornamental	1A	JKI, 2017	Intercepted on *Juglans nigra* in Germany. Bright, 1987 - 5 species of the *femorata* complex (at the time) considered together. Mentions that some of the records may refer to other species in the complex. Pre-dates Wellso & Manley, 2007. Nixon & McPherson, 1977. Nymph (i.e., larva). Publication pre-dates Wellso & Manley, 2007. Nix, 2013. Mentions larvae attacking *Juglans nigra*. General statement, no details. van Driesche *et al.,* 2012 – Attacked. Burke, 1919. No life stage indicated. Pre-dates Wellso & Manley, 2007. Nelson *et al.,* 2008. Larvae. Not known if takes account of the separation in Wellso & Manley 2007.			
Juglans regia	Juglandaceae	Native. Wild, wood, fruit, ornamental				1	Rijal & Seybold, 2019a	
Liquidambar styraciflua	Altingiaceae	Exotic (native to N. Am.). Ornamental	1B	Bright, 1987	5 species of the *femorata* complex (at the time) considered together. Mentions that some of the records may refer to other species in the complex. Pre-dates Wellso & Manley, 2007. Nelson *et al.,* 2008. Larvae. Not known if takes account of the separation in Wellso & Manley 2007.Burke, 1919 - No life stage indicated. Pre-dates Wellso & Manley, 2007.			
Liriodendron tulipifera		Exotic (native to N. Am.). Ornamental	2	van Driesche *et al.,* 2012	Attacked	1	Burke, 1929	killed
Malus	Rosaceae	Wild, forest, wood, fruit, ornamental	1B	MacRae, 1991	Adults emerged from trunks of dead or living trees. Publication pre-dates Wellso & Manley, 2007.			

Host plant	Family	Main use & availability in EPPO	*C. femorata*	*Ref.*	*Comments*	*C. mali*	*Ref.*	*comments*
					Nelson *et al.,* 2008. Larvae. Not known if takes account of the separation in Wellso & Manley 2007. Burke, 1919. Reared on apple. Does not mention which *Malus*. Pre-dates Wellso & Manley, 2007. Burke, 1919. - As 'apple'. Mentioned as food plant. Pre-dates Wellso & Manley, 2007. Bright, 1987. 5 species of the *femorata* complex (at the time) considered together. Mentions that some of the records may refer to other species in the complex. Publication pre-dates Wellso & Manley, 2007.			
Malus domestica	Rosaceae	Fruit, ornamental	1A	Eaton 2011	As cultivated apple. No host record was found in the "taxonomic" literature. However, several extensionpublications supporting damage in apple orchards (Ames, 2018; Eaton, 2011; Fenton, 1942). *Malus domestica* - van Driesche *et al.,* 2012. Attacked. As organic apple - Francis, 2009. *Malus pumila* General https://www.illinoiswildflowers.info/trees/plants/apple.html	1	Acheampong *et al.,* 2017, Burke, 1929	larvae "attacks" Homan, 2020
Malus sylvestris	Rosaceae	Native. Wild, fruit, rootstock for *M. domestica*	1A	Wellso & Manley, 2007	As *Pyrus malus.* Reared from.	1	Burke, 1919	As *Pyrus malus* Reared from
Osmaronia cerasiformis	Rosaceae	Exotic (native to W. USA). Ornamental				2	Burke, 1919	Taken 'larvae which appear to be this species' from this plant
Ostrya virginiana	Betulaceae	Exotic (native to Eastern N. Am.). Ornamental	1A	MacRae & Basham, 2013	Larval host			
Persea americana	Lauraceae	Fruit				2	Burke, 1929	*(as P. gratissima)*
Photinia serratifolia	Rosaceae	Exotic (native to E & SE Asia). Ornamental.				2	Burke, 1929	*As Photinia serrulata*
Pickeringia montana	Fabaceae	Exotic (native to California). No information found for EPPO region.				1	Burke, 1919	Reared from
Platanus occidentalis	Platanaceae	Exotic (native to N. Am.). Ornamental	1A	Wellso & Manley, 2007	Reared from MacRae, 1991. Adults collected on trunks. van Driesche *et al.,* 2012. Attacked.			

Host plant	Family	Main use & availability in EPPO	*C. femorata*	*Ref.*	*Comments*	*C. mali*	*Ref.*	*comments*
					Nelson *et al.,* 2008. Larvae. Not known if takes account of the separation in Wellso & Manley 2007. Bright, 1987. 5 species of the *femorata* complex (at the time) considered together. Mentions that some of the records may refer to other species in the complex. Publication pre-dates Wellso & Manley, 2007. Burke, 1919. As 'sycamore', with serious injury. Pre-dates Wellso & Manley, 2007 (note: sycamore in the USA is understood to be this species, not *Acer pseudoplatanoides*).			
Platanus orientalis	Platanaceae	Native, wild, ornamental				1	Burke, 1919	Reared from
Platanus racemosa	Platanaceae	Exotic (native to N. Am.). No information found for EPPO region				1	Burke, 1919	Reared from
Populus deltoides	Salicaceae	Exotic (native to N. Am.). Wood? Plantations	1A	Wellso & Manley, 2007	Reared from Burke, 1919. Reared from. Pre-dates Wellso & Manley, 2007.	2	Burke, 1929	
Populus fremontii	Salicaceae	Exotic (native to N. Am.). Ornamental (PRA *Euwallacea fornicatus*)	1A	Wellso & Manley, 2007	Reared from Burke, 1919. Reared from. Pre-dates Wellso & Manley, 2007.			
Populus nigra var. *italica*		Native. Plantation, ornamental. also plantation along roads, canals and in edges as windbreaks	1B	Burke, 1919	Larvae. Pre-dates Wellso & Manley, 2007.	2	Burke, 1919	Taken 'larvae which appear to be this species' from this plant.
Populus tremuloides	Salicaceae	Exotic (native to N. Am.). Ornamental	1A	Wellso & Manley, 2007	Reared from. Steed & Burton, 2015. Burke, 1919. Reared from. Pre-dates Wellso & Manley, 2007. Nelson *et al.,* 2008. Larvae. Not known if takes account of the separation in Wellso & Manley 2007.	1	Steed & Burton, 2015	Host, but not commonly attacked.
Populus trichocarpa	Salicaceae	Exotic (native to N. Am.). Forest, ornamental	1B	Burke, 1919	Reared from. As 'black cottonwood'. Pre-dates Wellso & Manley, 2007. The author also mentions 'small black cottonwood': 'destructive'.			
Prunus americana	Rosaceae	Exotic (native to Central and East N Am.). No information found for EPPO.	1B	Burke, 1919	Reared from. Pre-dates Wellso & Manley, 2007 (*P. americana* is a true host of *C. shawnee* - Wellso & Manley, 2007).			
Prunus armeniaca	Rosaceae	Fruit	1B	Nelson *et al.,* 2008	Larvae. Not known if takes account of the separation in Wellso & Manley 2007.	1	Burke, 1919	Reared from.

Host plant	Family	Main use & availability in EPPO	*C. femorata*	*Ref.*	*Comments*	*C. mali*	*Ref.*	*comments*
					Burke, 1919 - As 'apricot'. Mentioned as food plant. Pre-dates Wellso & Manley, 2007.			
Prunus avium	Rosaceae	Fruit				1	Burke, 1919	Reared from
Prunus cerasifera	Rosaceae	Native (Middle East). Wild, ornamental,				2	Burke, 1929	
Prunus cerasus	Rosaceae	Fruit				1	Burke, 1929	Most important pest of various fruit trees, incl.
Prunus domestica	Rosaceae	Fruit	1B	Burke, 1919	Reared from. Pre-dates Wellso & Manley, 2007. Burke, 1919. As plum (rearings, 'a few times') Pre-dates Wellso & Manley, 2007. Nelson *et al.,* 2008. Larvae. Not known if takes account of the separation in Wellso & Manley 2007.	1	Homan, 2020	"attacks" Burke, 1919 Reared from
Prunus dulcis	Rosaceae	Fruit				1	UC, 1999	Amongst wood boring beetles attacking almond in California. Strand & Ohlendrof, 1999 Burke, 1929 *as P. amygdalus*
Prunus ilicifolia	Rosaceae	Exotic (native to California, Baja California). No information found for EPPO.				1	Burke, 1919	Reared from
Prunus laurocerasus	Rosaceae	Native (SE Europe, SW Asia). Ornamental. Considered invasive alien in some EPPO countries (e.g. Ireland and Belgium)				2	Burke, 1929	
Prunus pendula	Rosaceae	Exotic (native to Japan). Ornamental. Considered by some as a syn. of *P. cerasus*, others as distinct species				1	Burke, 1919	Reared from
Prunus persica	Rosaceae	Fruit	1B	Burke, 1919	As 'peach'. Reared from and mentioned as food plant. Pre-dates Wellso & Manley, 2007. Nelson *et al.,* 2008. Larvae. Not known if takes account of the separation in Wellso & Manley 2007.	1	Burke, 1919	Reared from Mentioned as host in Homan, 2020.

Host plant	Family	Main use & availability in EPPO	*C. femorata*	*Ref.*	*Comments*	*C. mali*	*Ref.*	*comments*
					Bright, 1987. 5 species of the *femorata* complex (at the time) considered together. Mentions that some of the records may refer to other species in the complex. Publication pre-dates Wellso & Manley, 2007.			
Prunus serotina	Rosaceae	Exotic (native to N. Am). Wild (naturalized), wood, plantations. Invasive in some countries (EPPO List of IAP).	1A	Wellso & Manley, 2007	Reared from			
Prunus serrulata	Rosaceae	Ornamental				1	Burke, 1929	Killed
Prunus subcordata	Rosaceae	Exotic (native to Oregon, California). No information found for EPPO region.				1	Burke, 1919	Reared from
Pyracantha coccinea		Native (S Europe and W Asia).Ornamental				2	Burke, 1929	
Pyrus	Rosaceae	Includes native species. Fruit, ornamental	2	Burke, 1919	As 'pear'- Mentioned as food plant. Pre-dates Wellso & Manley, 2007. van Driesche *et al.,* 2012 Attacked.			
Pyrus calleryana	Rosaceae	Exotic (native to China & Vietnam). Ornamental.	2	MacRae & Basham, 2013	Adult host			
Pyrus communis	Rosaceae	Fruit	1A	Wellso & Manley, 2007	Reared from	1	Homan, 2020	Mentioned as host
Quercus	Fagaceae	Wild, wood, ornamental	1B	Muilenburg *et al.,* 2014	Emergence of adult from oak crown material, in abundance. The species is not specified, but at least *Q. rubra*, *Q. alba* and *Q. velutina* were present in the area covered by the study. Burke, 1919. As 'oak'. Mentioned as food plant. Pre-dates Wellso & Manley, 2007.			
Quercus agrifolia	Fagaceae	Exotic (native to California, Baja California). Ornamental.	1B	Burke, 1919	Reared from. Pre-dates Wellso & Manley, 2007. Nelson *et al.,* 2008. Larvae. Not known if takes account of the separation in Wellso & Manley 2007.	1	Burke, 1919	Reared from
Quercus alba	Fagaceae	Exotic (native to Central and Eastern N Am.).Ornamental.	2	Burke, 1919	No life stage indicated. Pre-dates Wellso & Manley, 2007. Nelson *et al.,* 2008. Larvae. Not known if takes account of the separation in Wellso & Manley 2007. van Driesche *et al.,* 2012. Attacked. Haack *et al.,* 1983. Pre-dates Wellso & Manley, 2007.			

Host plant	Family	Main use & availability in EPPO	*C. femorata*	*Ref.*	*Comments*	*C. mali*	*Ref.*	*comments*
Quercus chrysolepis	Fagaceae	Exotic (native to W. Mexico & USA). No information found for EPPO region.				2	Burke, 1929	
Quercus douglassii		Exotic (native to endemic to California). Ornamental, but apparently rare.	1B	Burke, 1919	Larvae which appear to be this species. No clear identification. Pre-dates Wellso & Manley, 2007.			
Quercus gambeli		Exotic (native to W. Mexico & USA). Ornamental (apparently rare).	1B	Burke, 1919	Reared from. Pre-dates Wellso & Manley, 2007.			
Quercus kelloggii	Fagaceae	Exotic (native to W USA). Ornamental (apparently rare).	1B	Burke, 1919	As *Q. californica*. Reared from. Pre-dates Wellso & Manley, 2007. Nelson *et al.,* 2008. Larvae. Not known if takes account of the separation in Wellso & Manley 2007.	2	Burke, 1919	As *Q. californica*. Taken 'larvae which appear to be this species' from this plant.
Quercus laurifolia	Fagaceae	Exotic (native to SE USA). Ornamental.	1B	Nelson *et al.,* 2008	Larvae. Not known if takes account of the separation in Wellso & Manley 2007.			
Quercus lobata	Fagaceae	Exotic (native to California). Ornamental.	1B	Burke, 1919	Reared from. Pre-dates Wellso & Manley, 2007. Nelson *et al.,* 2008. Larvae. Not known if takes account of the separation in Wellso & Manley 2007.			
Quercus michauxii	Fagaceae	Exotic (native to C & E USA). Ornamental.	2	Burke, 1919	As *Q. prinus*. No life stage indicated. Pre-dates Wellso & Manley, 2007.			
Quercus rubra	Fagaceae	Wild (naturalized), wood, ornamental. Considered invasive in some places	2	MacRae, 1991	Adults collected on trunks. Publication pre-dates Wellso & Manley, 2007. Haack *et al.,* 1983. Pre-dates Wellso & Manley, 2007.			
Quercus vaccinifolia		Exotic (native to Oregon and California). Ornamental (apparently rare).				2	Burke, 1929	
Quercus velutina	Fagaceae	Exotic (native to Eastern and Central N Am.). Ornamental.	2	van Driesche *et al.,* 2012	Attacked. Haack *et al.,* 1983 Pre-dates Wellso & Manley, 2007.			
Quercus wislizeni		Exotic (native to W. USA & Mexico). Ornamental (apparently rare).	1B	Burke, 1919	Reared from. Pre-dates Wellso & Manley, 2007. Nelson *et al.,* 2008. Larvae. Not known if takes account of the separation in Wellso & Manley 2007.			
Raphiolepis umbellata		Exotic (native to Korea and Japan). Ornamental				2	Burke, 1929	As *R. japonica*

Host plant	Family	Main use & availability in EPPO	*C. femorata*	*Ref.*	*Comments*	*C. mali*	*Ref.*	*comments*
Rhamnus crocea	Rhamnaceae	Exotic (native to Western N. Am.). No information found for EPPO region.				2	Burke, 1919	Taken 'larvae which appear to be this species' from this plant.
Ribes	Grossulariaceae	Wild, fruit	2	Burke, 1919	As 'currant'. Mentioned as food plant. Pre-dates Wellso & Manley, 2007.			
Ribes uva-crispa	Grossulariaceae	Native (Europe, Caucasus and N Africa). Wild, fruit				2	Burke, 1929	As gooseberry, serious pest, but older record.
Ribes rubrum	Grossulariaceae	Native (Europe). Wild, fruit.				1	Burke, 1919	Reared from
Ribes sanguineum	Grossulariaceae	Exotic (native to W. USA, Canada). Wild (widely naturalized), ornamental				2	Burke, 1929	
Rosa	Rosaceae	Wild, ornamental	1B	Fenton & Maxwell, 1937	Considerable damage (implying larvae). Pre-dates Wellso & Manley, 2007. Maxwell, 1935.	1	Burke, 1919	Reared from
Rubus vitifolius	Rosaceae	Exotic (native to Western N. Am.). No information found for EPPO region				2	Burke, 1929	
Salix	Salicaceae	Wild, ornamental, forest	2	Burke, 1919	As 'willow'. Mentioned as food plant. Pre-dates Wellso & Manley, 2007. van Driesche *et al.,* 2012. Attacked. Bright, 1987 - 5 species of the *femorata* complex (at the time) considered together. Mentions that some of the records may refer to other species in the complex. Publication pre-dates Wellso & Manley, 2007.			
Salix babylonica	Salicaceae	Exotic (native to China). Wild (naturalised), ornamental				2	Burke, 1919	Taken 'larvae which appear to be this species' from this plant.
Salix fragilis		Native (Europe, W. Asia). Wild, ornamental.				2	Burke, 1929	
Salix interior	Salicaceae	Exotic (native to N. Am.). Ornamental (apparently rare).	2	MacRae, 1991	Adults collected on trunks. Publication pre-dates Wellso & Manley, 2007.			

Host plant	Family	Main use & availability in EPPO	*C. femorata*	*Ref.*	*Comments*	*C. mali*	*Ref.*	*comments*
Salix laevigata	Salicaceae	Exotic (native to Southwestern N. Am.). No information found for EPPO region.	1B	Burke, 1919	Reared from. Pre-dates Wellso & Manley, 2007.	2	Burke, 1919	Taken 'larvae which appear to be this species' from this plant
Salix lasiolepis	Salicaceae	Exotic (native to Western N. Am.). No information found for EPPO region.	1B	Burke, 1919.	Reared from. Pre-dates Wellso & Manley, 2007. Nelson *et al.,* 2008. Larvae. Not known if takes account of the separation in Wellso & Manley 2007.	1	Burke, 1919	Reared from
Salix nigra	Salicaceae	Exotic (native to N. Am.). No information found for EPPO	1A	MacRae & Basham, 2013	Larval host			
Sorbus	Rosaceae	Wild, many ornamental species	2	Bright, 1987	5 species of the *femorata* complex (at the time) considered together. Mentions that some of the records may refer to other species in the complex. Publication pre-dates Wellso & Manley, 2007.			
Sorbus americana	Rosaceae	Exotic (native to Eastern N. Am.). Ornamental.	1B	Burke, 1919	As 'mountain ash'. Mentioned as food plant. Pre-dates Wellso & Manley, 2007. Nelson *et al.,* 2008. Larvae. Not known if takes account of the separation in Wellso & Manley 2007.			
Sorbus aucuparia	Rosaceae	Native. Forest, wild, ornamental, marginal use of fruit	2	MacRae, 1991	Adults collected on trunks.	1	Burke, 1919	Reared from
Tilia	Malvaceae	Wild, many ornamental spp., and some forestry	2	Burke, 1919	As linden. Mentioned as food plant. Pre-dates Wellso & Manley, 2007.			
Tilia americana	Malvaceae	Exotic (native to N. Am.). Ornamental	1A	MacRae & Basham, 2013	Larval host. Nelson *et al.,* 2008. As *Tilia glabra*. Larvae. Not known if takes account of the separation in Wellso & Manley 2007.			
Tilia cordata	Malvaceae	Native. Wild, forest, ornamental	2	MacRae, 1991	Adults collected on trunks. Publication pre-dates Wellso & Manley, 2007.			
Ulmus	Ulmaceae	Wild, forest, ornamental, bonsai	2	van Driesche *et al.,* 2012	Attacked			
Ulmus americana	Ulmaceae	Exotic (native to N. Am.). Ornamental	1A	Wellso & Manley, 2007	Reared from. Nelson *et al.,* 2008. Larvae. Not known if takes account of the separation in Wellso & Manley 2007.MacRae, 1991. Adults collected on trunks. Publication pre-dates Wellso & Manley, 2007.	1	Burke, 1919	Reared from
Ulmus glabra		Native, wild, forest, wood, ornamental.				1	Burke, 1919	*Ulmus scabra pendula*

Host plant	Family	Main use & availability in EPPO	*C. femorata*	*Ref.*	*Comments*	*C. mali*	*Ref.*	*comments*
								Camperdown elm. Reared from
Ulmus parvifolia	Ulmaceae	Ornamental, but mostly bonsai?	1B	Nelson *et al.*, 2008	Larvae. Not known if takes account of the separation in Wellso & Manley 2007.			
Ulmus rubra	Ulmaceae	Exotic (native to N. Am.) Ornamental	1A	MacRae & Basham, 2013	Larval host. MacRae, 1991. Adults collected on trunks. Publication pre-dates Wellso & Manley, 2007.			
Ulmus × hollandica		Wild, ornamental. (forest, but possibly not planted any longer ?)				1	Burke, 1919	As *Ulmus scabra huntingdoni* Huntingdon elm. Reared from
Vaccinium	Ericaceae	Fruit. Bush types likely to be suitable for *Chrysobothris* are only cultivated. Wild/native species are low plants with very small stems				1	Cahill, 2020, Haviland, no date	
Vaccinium corymbosum hybrids	Ericaceae	Fruit.				1		Found on Southern highbush blueberries in California (hybrids of *V. corymbosum* with species such as *V. virgatum*, *V. angustifolium* and *V. darrowii.* Haviland, no date; and D. Haviland, pers. comm.)
Vaccinium darrowii	Ericaceae	No data found if cultivated in EPPO (Dropsa project)	1A	Ashman & Liburd, 2019	As 'Southern highbush blueberries'. Larvae.			
Wisteria sinensis	Fabaceae	Exotic (native to China). Ornamental.				2	Burke, 1929	

<u>Additional notes</u>

- *Acer campestre* was reported as being attacked according to one of the tables in a publication of a study of the relative susceptibility of *Acer* species (Table 3, Seagraves *et al.*, 2013). However, this result was not supported by the text and another table in the publication (Table 2, Seagraves *et al.*, 2013). This apparent discrepancy was checked with the corresponding author and he stated that there was an error in Table 3 and that no attacks on *A. campestre* were found during the study (D. Potter, University of Kentucky). Further, an expert on *C. femorata* as a pest of *Acer* spp. had never observed attacks on *A. campestre* (A. Fulcher, University of Tennessee).

Because of the polyphagous nature of *C. femorata*, it is nevertheless possible that *A. campestre* might be attacked in settings where the trees are stressed by drought, soil compaction, poor planting, lawn mower wounds, or other factors.

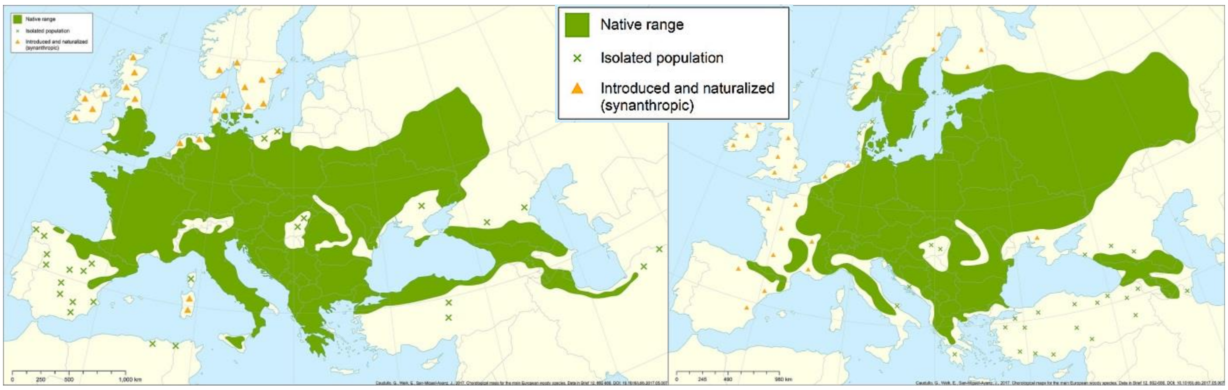
- *Quercus* host status is unclear. No record for *Quercus* spp. fulfils the criteria for Category 1 (*C. femorata s.s.*, immature stages) and Wellso & Manley (2007) state that: "*C. femorata* is not typically found on oaks". It is noted that *C. quadriimpressa* and *C. shawnee* (considered by some as possible synonyms of *C. femorata s.s.*) are associated almost exclusively with oaks (MacRae & Basham, 2013). Addesso (2019) mentions damage records on oaks as being frequent, but this relates to the *femorata* complex. In Michigan, the *C. femorata* species group is recorded as being part of the forest environment (captures in traps), especially associated to oaks (Redilla & McCullough, 2017). McCullough stated that although it seems very likely that the *C. femorata* beetles developed on oak, it was not explicitly shown in this study (pers. comm., 2021). Finally, Muilenburg et al. (2014) mentioned emergence of *C. femorata* from oak crown material (the *Quercus* species is not specified and the study seems to have been performed in 2004, i.e. it may relate to other species in the *femorata* complex). It is noted that if some species in the *femorata* complex are synonymised with *C. femorata* in the future, this would increase the number of confirmed hosts of *C. femorata*, most notably with several *Quercus* species.
- Addesso et al. (2019) provides a summary of genera on which *C. femorata* (complex) has been found associated with in the US National Plant Diagnostic Database damage reports for *Chrysobothris* species (2005-2019). Because these records are informational only, and are not confirmed, they have not been added to the host list. Some of the genera in Addesso (2019) are already on the host list with species supported by other references, and only few genera are not otherwise mentioned in the host list: *Fothergilla*, *Itea*, *Parrotia* and *Pinus*.
- In particular, *Pinus* is not considered a host. The record may relate to another species in the *femorata* complex (one species of the complex, *C. viridiceps*, has been recorded on *Pinus* in addition to deciduous woody plants – Paiero *et al.*, 2012). Another similar appearing and pine-attacking species (*C. cribraria* Mannerheim), not in the *C. femorata* complex, also could have been mistakenly identified. No other record of *C. femorata* on conifers was found.

ANNEX 5. Presence of hosts in the EPPO region

This Annex focuses on known host species (of economic, environmental or social interest) of *C. femorata* and *C. mali* (mainly from Category 1) that are native to the EPPO region or widely introduced, as well as some other species in the same genera occurring in the EPPO region. Information is provided for the following genera: *Acer*, *Betula*, *Carpinus*, *Carya*, *Corylus*, *Juglans*, *Malus*, *Prunus*, *Pyrus*, *Populus*, *Salix*.
Bold: Category 1A (for *C. femorata*) or 1 (for *C. mali*) hosts.
Not bold. Category 1B (*C. femorata*) or 2, or other species from the EPPO region that are not known to be hosts.

This annex is not exhaustive. Some information is summarized from recent EPPO PRAs and studies, which provide references (EPPO PRAs are available at www.eppo.int).

ACER. Acer platanoides and ***A. pseudoplatanus*** are widespread native species in the EPPO region. A third species is *A. campestre*, for which there is no known host record (see note in section 7). All three have also been planted extensively as ornamentals, including as urban trees. *A. campestre* is native from Europe to Russia and the Black Sea. In the wild, it is part of temperate mixed deciduous forests (Zecchin *et al.,* 2016). ***A. platanoides*** is widespread in central Europe to the Ural Mountains, and has a wide range from Mediterranean to Scandinavian countries. In the wild, it is a secondary species in temperate mixed forests, with conifers and broadleaves (Caudullo & de Rigo, 2016). ***A. pseudoplatanus*** is native to central, eastern and southern Europe, Caucasus and northern Minor Asia. It often dominates mixed softwood deciduous forests (Pasta *et al.,* 2016). Amongst native North American hosts, ***A. negundo*** has been widely used in the EPPO region as an ornamental, and is considered an invasive alien plant in many EPPO countries. It is widely available on the Internet and advertised as an easier alternative to ***A. saccharum*** for producing maple syrup. ***A. saccharum*** and ***A. rubrum*** are commonly used for ornamental purposes. All three have long been present in the region. Finally, *Acer* are also grown as bonsais (especially the Asian species *A. palmatum* or *A. japonicum*, but also species such as ***A. negundo*** and *A. campestre*).

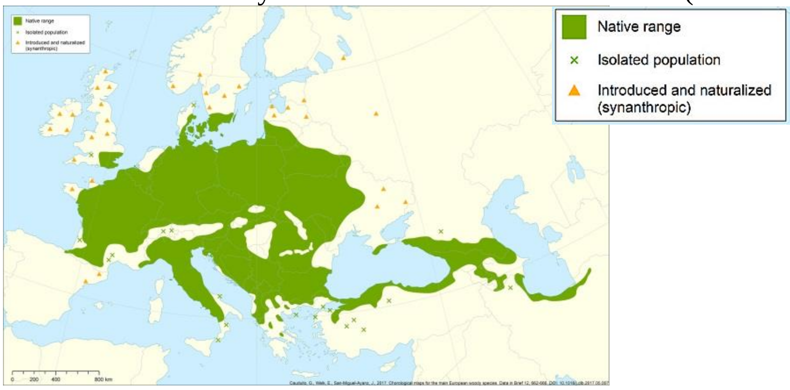


Acer campestre (Caudullo *et al.*, 2017) *Acer platanoides* (Caudullo *et al.*, 2017)

BETULA*.** Birches are widespread in the PRA area, both as forest and amenity trees. Birch as a stand-forming tree species are especially common in northern Europe and Russia, but also throughout western and central Europe. For the most part, birch is not present in the warmest Mediterranean areas, although there are some birch forests in Mediterranean mountainous habitats. The main species of birch in the western part of the PRA area in forests are *B. pendula* and ***B. pubescens, and are present in pure stands or as secondary species in mixed stands, with also *B. humilis* from central Europe to the eastern part of the PRA area. There are many native species of *Betula* in the EPPO region, especially in the east, including several rare and threatened species (see PRA on *Agrilus anxius* for a list). A number of Asian and American species are present in the PRA area in forests and woodlands (e.g. *B. davurica*, *B. ermanii, B. maximowicziana, B. platyphylla*, ***B. occidentalis, B. papyrifera***, *B. populifolia*). Many birch species are used as ornamentals in Europe (e.g. landscape, amenity areas, parks, private gardens, urban environment) including European, Asian and North American species, incl. ***B. pubescens* and *B. papyrifera***. Bonsai birch are produced from several birch species, including ***B. pubescens*** (EPPO, 2011a).

Betula pubescens (Caudullo *et al.*, 2017)

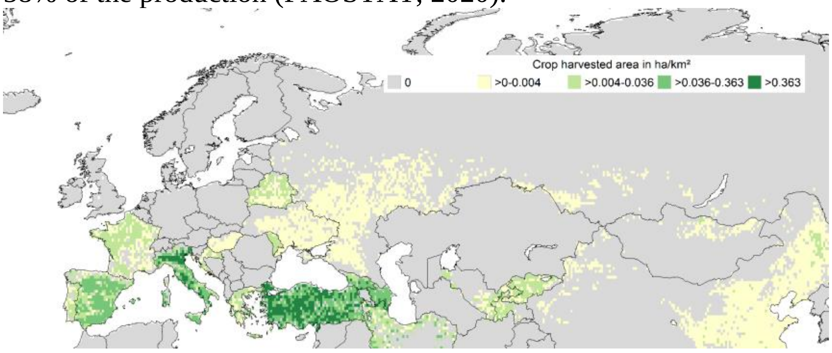
CARPINUS. ***Carpinus betulus*** is mostly a secondary species or understorey tree, as well as a coloniser of bare and disturbed soils. ***C. betulus*** grows mostly in mixed stands dominated by deciduous oaks, in association with species such as ***Prunus avium***, *Acer campestre* and ***Corylus avellana***, and can also be found in ***Fagus sylvatica*** forests. ***C. betulus*** generally does not occur in pure stands. Its wood has low commercial interest, and it has never been industrially cultivated. Used as an ornamental (Sikkema *et al.*, 2016).



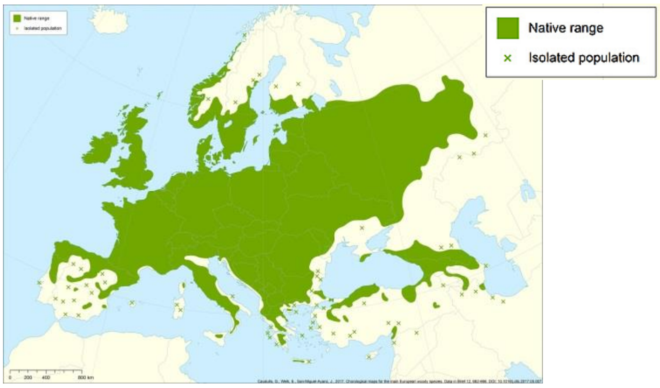
Carpinus betulus (Caudullo *et al.*, 2017)

CARYA. Carya illinoiensis is cultivated commercially in a very limited part of the region (e.g. NE Italy, Turkey mainly Antalya). Available as ornamental/fruit plant in nurseries (EPPO PRA on *Gymnandrosoma aurantianum*). Also limited cultivation in Spain (Ebro valley, Guadalhorce valley, Malaga, Murcia). At the moment, pecan production in Malaga is about 200 tonnes a year (Peláez, 2017).

CORYLUS. Corylus avellana is grown for nuts commercially mostly in the southern and eastern part of the region, also in gardens. It is also coppiced for wood production, at least in the southern UK (Woodland Trust, 2020). Its distribution extends throughout the EPPO region, and it is widespread in the wild. In 2019, Turkey, Italy and Azerbaijan accounted for 86% of the area cultivated with hazelnut worldwide and 79% of the world's production. Turkey was by far the largest producer worldwide, with 74% of the area (over 728.000 ha) and 58% of the production (FAOSTAT, 2020).



Corylus – commercial area **(**Monfreda *et al.*, 2008)



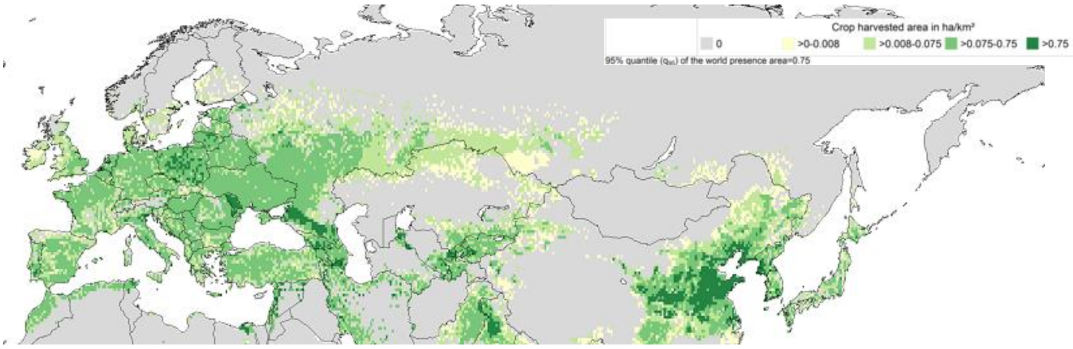
wild *Corylus* (Caudullo et al.caudullo, 2017)

JUGLANS. Juglans regia is the most widespread *Juglans* in the PRA area. It is used commercially for nuts and wood, and as an amenity tree. ***J. regia*** is native to Asia, possibly also to Central Europe and the Balkans, and locally naturalized in southern and western Europe. ***J. regia*** is important in the wild in Central Asia; in particular wild ***J. regia*** forests of Kyrgyzstan are unique in the EPPO region, as they cover large areas and are also grown as pure stands (unusual for ***J. regia***). ***J. regia*** also grows naturally in other parts of the region in the border of forests, in forested areas and in the mountains (e.g. Central Turkey). Commercial production of walnuts is recorded in most of the EPPO region (except Northern Europe and part of North Africa **-** except for Morocco, which has a substantial production). It is likely that there is some local or garden production in most countries. For silviculture, ***J. regia*** is planted in different cultivations systems as pure or mixed plantations, in agroforestry systems (alone or with cereal and fodder plants), or for combined nut and wood production.
J. nigra (North American origin) was introduced into Europe from North America in the 17th century, has been used as a forest tree since the 19th century and is acclimatized from Western Europe to Ukraine and Russia, through Central Europe. It has been planted for wood production in parts of Central and Eastern Europe, in pure or mixed stands. It is also available for sale as an ornamental (EPPO PRA on thousand cankers disease).
Other North American species of *Juglans* are reported as planted in the EPPO region, and are available as ornamentals, such as *J. cinerea* or *J. californica*. A number of Asian species also occur in the EPPO region, such as *J. ailantifolia* or *J. mandshurica*. Hybrid *Juglans* are used in the EPPO region, for example as forest trees (*J. nigra* × *J. regia*, ***J. regia*** with North American *Juglans* (***J. nigra***, *J. major*, *J. hindsii*) etc.). Many other species of various origins are available for sale in nurseries in Europe (EPPO PRA thousand cankers).

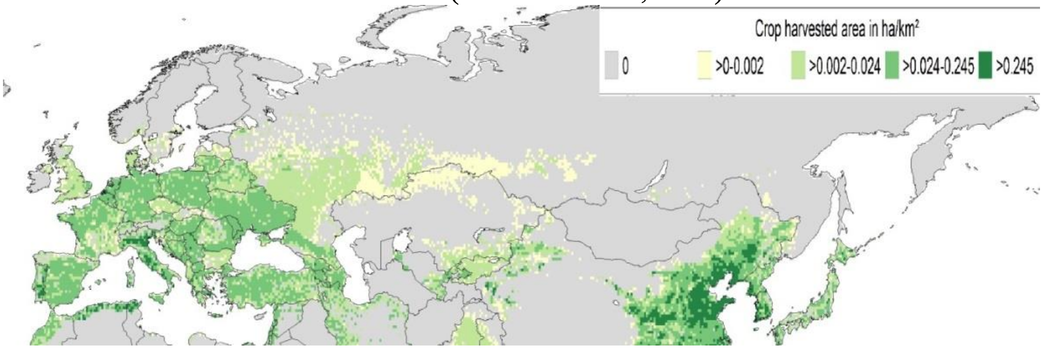
Juglans regia (Caudullo *et al.*, 2017)

MALUS* and *PYRUS
- ***Malus domestica*** is grown throughout the EPPO region, commercially and in gardens. Commercial cultivation occupies 1,474,114 ha, with more than 50% in 6 countries (Poland, Russia, Turkey, Ukraine, Uzbekistan and Belarus). In Russia and the countries of the Commonwealth of Independent States, apple trees are grown south of a line joining (roughly) Ladoga Lake in the West (60°North) to south of Sakhalin Island in the East (circa 45°North). A wide range of other *Malus* spp. are also used in the PRA area as rootstocks for other fruit trees and ornamentals. There are also wild *Malus* spp. in the PRA area (e.g. ***M. sylvestris***) and some native and endangered species (e.g. *M. niedzwetzkyana* and *M. sieversii*) (EPPO PRAs on *Oemona hirta* and *Meloidogyne mali*). ***M. sylvestris*** is widely distributed (map below) (this PRA).

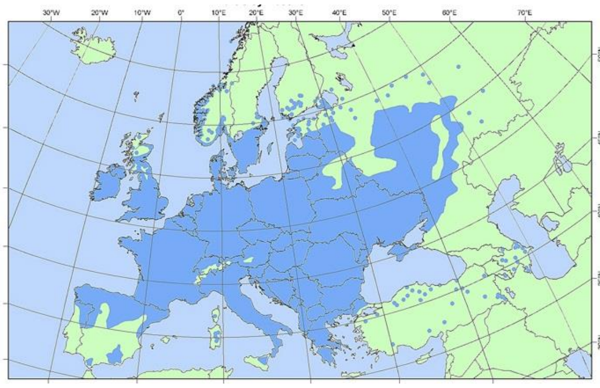
- ***Pyrus communis*** (this PRA) is grown commercially in a similar but slightly more southern areas than *Malus*, and ***P. communis*** is also grown in gardens. The wild *P. pyraster* is widespread.

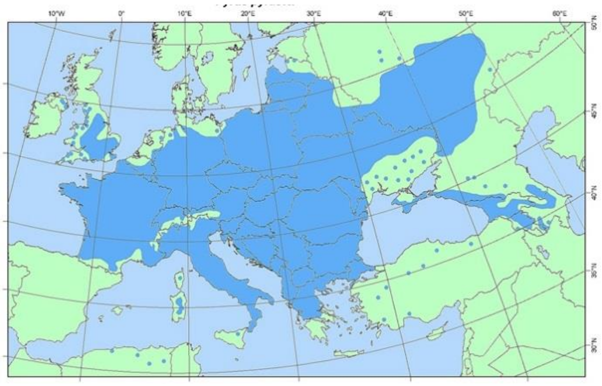


***Malus domestica* - commercial area** (Monfreda *et al.*, 2018)



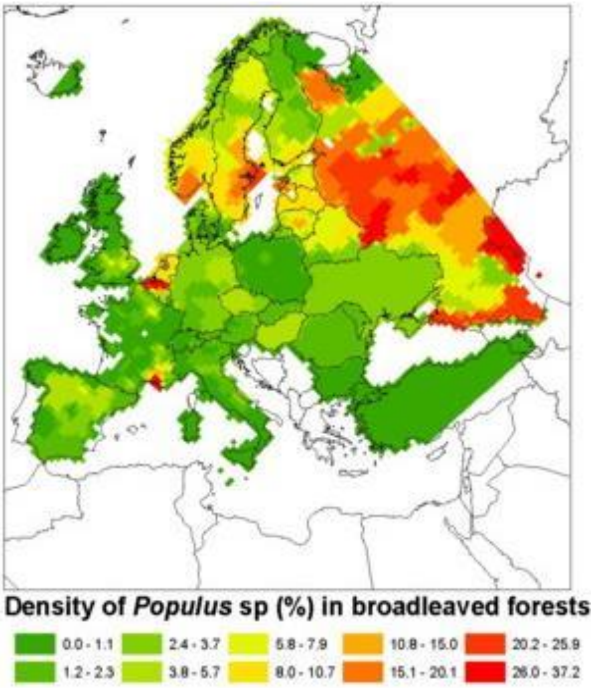
***Pyrus communis* – commercial area** (Monfreda *et al.*, 2018)





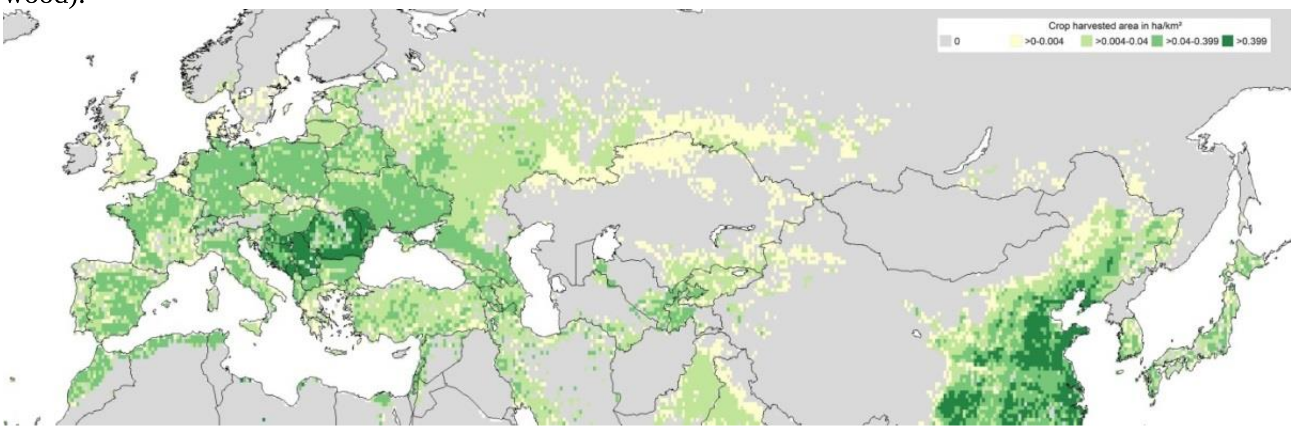
Malus sylvestris (EUFORGEN, 2021) *Pyrus pyraster* (EUFORGEN, 2021)

POPULUS* AND *SALIX. Poplars and willows are widespread and important species in the PRA area. They occur in indigenous forests (pure and mixed) and are grown extensively in commercial plantations for wood production, fibre, pulp and biofuel. The wood is used for construction, furniture, flooring, plywood, packaging, matches and firewood. Poplars and willows are also planted for environmental purposes, especially phytoremediation of polluted soils and water, carbon exchange and storage, forest landscape restoration, rehabilitation of degraded lands and combating desertification (EPPO, 2019c). They commonly are planted in rows to provide a windbreak (EPPO PRA on *Oemona hirta* citing others). Major planted *Populus* are *P. nigra* and *P. tremula*. *P. nigra* and *P. alba,* which are common in natural forests and riverine woodlands. *P. nigra* var. *italica* is the most ancient poplar cultivar and the one with the widest distribution. In Europe, the majority of the planted poplar genotypes (or clones or cultivars) are *Populus* × *canadensis*, i.e. hybrids between *P. nigra* and ***P. deltoides***, and *Populus* × *interamericana*. *P. tremula* has the largest native range of any species in the genus (from 40° to 70°N latitude), from Western Europe to North Africa through to central Siberia and China. There are other *Populus* spp. and *Salix* spp. in the PRA area, some of which are widespread and abundant (e.g. *P. canescens*) and others which are rare and endangered (e.g. *P. berkarensis*) (EPPO, 2019c). The known *Salix* host, ***Salix nigra*** is native to North America, and is available in nurseries in the EPPO region. Several *Populus* host species native to North America have been investigated for use in plantations in EPPO countries, such as ***P. deltoides*, *P. tremuloides*** and *P. trichocarpa* (FAO, 2016).



Populus sp. (Skjøth *et al.*, 2008)

PRUNUS. Present in a wide variety of habitats, including in the wild, planted as forest trees or orchards, and as landscape and ornamental trees. *Prunus* are widely cultivated commercially for fruit production and in gardens, such as cherries, plums, apricots, peaches and almonds. ***P. armeniaca*** and ***P. persica*** are grown commercially mostly in the southern part of the region but are also present further North in small holdings and gardens (as well as *P. persica* var. *nucipersica*). In the Western part of the EPPO region, ***P. avium***, ***P. cerasifera***, *P. mahaleb*, *P. padus* and *P. spinosa* are present in natural environments. (from EPPO PRA on *Candidatus* 'Phytoplasma phoenicium'). ***P. domestica*** is widely grown (map below). ***P. dulcis*** is grown commercially in the Mediterranean Basin and East to Uzbekistan (from EPPO PRA on *Candidatus* 'Phytoplasma phoenicium').
Native to North America, ***P. serotina*** (EPPO List of Invasive Alien Plants) is widespread in the EPPO region. It was introduced as early as the 17th century and planted as an ornamental, for wood production or soil amelioration; ***P. serotina*** has become invasive especially in those countries where it had been introduced for forestry use (EPPO, 2020b, EPPO study on the risk of bark and ambrosia beetles associated to non-coniferous wood).



Plum – commercial area (Monfreda *et al.*, 2018)

ANNEX 6. Definitions used in the EPPO Study on wood commodities
(EPPO, 2015c)

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 7. Trade data for wood commodities

Table 1. 'Industrial roundwood, non-coniferous non-tropical'. FAOSTAT

(Exports quantities from the USA and Canada, in m^3)

	Canada			USA		
	2015	**2016**	**2017**	**2015**	**2016**	**2017**
Albania					241	
Algeria				2085	1271	1373
Austria	1000	2000	399	8000	2000	10000
Belarus						1272
Belgium	1000		41	37000	29000	12000
Bosnia and Herzegovina					352	799
Croatia				447	420	
Cyprus					855	714
Czech Rep.	4000	1697		15000	1000	5000
Denmark		42		23000	19000	8000
Estonia				25477	19226	20027
Finland				6000	6000	7000
France	158	90	385	17000	22000	3593
Germany	7000	10000	2000	128000	119000	154000
Greece				3405	419	
Ireland	853			16419	10447	11845
Israel				15069	12977	11747
Italy		494		189000	175000	297000
Jordan				5021	5431	3533
Latvia						101
Lithuania				7000	2000	521
Luxembourg			5			7
Malta				4986	2426	929
Morocco				6994	5188	3709
Netherlands	221	3		17922	12470	7686
Norway	1230		363	15659	30245	36202
Poland				9000	3000	1000
Portugal				143000	112000	139000
Romania				1000	2000	2000
Russian Federation				659		
Slovenia	375	2	293	8696	2551	2686
Spain	8			95000	121000	62000
Sweden	4000	305		30000	24000	26000
Switzerland	608			1910	695	60
Turkey				167051	129065	99909
Ukraine					1248	2216
United Kingdom	27155	1554	101	280925	232048	22000
Total	**47608**	**16187**	**3587**	**1280725**	**1104575**	**953929**

Table 2. 'Sawnwood, non-coniferous all'. FAOSTAT

(Exports quantities from the USA and Canada, in m^3)

	Canada			USA		
	2015	**2016**	**2017**	**2015**	**2016**	**2017**
Albania				159	508	270
Algeria	26	427		293	286	85
Armenia	45	24		50		40
Austria	316	267	81	1000	1000	433
Azerbaijan						6
Belarus				347	436	236
Belgium	1000	1000	2000	11000	12000	12000
Bosnia and Herzegovina	9	2		25	56	69
Bulgaria		141	366	309	316	57
Croatia	52	104	139	28	149	142
Cyprus	76	148	316	635	794	1122
Czech Rep.		5	16	301	636	158
Denmark	1737	2023	1000	4286	7468	5000

	Canada			USA		
	2015	2016	2017	2015	2016	2017
Estonia	761	1080	1057	7626	7517	9696
Finland	335	192	225	2538	3099	2930
France	1000	1000	1000	5000	7000	5000
Georgia			511	266	152	107
Germany	10000	10000	9000	45000	53000	57000
Greece	160	345	145	3485	4693	3489
Hungary			95	79	17	
Ireland	2433	2559	1997	13196	15136	11699
Israel	1271	822	592	8922	7997	9300
Italy	2000	2000	1000	59000	57000	55000
Jordan	1138	1996	360	5082	4632	4771
Kazakhstan					17	
Kyrgyzstan				378		
Latvia		9	23	607	265	21
Lithuania	416	1000	1000	3000	3000	3000
Malta	291			2605	3411	2838
Morocco	2505	1920	799	3067	3246	2539
Netherlands	1000	2000	2000	7000	6000	6000
Norway	259	233	570	6659	6456	6964
Poland	498	394	138	3000	4000	3000
Portugal	1278	1441	2669	15690	17076	14852
Republic of Moldova			37		11	4
Romania				887	758	1142
Russian Federation	14	6	110	636	1072	589
Slovakia	23	26	2	6	23	25
Slovenia	42			70	93	3495
Spain	1000	1000	2000	45000	47000	48000
Sweden	433	1796	2091	15401	15565	11394
Switzerland	178	67	89	107	213	256
Tunisia	3		14			9
Turkey	4746	2699	2304	17140	11907	11398
Ukraine			6	4		14
United Kingdom	15000	13000	10000	95000	113000	145000
Total	**50045**	**49726**	**43752**	**384884**	**417005**	**439150**

Table 3. 'Fuel wood, in logs, billets, twigs, faggots or similar forms, non-coniferous (2017 onwards)'. Imports by EU countries. EUROSTAT

Quantities in 100 kg (0 means below 100 kg).

	Canada			USA		
	2017	2018	2019	2017	2018	2019
Denmark				104	0	120
Estonia						39
Finland				14		15
Germany			16		169	
Ireland					0	
Italy					0	0
Latvia				1140	1920	818
Netherlands					0	
Poland				0		
Romania					1	
Sweden					0	107
UK	279			7	7	59
Total	**279**		**16**	**1265**	**2097**	**1158**

Table 4. Round wood of birch. Imports by EU countries. EUROSTAT

Quantities in 100 kg (0 means below 100 kg).

Eurostat includes two different categories in each of the periods 2002-2016 and 2017 onwards (birch in the rough and sawlogs).

2015. Volumes were added for:

-Birch, 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 cut into boards or beams, etc.; wood treated with paint, stains, creosote or other preservatives)
-Sawlogs of birch, whether or not stripped of bark or sapwood, or roughly squared
2017 onwards: Birch "*Betula* spp." in the rough, of which any cross-sectional dimension is =>15 cm, whether or not stripped of bark or sapwood, or roughly squared (excl. sawlogs; wood in the form of railway sleepers; wood cut into beams, etc.; wood treated with paint, stains, creosote or other preservatives)
There was no recorded import of 'sawlogs of birch' in 2017-2019.

	Canada				USA			
	2015	**2017**	**2018**	**2019**	**2015**	**2017**	**2018**	**2019**
Czech rep.							0	
Denmark					946			
France	0				204			
Ireland			56					
Italy					597			
Portugal					445			
Total	**0**		**56**		**2192**			

Table 5. Round wood of poplar. Imports by EU countries. EUROSTAT
Quantities in 100 kg (0 means below 100 kg).
- Poplar in the rough, whether or not stripped of bark or sapwood, or roughly squared (excl. rough-cut wood for walking sticks, umbrellas, tool shafts and the like; wood cut into boards or beams, etc.; wood treated with paint, stains, creosote or other preservatives) (1988-2016)
- Poplar and aspen "*Populus* spp." in the rough, whether or not stripped of bark or sapwood, or roughly squared (excl. 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) (2017 onwards)

	Canada				**USA**			
	2015	**2017**	**2018**	**2019**	**2015**	**2017**	**2018**	**2019**
Germany								462
Spain					7 610			
Italy					1 916	466	73	
Finland			0					
Sweden					440	182	193	220
UK					404			
Greece								200
Total			**0**		**10370**	**648**	**266**	**882**

Table 6. Other deciduous round wood. Imports by EU countries. EUROSTAT
Quantities in 100 kg (0 means below 100 kg).
- Wood in the rough, whether or not stripped of bark or sapwood, or roughly squared (excl. rough-cut wood for walking sticks, umbrellas, tool shafts and the like; wood cut into boards or beams, etc.; wood treated with paint, stains, creosote or other preservatives, tropical wood of Subheading Note 1 to this chapter and coniferous wood, oak, beech, poplar, eucalyptus and birch wood) (2002-2016)
- Wood in the rough, whether or not stripped of bark or sapwood, or roughly squared (excl. rough-cut wood for walking sticks, umbrellas, tool shafts and the like; wood cut into boards or beams, etc.; wood treated with paint, stains, creosote or other preservatives, coniferous and tropical wood, oak, beech, birch, poplar, aspen and eucalyptus) (2017 onwards)

	Canada				USA			
	2015	**2017**	**2018**	**2019**	**2015**	**2017**	**2018**	**2019**
Belgium		4	103		405		12	20
Bulgaria								239
Czech Rep.	2744			0	8828	253	3158	16554
Denmark					7459	4994	317745	10338
Germany	380	767	1001	462	126143	102768	90029	92229
Ireland					195	0	0	0
Spain					10444	25828	24636	15843
France		208	243	247	817	190	0	0
Croatia								0
Italy				956	396591	372593	341250	240960
Luxembourg		2						
Hungary							209	
Netherlands			105	10	15506	3769	8652	7938
Austria				240	6528	2570	2146	2229

	Canada				USA			
	2015	**2017**	**2018**	**2019**	**2015**	**2017**	**2018**	**2019**
Poland					203	3	442	230
Portugal					44500	44590	49186	42625
Romania						776		
Slovenia					8017	970	859	1371
Finland					0	6	4	0
Sweden					554			
UK	6194	840	425	1	2662	2134	933	913
Total	**9318**	**1821**	**1877**	**1916**	**628852**	**561444**	**839261**	**431489**

Table 7. Maple "*Acer* spp.", sawn or chipped lengthwise, sliced or peeled, of a thickness of >6 mm (excl. planed, sanded or end-jointed) (2007-2500)**. Imports by EU countries. EUROSTAT**
Quantities in 100 kg (0 means below 100 kg).

	Canada				USA			
	2015	**2017**	**2018**	**2019**	**2015**	**2017**	**2018**	**2019**
Belgium	1026	896	1078	876	1335	842	1070	1453
Czech Rep.		20	20	0	44	16	20	12
Denmark	15	0	32	1				
Germany	16496	8507	12749	12304	9043	7735	6150	3637
Estonia					273		74	82
Ireland	391	159	73		589	1186	1182	644
Spain	758	3172	1881	2822	838	562	867	1286
France	1531	1384	1271	485	48			0
Croatia		247						
Italy	1111	238	360	902	450	385	348	681
Cyprus		105			19			36
Lithuania	2068	2926	3382	1706	787	251		
Luxembourg			1					
Malta			1			35		84
Netherlands	9548	780	592	1306	422	540	858	923
Austria	1784	735	1484	1486		232	252	
Poland	919				227			
Portugal	381	635	46	1221	1655	2637	3637	2246
Slovenia					227			
Slovakia								4
Finland	19			0		40	0	19
Sweden	397	1047	1235	500	78	37	124	23
UK	10861	12111	17515	21820	15150	13786	16227	15900
Greece						62	77	63
Total	**47305**	**32962**	**41720**	**45429**	**31185**	**28346**	**30886**	**27093**

Table 8. Maple "*Acer* spp.", sawn or chipped lengthwise, sliced or peeled, of a thickness of >6 mm, planed, or end-jointed, whether or not planed or sanded (2007-2500)**. Imports by EU countries. EUROSTAT**
Quantities in 100 kg (0 means below 100 kg).

	Canada				USA			
	2015	**2017**	**2018**	**2019**	**2015**	**2017**	**2018**	**2019**
Belgium	96	873	734	919		1	12	
Czech rep.			18	20	32	28	21	21
Denmark					14			
Germany	1	474		85	0	249	6	3
Ireland	235	416	110	319			316	18
Spain	427			160	1			1
France	244	336	784				10	
Italy	339	705	878	1 193		7		
Hungary		467						
Malta	79					36		
Netherlands	13	3 438	46	3 126	13		13	176
Austria				1				
Poland						6	2	4

	Canada				USA			
	2015	**2017**	**2018**	**2019**	**2015**	**2017**	**2018**	**2019**
Finland				0	112			0
Sweden		26	22	22	20	90	71	41
UK	554			280	181		125	228
Total	**1988**	**6735**	**2592**	**6125**	**373**	**417**	**576**	**492**

Table 9. Maple "*Acer* spp.", sawn or chipped lengthwise, sliced or peeled, of a thickness of >6 mm, sanded (excl. end-jointed) (2007-2500)**. Imports by EU countries. EUROSTAT**
Quantities in 100 kg (0 means below 100 kg).

	Canada				USA			
	2015	**2017**	**2018**	**2019**	**2015**	**2017**	**2018**	**2019**
Austria					0			
Czech Rep.								0
Finland	0	0						
Germany			2					
Ireland							0	0
Luxembourg				1				
Netherlands	98	162					6	
Poland						0	3	2
Slovenia							0	
Spain	5							
Total	**103**	**162**	**2**	**1**		**0**	**9**	**2**

Table 10. Cherry "*Prunus* spp.", sawn or chipped lengthwise, sliced or peeled, of a thickness of >6 mm (excl. planed, sanded or end-jointed) (2007-2500)**. Imports by EU countries. EUROSTAT**
Quantities in 100 kg (0 means below 100 kg).

	Canada				USA			
	2015	**2017**	**2018**	**2019**	**2015**	**2017**	**2018**	**2019**
Belgium					668	387	171	
Czech Rep.						0	72	
Denmark	108				28	580	83	
Germany	3 166	2 002	1 369	1 319	5 427	3 925	3 618	2 266
Estonia					19	50		
Ireland	100	117	44		328	313	653	22
Spain			74	97	650	429	528	320
France	6				74			
Italy		173	28	55	1 219	1 114	879	1 054
Lithuania	226	407		202			404	
Malta		152				24		15
Netherlands	3 455	234		187	1 084	819	265	195
Poland	119	64						
Portugal				34	335	49	226	380
Finland						34	70	
Sweden			36		282	369	380	86
UK	2 631	1 634	1 794	550	4 906	2 529	2 408	2 230
Greece						18	11	52
Total	**9811**	**4783**	**3345**	**2444**	**15020**	**10640**	**9768**	**6620**

Table 11. Cherry "*Prunus* spp.", sawn or chipped lengthwise, sliced or peeled, of a thickness of >6 mm, planed, or end-jointed, whether or not planed or sanded (2007-2500)**. Imports by EU countries. EUROSTAT**
Quantities in 100 kg (0 means below 100 kg).

	Canada				USA			
	2015	**2017**	**2018**	**2019**	**2015**	**2017**	**2018**	**2019**
Belgium	119	64	94	29				
Czech Rep.					0			
Ireland	119	126	178	60				
Spain	57							
Italy	183		54	33				
Cyprus							32	
Poland	241							

	Canada				USA			
	2015	2017	2018	2019	2015	2017	2018	2019
Sweden			109	14		31	20	66
UK	378	94		249	36		198	
Total	**1097**	**284**	**435**	**385**	**36**	**31**	**250**	**66**

Table 12. Cherry "*Prunus* spp.", sawn or chipped lengthwise, sliced or peeled, of a thickness of >6 mm, sanded (excl. end-jointed) (2007-2500)**. Imports by EU countries. EUROSTAT**
Quantities in 100 kg (0 means below 100 kg).

	Canada				USA			
	2015	2017	2018	2019	2015	2017	2018	2019
Netherlands	46							

Table 13. Birch "*Betula* spp.", sawn or chipped lengthwise, sliced or peeled, of a thickness of >6 mm (excl. planed, sanded or end-jointed) (2017 onwards)**. Imports by EU countries. EUROSTAT**
Quantities in 100 kg (0 means below 100 kg).

	Canada				USA			
	2015	2017	2018	2019	2015	2017	2018	2019
Italy		483				2 765	1 373	1 839
Lithuania							356	
Netherlands			0				0	
Finland						29		
UK				231		2 218	2 614	338
Total		**483**	**0**	**231**	**0**	**5012**	**4343**	**2177**

Table 14. Birch "*Betula* spp.", sawn or chipped lengthwise, sliced or peeled, of a thickness of >6 mm, sanded (excl. end-jointed) (2017 onwards)**. Imports by EU countries. EUROSTAT**
Quantities in 100 kg (0 means below 100 kg).

	Canada				USA			
	2015	2017	2018	2019	2015	2017	2018	2019
France							4	0
Luxembourg				0				

Table 15. Poplar, sawn or chipped lengthwise, sliced or peeled, of a thickness of >6 mm (excl. planed, sanded or end-jointed)**. Imports by EU countries. EUROSTAT**
Quantities in 100 kg (0 means below 100 kg).

	Canada				USA			
	2015	2017	2018	2019	2015	2017	2018	2019
Austria					1042			225
Belgium			593	565	1417	3626	7280	4238
Cyprus		116		190	1397	2443	3181	3960
Denmark						210	34	
Estonia					1952	209		1191
Finland	22	35				130		129
France					75			185
Germany	508	150	1834	504	429	1327	327	15
Greece					3074		812	1926
Ireland					13458	4785	3988	10466
Italy				247	13186	3807	5414	4528
Lithuania					220			
Malta					2615		2171	7439
Netherlands						105	100	825
Poland						1		
Portugal					3233	5370	5855	2176
Romania							32	
Spain					4107	340	1702	631
Sweden					1048	376		27
UK	1122	1129			131965	148797	150801	128912
Total	**1652**	**1430**	**2427**	**1506**	**179218**	**171526**	**181697**	**166873**

Table 16. Poplar and aspen "*Populus* spp.", sawn or chipped lengthwise, sliced or peeled, of a thickness of >6 mm, planed, or end-jointed, whether or not planed or sanded (2017 onwards)**. Imports by EU countries. EUROSTAT**

Quantities in 100 kg (0 means below 100 kg).

	Canada			USA		
	2017	2018	2019	2017	2018	2019
Belgium				202		
Ireland				505	1 059	416
France				42		
Cyprus				50		
Malta						247
Finland			216			
Sweden				45		
UK					377	
Greece						864

Table 17. Poplar and aspen "*Populus* spp.", sawn or chipped lengthwise, sliced or peeled, of a thickness of >6 mm, sanded (excl. end-jointed) (2017 onwards)**. Imports by EU countries. EUROSTAT**

Quantities in 100 kg (0 means below 100 kg).

	USA		
	2017	2018	2019
UK		15	

Table 18. Other deciduous sawn wood (except oak, beech, maple, cherry, ash, birch, poplar and aspen. Imports by EU countries. EUROSTAT

Quantities in 100 kg (0 means below 100 kg).

Wood, sawn or chipped lengthwise, sliced or peeled, of a thickness of >6 mm (excl. planed, sanded or end-jointed; tropical wood, coniferous wood, oak "*Quercus* spp.", beech "*Fagus* spp.", maple "*Acer* spp.", cherry "*Prunus* spp.", ash "*Fraxinus* spp.", birch "*Betula* spp.", poplar and aspen "*Populus* spp.") (2017 onwards)

	Canada			USA		
	2017	2018	2019	2017	2018	2019
Austria	180		520	4		473
Belgium	2432	1963	1411	48436	50526	64157
Bulgaria	302	310				
Cyprus	89	411	180	602	1356	1006
Czech Rep.				1368	1229	1517
Denmark	1414	606	1337	6410	3903	4539
Estonia	352			4322	2874	2474
Finland	18	92	45	746	575	532
France	362	71	332	4086	4849	3059
Germany	9394	12635	7936	122328	119566	120185
Greece	110		16	7918	6184	6057
Hungary	0					
Ireland	351	608	181	17050	17062	8477
Italy	1093	709	1701	197867	188141	137127
Latvia					19	
Lithuania	564	336		1786	1054	1730
Luxembourg			1			
Malta				12852	10066	6872
Netherlands	1078	2453	593	38073	42372	21351
Poland	193			5239	4224	2682
Portugal	406	285	126	15262	23344	22302
Romania				1305	746	
Slovakia					1	
Slovenia				166		
Spain	354	404	872	16069	13813	12945
Sweden	3	36	21	7375	5851	4630
UK	12263	12462	9882	74451	91295	88363
Total	**30958**	**33381**	**25154**	**583715**	**589050**	**510478**

Table 19. 'Wood chips and particles'. FAOSTAT

(Exports quantities from the USA and Canada, in m^3)

	Canada			USA		
	2015	**2016**	**2017**	**2015**	**2016**	**2017**
Austria	1			86		22
Belgium	20	10	37	1278		13
Czech Rep.		15		15	1	
Denmark		18	127	11000		
Finland	24		21	23	7	11
France			5	38000	28000	85000
Georgia				20		
Germany	1000	11	1000	18000	27000	193000
Greece		9	106			
Hungary		2	244	13		
Ireland				16		
Israel	2		354	8186	2	466
Italy	11	31	24	15000	37000	76000
Lithuania			228			
Malta		9	18			
Netherlands	1000	447	1000	9000	1	236
Norway				10		
Poland	4	2	1	1000	1	38
Portugal					11	5
Republic of Moldova					1	3
Russian Federation				10	3	2
Slovenia				18		22
Spain	84		75	29080	7	
Sweden	39	30	379	173		195
Switzerland		2		27		2
Turkey	460000	352000	236000	1703000	2246000	2168000
United Kingdom	107	70	92	8058	8	203
Total	**462292**	**352656**	**239711**	**1842013**	**2338042**	**2523218**

Table 20. 'Wood in chips or particles (excl. those of a kind used principally for dying or tanning purposes, and coniferous wood)' Imports by EU countries. EUROSTAT

Quantities in 100 kg (0 means below 100 kg).

	Canada				USA			
	2015	**2017**	**2018**	**2019**	**2015**	**2017**	**2018**	**2019**
Austria	6				180		0	0
Belgium		2	0	2	293	128	15	171
Bulgaria							201	4
Croatia								0
Cyprus							0	
Czech Rep.					37	7	8	11
Denmark	0		2	315373	1151	33	96	147
Estonia					1			
Finland				2	16	74	85	90
France					3727	2501	2750	3435
Germany			7	85	2736	449	404	178
Greece							0	
Hungary	0	32			62		4	4
Ireland							0	0
Italy					338	1116	763	473
Lithuania					0	1		0
Luxembourg								0
Malta		258	20	0		70	37	2
Netherlands	123	2	4	3	361	691	433	251
Poland	2				169	377	0	32
Portugal						55	151	91
Romania				1				2
Slovenia						0		
Spain					1949	4543	2865	1127
Sweden	1	1	202	9	23	10	5	14

UK		1		7	820	2018	1114	210
Total	**132**	**296**	**235**	**315482**	**11863**	**12073**	**8931**	**6242**

Table 21. 'Wood waste and scrap, not agglomerated (excl. sawdust)' (combining data for 2013-2016 & 2017 onwards). Imports by EU countries. EUROSTAT

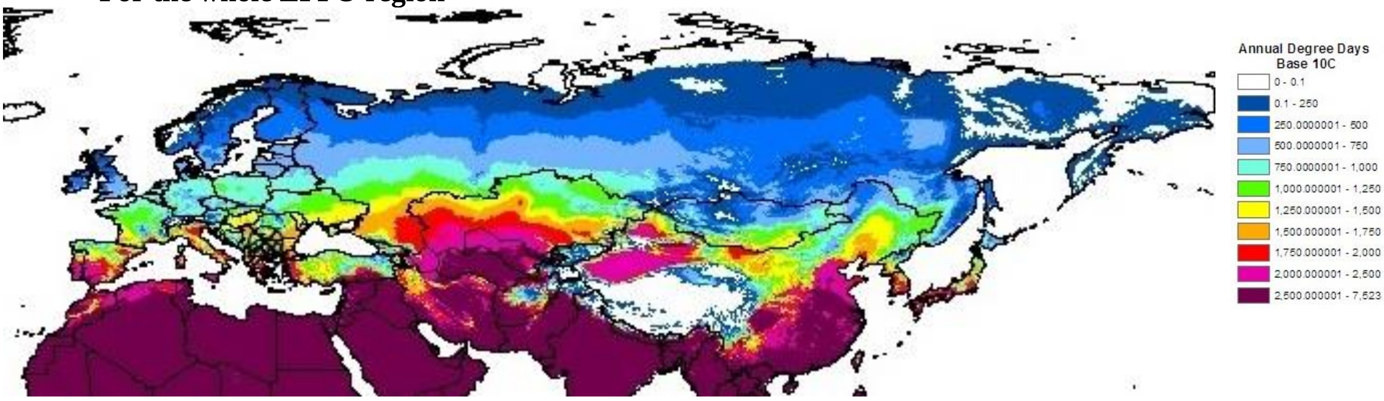
Quantities in 100 kg (0 means below 100 kg).

	Canada				**USA**			
	2015	**2017**	**2018**	**2019**	**2015**	**2017**	**2018**	**2019**
Belgium	172				3437	1		277
Bulgaria					1			
Czech rep.	0				129			
Denmark					0			
Germany					12273	10848	16402	15893
Estonia							0	
Ireland					0		2	0
Spain					0	0		0
France		7	54	29	2913	146330	539009	1539489
Italy					57	289	146	251
Latvia							41	
Hungary						0		
Netherlands					509		4	
Poland	5				0			0
Portugal					183			
Romania					1			
Slovenia					0		0	
Slovakia					9			
Finland						0		7
Sweden					5	0		0
UK				788	2692	138		26
Total	**177**	**7**	**54**	**817**	**22209**	**157606**	**555604**	**1555943**

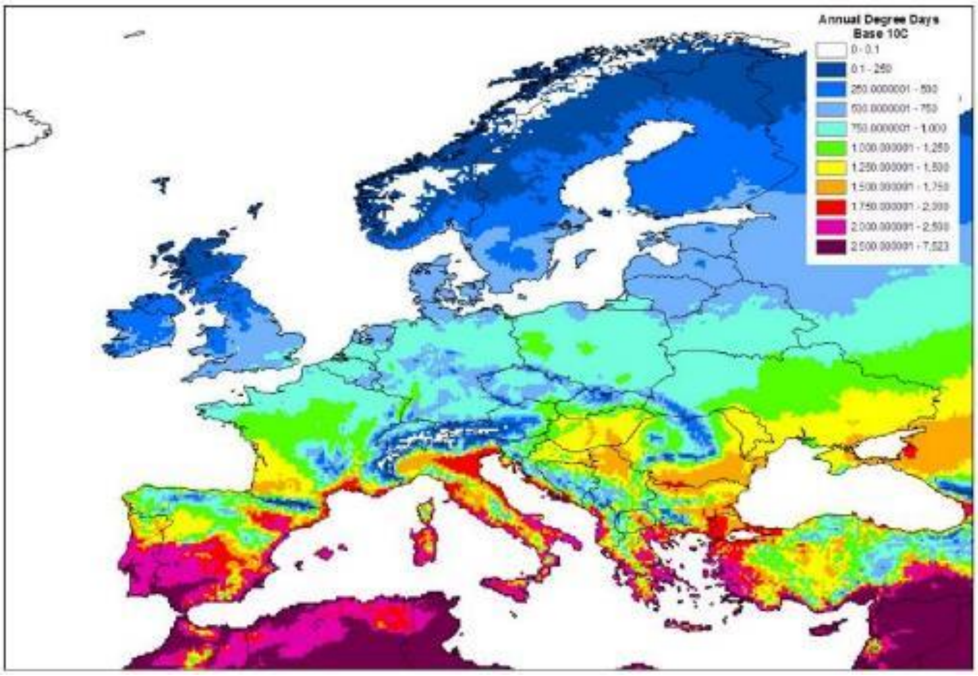
ANNEX 8. Climate in North America and the EPPO region

Fig. 1 Maps of temperature accumulation (Degree Days) based on a threshold of 10°C using 1961-90 monthly average maximum and minimum temperatures taken from the 10-minute latitude and longitude Climatic Research Unit database (New *et al.*, 2002). [Extracted from the world map in Annex 4 of Baker *et al.*, 2011]

- **For the whole EPPO region**



- **For Europe and the Mediterranean area**



- **For North-America**

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

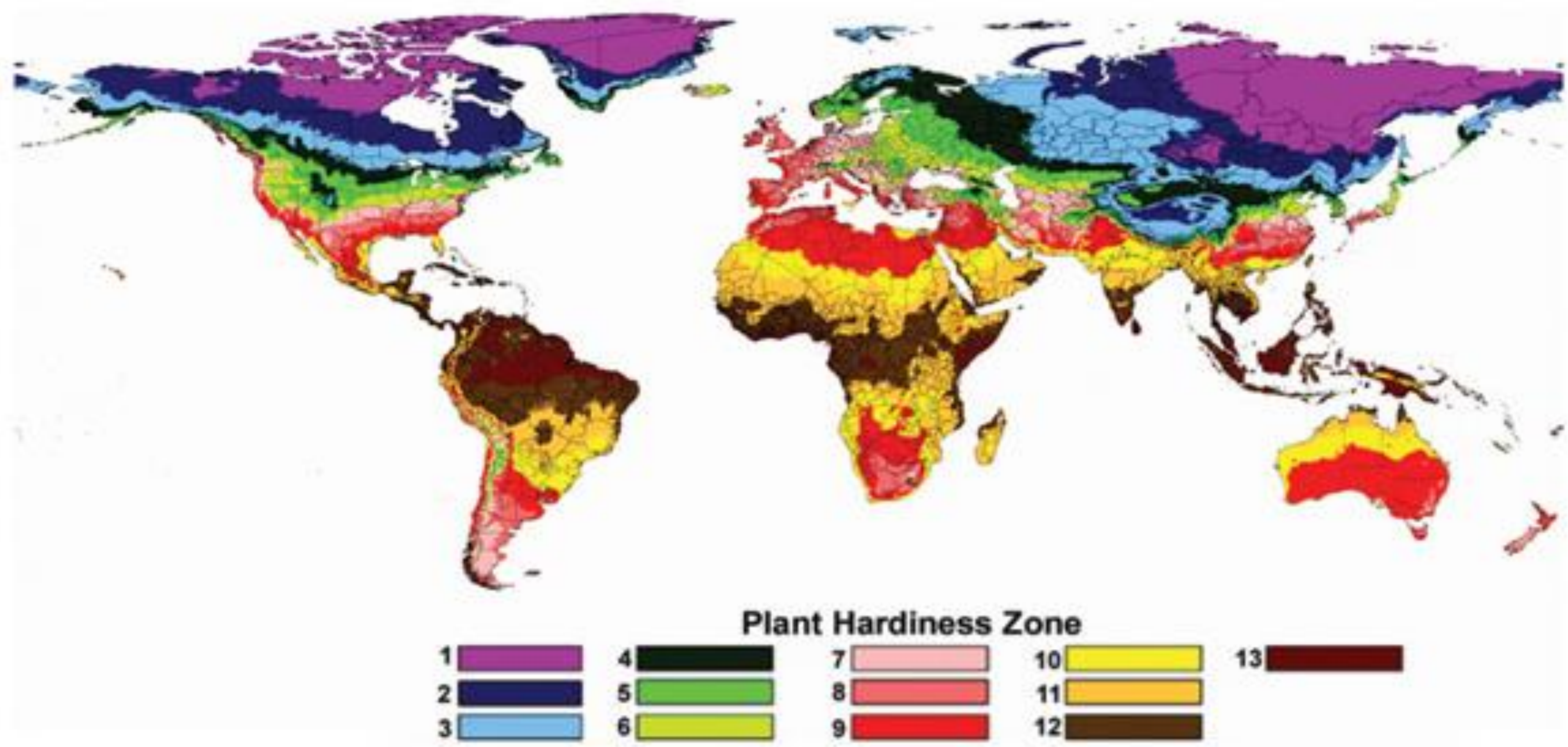


Fig. 3 Hardiness zones in Europe (prepared in the framework of the EU project PRATIQUE, based on Magarey et al. (2008)

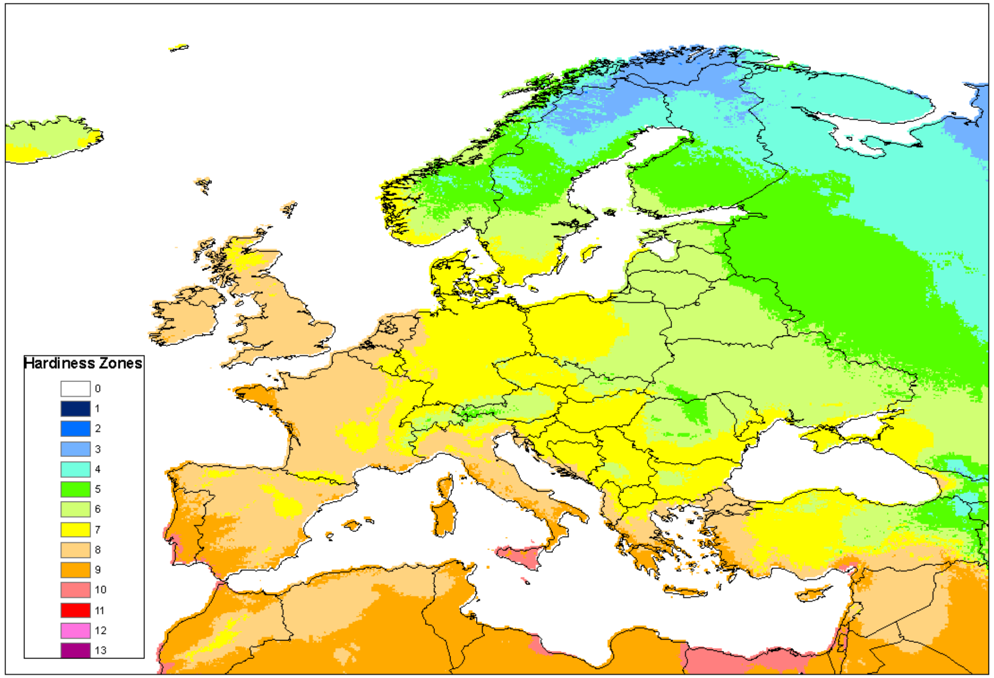


Fig. 4.

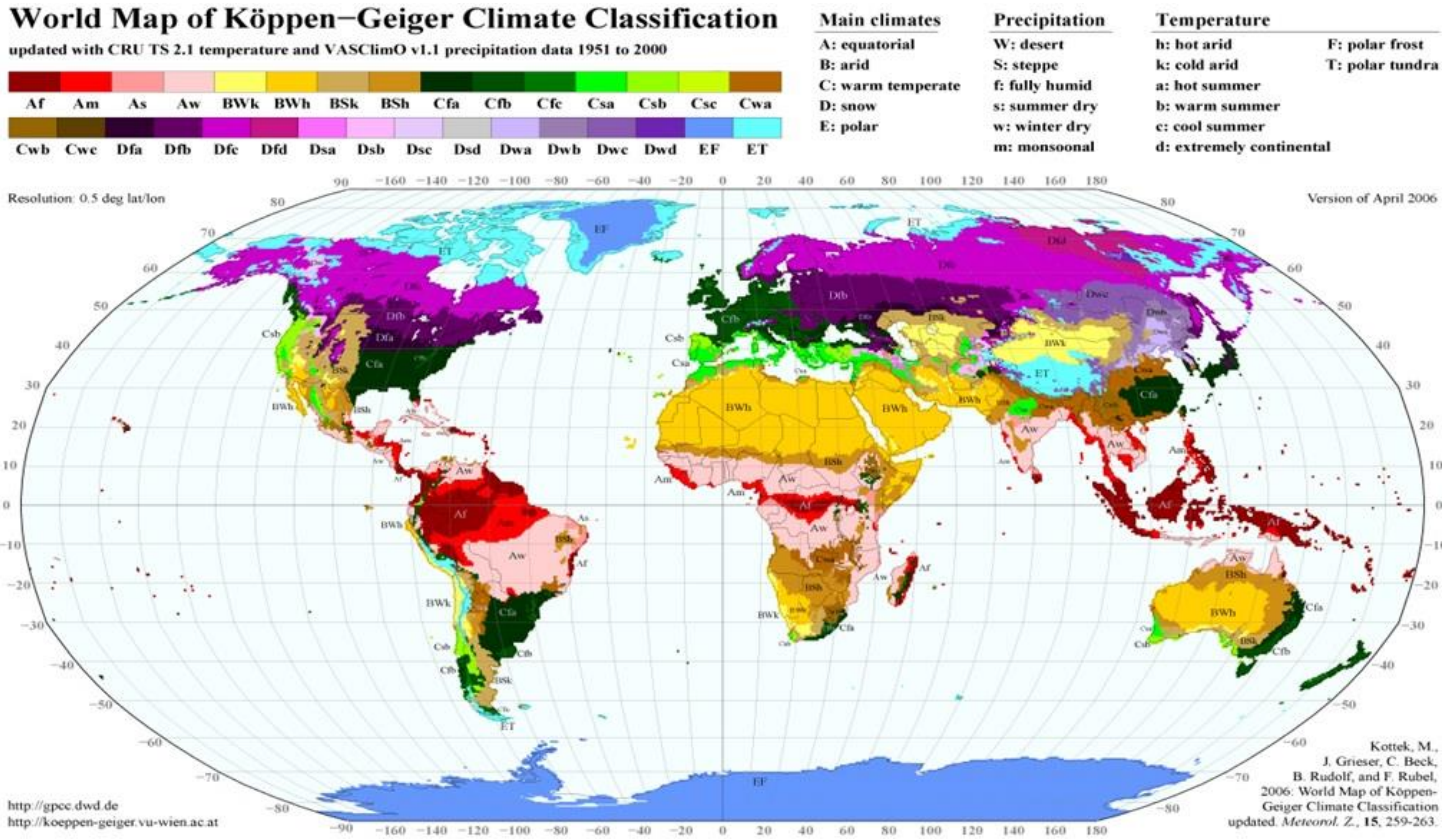

World Map of Köppen−Geiger Climate Classification
updated with CRU TS 2.1 temperature and VASClimO v1.1 precipitation data 1951 to 2000
Af Am As Aw BWk BWh BSk BSh Cfa Cfb Cfc Csa Csb Csc Cwa
Cwb Cwc Dfa Dfb Dfc Dfd Dsa Dsb Dsc Dsd Dwa Dwb Dwc Dwd EF ET
Main climates
A: equatorial
B: arid
C: warm temperate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

Fig. 5. Köppen-Geiger climate classification showing only climates that occur in the EPPO region (based on Rubel and Kottek (2010), adapted by Richard Baker, Fera, UK, August 2013 – EPPO Study on tomato fruit)

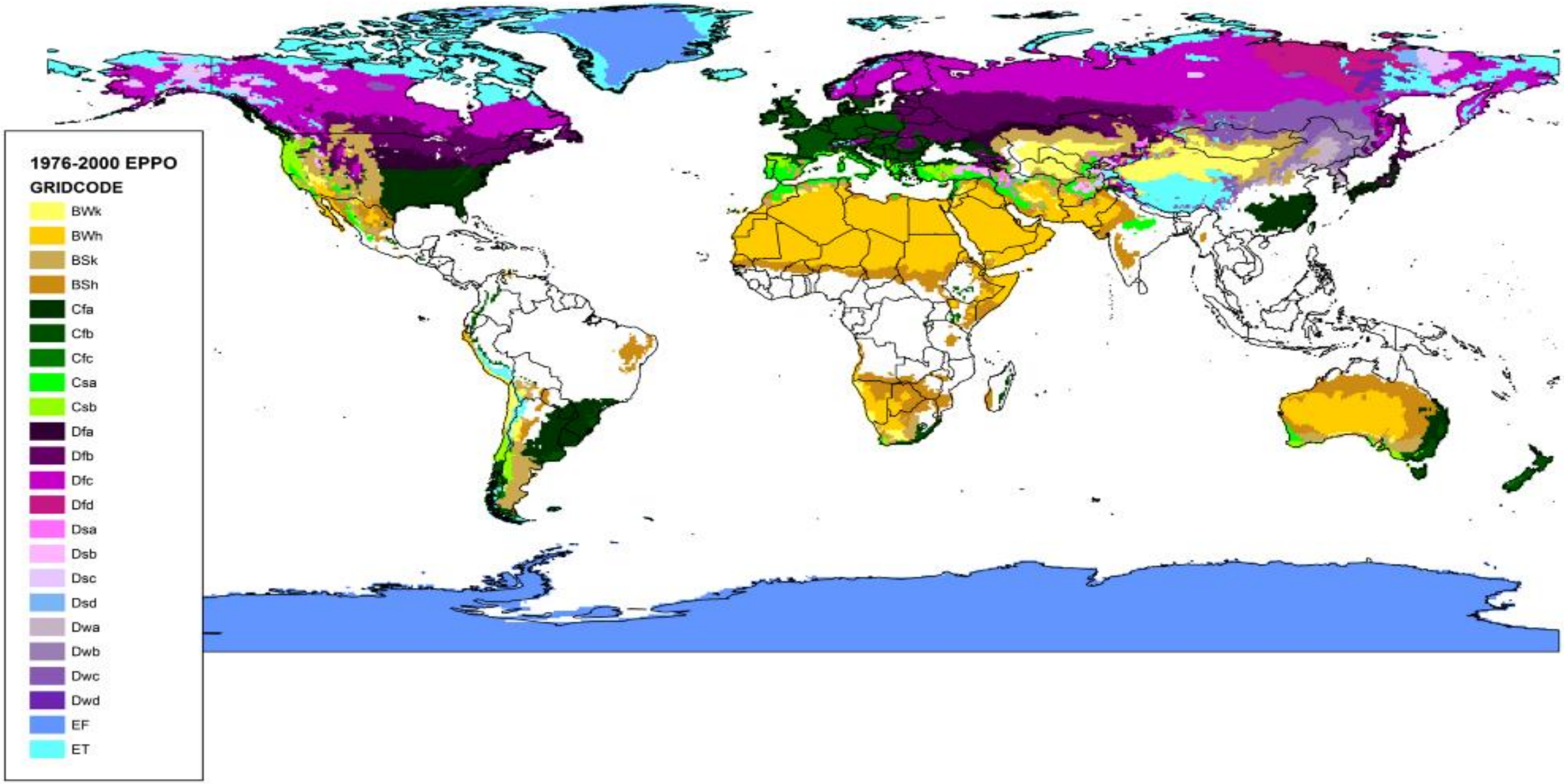
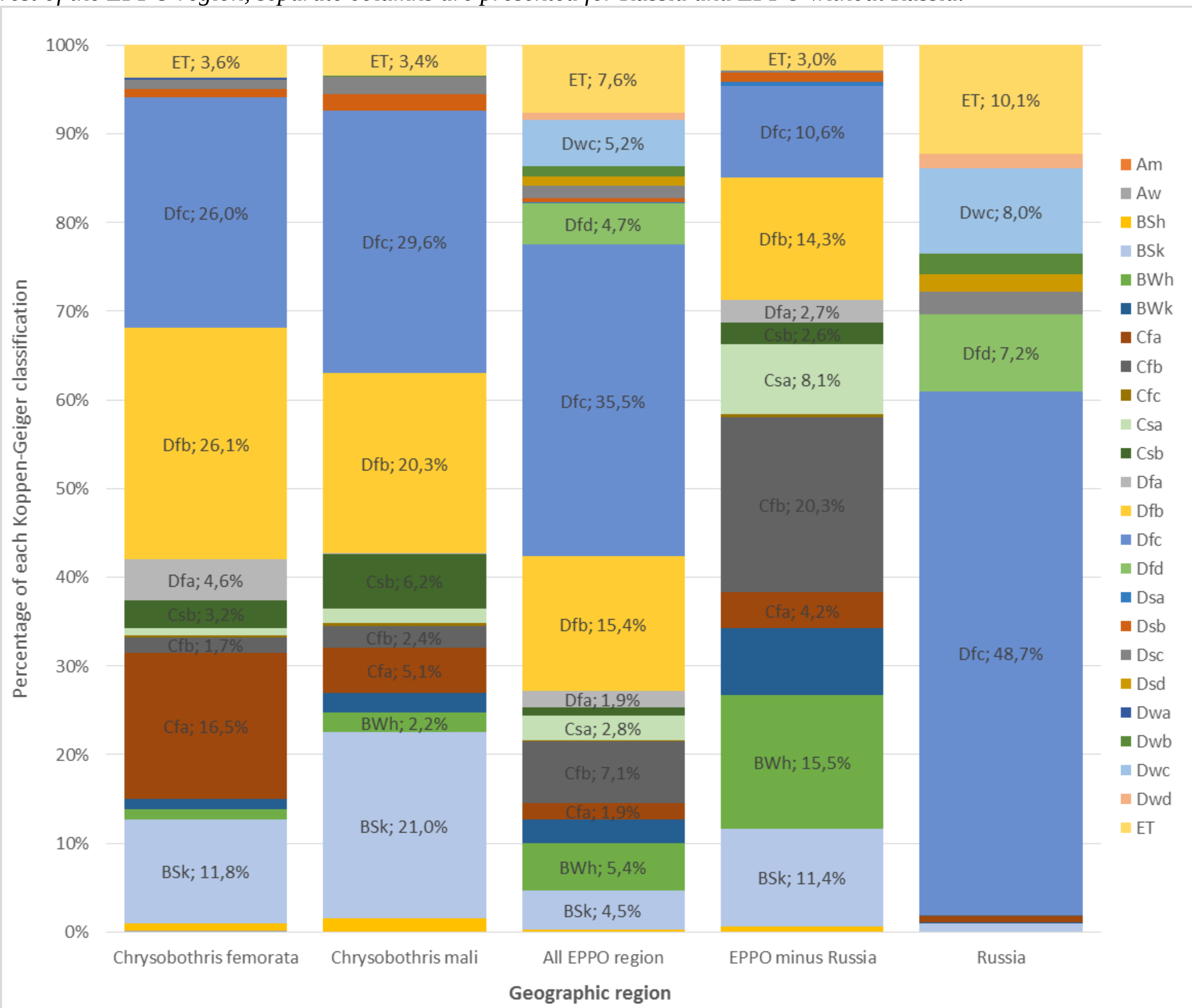


Fig. 6 Köppen Geiger climate types in the distribution of *C. femorata* and *C. mali*, and in the EPPO region. *Based on data from MacLeod & Korycinska (2019). Köppen-Geiger climate types that are represented in the distribution of* C. femorata *and* C. mali *(in terms of US States or Canadian provinces, not specific collection points, i.e. it is not known if the pests occur under all these climate types), as well as the climate types present in the EPPO region. The figure shows the percentage of grid cells in each Köppen-Geiger classification. All climate types that occur in the US states or Canadian provinces where* C. femorata *and* C. mali *occur are presented in the first two columns. The climate types that occur in the EPPO region are presented in the last three columns. Because Russia is so large compared to the rest of the EPPO region, separate columns are presented for Russia and EPPO without Russia.*



Notes.

- For *C. femorata*, the humid sub-tropical and oceanic, warm temperate, fully humid climates with hot summer [Cfa] and with warm summer [Cfb] are the only ones occurring in some southeastern states where the pest has been especially damaging, i.e. Tennessee, North Carolina and Alabama. Note that for *C. mali*, it was not possible to conduct a similar analysis because there are many climate types in California (10), Oregon (8) and British Columbia (10), but severe damage has been reported only from restricted areas.
- For both species, the Mediterranean climate types [Warm temperate, summer dry with hot or warm summers - Csa & Csb] are prevalent in California.
- *C. femorata* and *C. mali* probably do not occur, or only marginally, in the subarctic climate type [snow, fully humid, cold summer – Dfc], nor under the tundra climate [ET], both at the northern limits of their distribution in Canada and in parts of the Rocky Mountains in the USA.
- Arid, summer dry, cold arid [Bsk] : occurs in a large area in Western USA
- Arid, winter dry, cold arid [Bwk], winter dry, dry arid [Bwh]; summer dry, hot arid [Bsh]: occupy only a small area in North America.
- Humid continental [Snow, fully humid, hot or warm summer Dfa & Dfb], continental with dry winters [snow, winter dry, hot or warm summer Dwa, Dwb], warm temperate climates [fully humid, with cool summer Cfc; dry and cool summer Csc]: occupy a very limited area of the distributions of *C. femorata* and *C. mali* (less than 0.2% of grid cells, i.e. fewer than 460 grid cells).

ANNEX 9. Natural enemies of **C. femorata** *and* **C. mali**

Species mentioned in the literature as attacking *C. femorata* or *C. mali* include:

C. femorata - *Labena grallator*, *Cryptohelcostizus chrysobothridis* (Hymenoptera: Ichneumonidae); *Phasgonophora sulcata* (Hymenoptera: Chalicidae); *Eusandalum spp.* (Hymenoptera: Eupelmidae); *Heterospilus astigmus*, *Atanycolus rugosiventris* (Hymenoptera: Braconidae) (Fenton, 1942). *Spathius floridanus*, *Atanycolus charus*, *Atanycolus femoratae* (Hymenoptera: Braconidae), *Xorides neoclyti* (Hymenoptera: Ichneumonidae), *Trigonura californica*, *Trigonura elegans* (Hymenoptera: Chalicidae), *Metapelma spectabile* (Hymenoptera: Eupelmidae), *Tetrastichus holbeini*, *Horismenus carolinensis* (Hymenoptera: Eulophidae) (Capizzi *et al.*, 1982). *Chariessa pilosa*, *C. pilosa onusta* (Coleoptera: Cleridae), *Andrenosoma fulvicauda* (Diptera: Asilidae) (Hansen *et al.*, n.d.).

C. mali - *Atanycolus malii* (Hymenoptera: Braconidae), *Cryptohelcostizus alamedensis* (Hymenoptera: Ichneumonidae), *Euchrysia hvalinipennis* (Hymenoptera: Pteromalidae), *Trigonura californica* (Hymenoptera: Chalicidae), *Tetrastichus holbeini* (Hymenoptera: Eulophidae) (Capizzi *et al.*, 1982).

Trombiculidae (harvest mites) have been observed attacking *C. mali* larvae in galleries (Wiman pers. comm.) and the mite *Pyemotes ventricosus* (= *Pediculoides ventricosus*) was described as the most important natural enemy of *C. mali* in Oregon (Burke, 1929).

Woodpeckers may also consume larvae (Krischik & Davidson, 2013).