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Pest categorisation of *Saperda tridentata*

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Abstract

The EFSA Panel on Plant Health (PLHP) performed a pest categorisation of *Saperda tridentata* (Coleoptera: Cerambycidae) for the EU. *S. tridentata* (elm borer) occurs in eastern North America. *Ulmus americana* and *U. rubra* are almost exclusively reported as hosts, apart from two 19th century records from the USA of larvae from *Acer* sp. and *Populus* sp. The Panel does not exclude the possibility of a post-entry shift in host range to European *Ulmus* or *Acer* and *Populus*. *S. tridentata* infests trees that are already weakened, and severe infestations can result in tree death. *S. tridentata* occurs across a range of climate types in North America that occur also in Europe. Between 2016 and 2019, *S. tridentata* larvae were intercepted with North American *Ulmus* logs imported into the EU. In the EU, American *Ulmus* species are mainly found in arboreta and as ornamental specimen trees. If only North American *Ulmus* are hosts, establishment is unlikely. However, if European *Ulmus*, *Populus* or *Acer* species become hosts, establishment is much more likely, with impact confined to already weakened trees. The information currently available on geographical distribution, biology, impact and potential entry pathways of *S. tridentata* has been evaluated against the criteria for it to qualify as potential Union quarantine pest or as Union regulated non-quarantine pest (RNQP). Since the pest is not reported in EU, it does not meet the criteria assessed by EFSA to qualify as potential Union RNQP. *S. tridentata* satisfies the criterion for quarantine pest regarding entry into the EU territory. Due to the scarcity of data, the Panel is unable to conclude if *S. tridentata* meets the post-entry criteria of establishment, spread and potential impact.

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Keywords: Elm borer, longhorn beetle, pest risk, plant health, plant pest, quarantine, host range uncertainty

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1. Introduction

1.1. Background and Terms of Reference as provided by the requestor

1.1.1. Background

Council Directive 2000/29/EC¹ on protective measures against the introduction into the Community of organisms harmful to plants or plant products and against their spread within the Community establishes the present European Union plant health regime. The Directive lays down the phytosanitary provisions and the control checks to be carried out at the place of origin on plants and plant products destined for the Union or to be moved within the Union. In the Directive's 2000/29/EC annexes, the list of harmful organisms (pests) whose introduction into or spread within the Union is prohibited, is detailed together with specific requirements for import or internal movement.

Following the evaluation of the plant health regime, the new basic plant health law, Regulation (EU) 2016/2031 on protective measures against pests of plants, was adopted on 26 October 2016 and will apply from 14 December 2019 onwards, repealing Directive 2000/29/EC. In line with the principles of the above mentioned legislation and the follow-up work of the secondary legislation for the listing of EU regulated pests, EFSA is requested to provide pest categorisations of the harmful organisms included in the annexes of Directive 2000/29/EC, in the cases where recent pest risk assessment/pest categorisation is not available.

1.1.2. Terms of Reference

EFSA is requested, pursuant to Article 29(1) of Regulation (EC) No 178/2002, to provide a scientific opinion in the field of plant health.

EFSA is requested to prepare and deliver a pest risk assessment (step 1 and step 2 analysis) for *Saperda tridentata*. The opinion should address all entry pathways, spread, establishment and risk reduction options. As explained in the background, please pay particular attention to the pathway of wood of *Ulmus*.

1.1.2.1. Background

The new Plant Health Regulation (EU) 2016/2031, on the protective measures against pests of plants, will be applying from 14 December 2019. Provisions within the above Regulation are in place for the listing of "high risk plants, plant products and other objects" (Article 42) on the basis of a preliminary assessment, and to be followed by a risk assessment. Commission Implementing Regulation (EU) 2018/2019 is establishing a provisional list of high risk plants, plant products or other objects, within the meaning of Article 42 of Regulation (EU) 2016/2031. The import of commodities included in the above mentioned list will be banned from 14 December 2019, awaiting the outcome of a risk assessment. Wood of *Ulmus* L. originating from third countries or areas of third countries where *S. tridentata* is known to occur, is included in this list and its introduction into the Union shall be provisionally prohibited.

1.2. Interpretation of the Terms of Reference

European Food Safety Authority (EFSA) is to prepare and deliver a two-step pest risk assessment for *S. tridentata* Olivier (Coleoptera: Cerambycidae). The first step will be to subject *S. tridentata* to the process of pest categorisation to determine whether it fulfils the criteria, which are within the remit for EFSA to assess, for it to be regarded as a quarantine pest or of a regulated non-quarantine pest for the area of the European Union (EU) excluding Ceuta, Melilla and the outermost regions of Member States referred to in Article 355(1) of the Treaty on the Functioning of the European Union (TFEU), other than Madeira and the Azores. The second step will require EFSA to conduct a more detailed assessment of all entry pathways, spread, establishment and risk reduction options. Particular attention will be given to the pathway of wood of *Ulmus*.

The new Plant Health Regulation (EU) 2016/2031,² on the protective measures against pests of plants, will be applying from December 2019. The regulatory status sections (Section 3.3) of the

¹ Council Directive 2000/29/EC of 8 May 2000 on protective measures against the introduction into the Community of organisms harmful to plants or plant products and against their spread within the Community. OJ L 169/1, 10.7.2000, p. 1–112.

² Regulation (EU) 2016/2031 of the European Parliament of the Council of 26 October 2016 on protective measures against pests of plants, amending Regulations (EU) 228/2013, (EU) 652/2014 and (EU) 1143/2014 of the European Parliament and of the Council and repealing Council Directives 69/464/EEC, 74/647/EEC, 93/85/EEC, 98/57/EC, 2000/29/EC, 2006/91/EC and 2007/33/EC. OJ L 317, 23.11.2016, pp. 4–104.

present opinion are still based on Council Directive 2000/29/EC, as the document was adopted in November 2019.

2. Data and methodologies

2.1. Data

2.1.1. Literature search

A comprehensive literature search on *S. tridentata* was conducted at the beginning of the categorisation in the ISI Web of Science bibliographic database, using the scientific name and synonyms (Chapter 3.1.1) of the pest as search term. Relevant papers were reviewed, and further references and information were obtained from experts, as well as from citations within the references and grey literature.

Because of uncertainty around host plants, additional searches in the Biodiversity Heritage Library database (<https://www.biodiversitylibrary.org/>), and the JSTOR database (<https://www.jstor.org/>), were conducted using the scientific name of the pest and synonyms as a search term (more information in Appendix D).

2.1.2. Database search

Pest information, on host(s) and distribution, was retrieved from the European and Mediterranean Plant Protection Organization (EPPO) Global Database (EPPO, online) and relevant publications.

Data for the estimation of the import of elm wood were obtained from <https://www.americanhardwood.org/> and Eurostats.

Data about the area of hosts grown in the EU were obtained from the European Atlas of Forest Tree Species (<https://forest.jrc.ec.europa.eu/en/european-atlas/atlas-download-page/>).

The Europhyt database was consulted for pest-specific notifications on interceptions and outbreaks. Europhyt is a web-based network run by the Directorate General for Health and Food Safety (DG SANTÉ) of the European Commission and is a subproject of PHYSAN (Phyto-Sanitary Controls) specifically concerned with plant health information. The Europhyt database manages notifications of interceptions of plants or plant products that do not comply with EU legislation, as well as notifications of plant pests detected in the territory of the Member States (MS) and the phytosanitary measures taken to eradicate or avoid their spread.

2.2. Methodologies

The Panel performed the pest categorisation for *S. tridentata*, following guiding principles and steps presented in the EFSA guidance on quantitative pest risk assessment (EFSA PLH Panel, 2018) and in the International Standard for Phytosanitary Measures No 11 (FAO, 2014) and No 21 (FAO, 2004).

This work was initiated following an evaluation of potential high risk commodities to determine whether *S. tridentata* satisfied the criteria for it to qualify as a potential Union quarantine pest or a potential Union regulated non-quarantine pest in accordance with Regulation (EU) 2016/2031 on protective measures against pests of plants, and includes additional information required in accordance with the specific terms of reference received by the European Commission. In addition, for each conclusion, the Panel provides a short description of its associated uncertainty.

Table 1 presents the Regulation (EU) 2016/2031 pest categorisation criteria on which the Panel bases its conclusions. All relevant criteria have to be met for the pest to potentially qualify either as a potential quarantine pest or as a potential regulated non-quarantine pest. If one of the criteria is not met, the pest will not qualify. A pest that does not qualify as a quarantine pest may still qualify as a regulated non-quarantine pest that needs to be addressed in the opinion.

It should be noted that the Panel's conclusions are formulated respecting its remit and particularly with regard to the principle of separation between risk assessment and risk management (EFSA founding regulation (EU) No 178/2002); therefore, instead of determining whether the pest is likely to have an unacceptable impact, the Panel will present a summary of the observed pest impacts. Economic impacts are expressed in terms of yield and quality losses and not in monetary terms; addressing social impacts is outside the remit of the Panel (Table 1).

Table 1: Pest categorisation criteria under evaluation, as defined in Regulation (EU) 2016/2031 on protective measures against pests of plants (the number of the relevant sections of the pest categorisation is shown in brackets in the first column)

Criterion of pest categorisation	Criterion in Regulation (EU) 2016/2031 regarding Union quarantine pest	Criterion in Regulation (EU) 2016/2031 regarding Union regulated non-quarantine pest
Identity of the pest (Section 3.1)	Is the identity of the pest established, or has it been shown to produce consistent symptoms and to be transmissible?	Is the identity of the pest established, or has it been shown to produce consistent symptoms and to be transmissible?
Absence/ presence of the pest in the EU territory (Section 3.2)	Is the pest present in the EU territory? If present, is the pest widely distributed within the EU? Describe the pest distribution briefly!	Is the pest present in the EU territory? If not, it cannot be a regulated non-quarantine pest. (A regulated non-quarantine pest must be present in the risk assessment area).
Regulatory status (Section 3.3)	If the pest is present in the EU but not widely distributed in the risk assessment area, it should be under official control or expected to be under official control in the near future	Is the pest regulated as a quarantine pest? If currently regulated as a quarantine pest, are there grounds to consider its status could be revoked?
Pest potential for entry, establishment and spread in the EU territory (Section 3.4)	Is the pest able to enter into, become established in, and spread within, the EU territory? If yes, briefly list the pathways!	Is spread mainly via specific plants for planting, rather than via natural spread or via movement of plant products or other objects? Clearly state if plants for planting is the main pathway!
Potential for consequences in the EU territory (Section 3.5)	Would the pests' introduction have an economic or environmental impact on the EU territory?	Does the presence of the pest on plants for planting have an economic impact, as regards the intended use of those plants for planting?
Available measures (Section 3.6)	Are there measures available to prevent the entry into, establishment within or spread of the pest within the EU such that the risk becomes mitigated?	Are there measures available to prevent pest presence on plants for planting such that the risk becomes mitigated?
Conclusion of pest categorisation (Section 4)	A statement as to whether (1) all criteria assessed by EFSA above for consideration as a potential quarantine pest were met and (2) if not, which one (s) were not met	A statement as to whether (1) all criteria assessed by EFSA above for consideration as a potential regulated non-quarantine pest were met, and (2) if not, which one(s) were not met

3. Pest categorisation

3.1. Identity and biology of the pest

3.1.1. Identity and taxonomy

Is the identity of the pest established, or has it been shown to produce consistent symptoms and to be transmissible? (Yes or No)

Yes, *S. tridentata* is established as a recognised species.

S. tridentata Olivier, 1795 is a coleopteran in the family Cerambycidae. Synonyms include *Eutetrappa tridentata* (Olivier, 1795), *Compsidea tridentata* (Olivier, 1795) and *Saperda dubiosa* (Haldeman, 1847). In North America, *S. tridentata* is known as the elm borer (Bosik, 1997) or the elm tree borer.

The genus *Saperda* Fabricius, 1775, consists of around 42 species. Felt and Joutel (1904) reported 16 species from North America, but Bezark (2016) revised the genus and suggests that there are 15 species of *Saperda* in North America.

3.1.2. Biology of the pest

Much of the literature on the biology of *S. tridentata* was published in the late 19th century, when *S. tridentata* was first recognised as a pest of American elms, and during the first half of the 20th century when it was thought to vector *Ophiostoma ulmi*, a causal agent of Dutch elm disease. The disease arrived in North America in the 1930s but was primarily spread by the native elm bark beetle, *Hylurgopinus rufipes*. Dutch elm disease killed millions of American elm trees and they are no longer a prominent feature in natural or urban landscapes (Allen and Humble, 2002). Consequent to the great loss of elms, and decrease in the supply for elm wood, almost no studies have been conducted on *S. tridentata* in recent decades. Much of the recent literature that mentions *S. tridentata* are simply records of its spatial expansion, e.g. westwards into Saskatchewan (Heffern, 1998; Bousquet et al., 2013), Colorado (Heffern, 1998) and Idaho (Rice et al., 2017). The following is therefore taken mainly from older literature describing the natural history of the species rather than from papers reporting experimental studies.

Oviposition takes place at night. Females chew a slit in the bark of branches of hosts or on logs of *U. americana*, *U. rubra* or *U. crassifolia* in which a single egg is oviposited. A female can chew slits quite close together (Pechuman, 1940; Drooz, 1985; Campbell et al., 1989). Females living for a month or so can lay 50–60 eggs (Pechuman, 1940). Branches that have recently died or are weakened, stressed or are otherwise low in vitality are preferred for oviposition (Baker, 1941). Host trees that have been recently felled are also favoured (Craighead, 1923). Tucker (1907) found no evidence that *S. tridentata* attacked healthy trees. Pechuman (1940) also suggested that healthy trees are not attacked.

Eggs hatch after a few days and larvae chew through the bark into the sapwood (Perkins, 1890). Unlike many other cerambycid species, larvae of *S. tridentata* do not burrow deeply but tend to remain between the sapwood and bark. As larvae grow, the tunnels they create meander in all directions within the sapwood and inner bark. There are at least three larval instars (Perkins, 1890). Feeding loosens the bark which can be peeled away easily (Perkins, 1890; Pechuman, 1940). When abundant, tunnels can girdle branches and the host's trunk (Hoffmann, 1942). Once established in a damaged or weakened branch of a host, larvae can move to healthy areas (Pechuman, 1940) although Baker (1941) reported that only occasionally were larvae found in live branches.

Larvae overwinter under the bark and in sapwood. In the spring, they bore a small distance into sapwood to form a chamber 5–6 mm into the wood. Here they develop into pupae. However, in unfavourable conditions, some remain as larvae for another year before pupae are formed the following spring.

After eclosure adults can remain in the pupal chamber for up to 7 days. They eventually exit either via the larval tunnel leading into the chamber or gnaw a new tunnel through the wood, leaving via roundish exit holes (Pechuman, 1940). Adults emerge in late spring and early summer (Campbell et al., 1989). Adults emerging in May develop from pupae that take on average 24–27 days to develop whereas adults emerging in June develop from pupae that develop in 15–18 days (Pechuman, 1940). Males emerge first. Adults feed on the mid-rib and larger veins of host leaves, the surrounding leaf material, leaf petiole and the bark of young twigs (Craighead, 1923; Pechuman, 1940; Drooz, 1985). Adults can mate after 3 or 4 days of maturation feeding (Pechuman, 1940). Adults can fly and are most active at night; both males and females can be caught by light traps from May to August (Solomon et al., 1972; Gosling and Gosling, 1977). During the day adults shelter amongst foliage or bark (Pechuman, 1940). Adults live for 1 or 2 months.

There is usually one generation per year, but larvae hatching from eggs laid later in the summer e.g. during late July and August usually require an additional year to develop (Pechuman, 1940). When conditions are unfavourable for larval development, it may also take 2 years to complete development (Campbell et al., 1989). In wood that is dried out development may take 2 or 3 years (Pechuman, 1940).

3.1.2.1. Intraspecific diversity

Bousquet et al. (2013) list four subspecies of *S. tridentata*. However, no biologically relevant information could be found to justify considering them separately within this pest categorisation. The four are *S. tridentata dubiosa* Haldeman, 1847, *S. tridentata rubronotata* Fitch, 1858, *S. tridentata intermedia* Fitch, 1858 and *S. tridentata trifasciata* Casey, 1913.

3.1.3. Detection and identification of the pest

Are detection and identification methods available for the pest?

Yes, light traps can capture adults. Juvenile stages can be detected by visual inspections. Traditional morphological keys are available to identify larvae and adults to species.

Detection

As a species that spends the majority of its life within its host, *S. tridentata* is not easy to detect until the host shows symptoms. Symptoms of *S. tridentata* larval infestation include the premature yellowing of leaves by a month or so (Tucker, 1907), thinning foliage, a few high branches dying before the rest of the crown, frass and sawdust on branches. When heavily infested, bark becomes loosened and can easily be peeled back to reveal larval tunnels. The inner bark can be heavily mined (Felt and Joutel, 1904). Careful inspection of trees can reveal roundish emergence holes 4–4.5 mm in diameter. Large holes in leaf tissue surrounding the larger veins and young twigs dangling by a strip of bark as a result of being chewed by adults (Pechuman, 1940) could indicate adults infesting an elm.

Identification

Traditional morphological keys can be used to identify adults and larvae. Craighead (1923) provides a species key to larvae in the genus *Saperda*. Packard (1890) provides a detailed description of the larvae. Craighead (1923) provides a description of the pupae. Felt and Joutel (1904) describe the adult. An image of the adult is provided in Drooz (1985).

Mature larvae are whitish legless and rather flattened, 12–25 mm long (Drooz, 1985; Solomon, 1995). Adults are 9–17 mm long; males have antennae almost as long as their body, the antennae of females are shorter. The body is grey with three orange-yellow oblique bands on the elytra. There are twin black spots on each side of the pronotum and at the base of the elytra (Solomon, 1995).

3.2. Pest distribution

3.2.1. Pest distribution outside the EU

The genus *Saperda* occurs in temperate parts of the northern hemisphere (Felt and Joutel, 1904). *S. tridentata* is common in deciduous forests of eastern North America although it has been found as far west as Idaho (Rice et al., 2017). *S. tridentata* is not known to have spread outside North America. Figure 1 shows the known global distribution of *S. tridentata*.

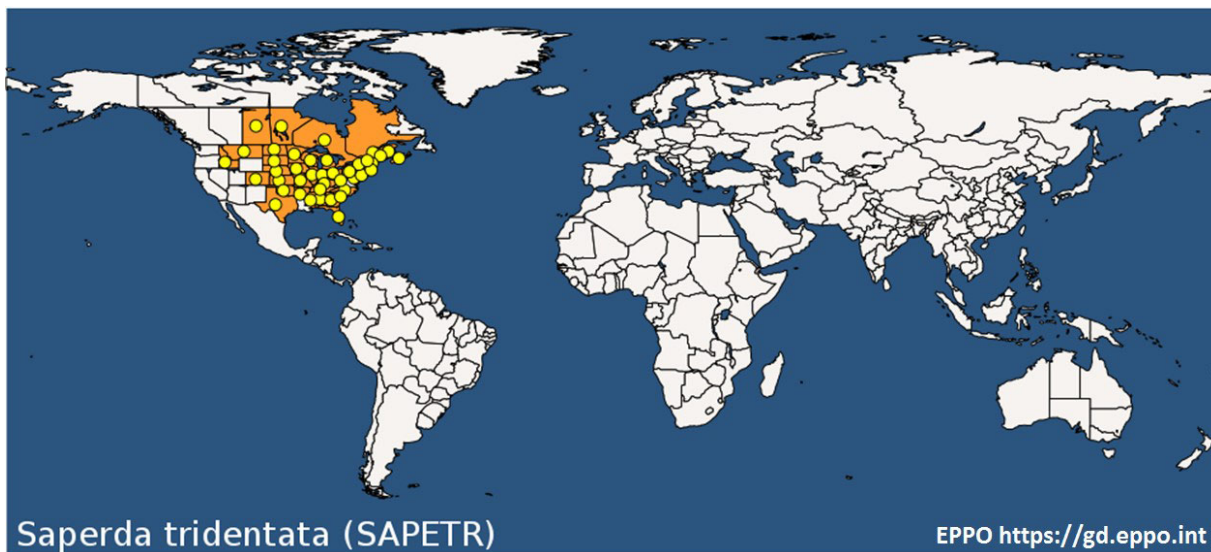


Figure 1: Global distribution of *S. tridentata* (last updated 7 November 2019). Extracted from the EPPO Global Database

3.2.2. Pest distribution in the EU

Is the pest present in the EU territory? If present, is the pest widely distributed within the EU?

No. *S. tridentata* is not known to be present in the EU.

3.3. Regulatory status

3.3.1. Council Directive 2000/29/EC

S. tridentata is not listed in Council Directive 2000/29/EC.

3.3.2. Legislation addressing the hosts of *Saperda tridentata*

The hosts range of *S. tridentata* is very uncertain (see Section 3.4.1). As a precaution, all legislation related to *Ulmus* species was included. *Ulmus* L. species comprise the major reported hosts of *S. tridentata*. Wood, cut branches and isolated bark of *Ulmus davidiana* Planch are controlled within Directive 2000/29/EC. Legislation relating to the genus *Ulmus* concerns the control of *Agrilus planipennis* (Annex IV A1, point 2.3, 2.4, 2.5), *Stegophora ulmea*, a pest listed in Annex II A I of the plant health directive 2000/29/EC, and *Candidatus* Phytoplasma ulmi (an Annex I A II pest). Tables 2 and 3 provide details of requirements pertaining to plants of *Ulmus* and *Candidatus* Phytoplasma ulmi).

Table 2: Regulated hosts and commodities that may involve *S. tridentata* in Annex IV of Council Directive 2000/29/EC

Annex IV Part A	Special requirements which must be laid down by all Member States for the introduction and movement of plants, plant products and other objects into and within all member states	
Section I	Plants, plant products and other objects originating outside the community	
	Plants, plant products and other objects	Special requirements
2.3	Whether or not listed among CN codes in Annex V, Part B, wood of [...], <i>Ulmus davidiana</i> Planch. [...] including wood which has not kept its natural round surface, and furniture and other objects made of untreated wood, originating in Canada, [...] and USA	Official statement that: (a) the wood originates in an area recognised as being free from <i>Agrilus planipennis</i> Fairmaire [...], or (b) the bark and at least 2.5 cm of the outer sapwood are removed in a facility authorised and supervised by the national plant protection organisation, or (c) the wood has undergone ionizing irradiation to achieve a minimum absorbed dose of 1 kGy throughout the wood.
2.4	Whether or not listed among CN codes in Annex V, Part B, wood in the form of chips, particles, sawdust, shavings, wood waste and scrap obtained in whole or in part from [...], <i>Ulmus davidiana</i> Planch. [...] originating in Canada, [...] USA	Official statement that the wood originates in an area recognised as being free from <i>Agrilus planipennis</i> Fairmaire [...].
2.5	Whether or not listed among CN codes in Annex V, Part B, isolated bark and objects made of bark of [...] <i>Ulmus davidiana</i> Planch. [...] originating in Canada, [...] and USA	Official statement that the bark originates in an area recognised as being free from <i>Agrilus planipennis</i> Fairmaire [...].
14.	Plants of <i>Ulmus</i> L., intended for planting, other than seeds, originating in North American countries	Without prejudice to the provisions applicable to the plants in Annex IV (A)(I)(11.4), official statement that no symptoms of <i>Candidatus</i> Phytoplasma ulmi have been observed at the place of production or in its immediate vicinity since the beginning of the last complete cycle of vegetation.

Table 3: Regulated hosts and commodities that may involve *S. tridentata* in Annex V of Council Directive 2000/29/EC

Annex V	Plants, plant products and other objects which must be subject to a plant health inspection ([...] — in the country of origin or the consignor country, if originating outside the Community) before being permitted to enter the community	
PART B	Plants, plant products and other objects originating in territories, other than those territories referred to in Part A	
Section 1	Plants, plant products and other objects which are potential carriers of harmful organisms of relevance for the entire Community	
6. (b)	Wood within the meaning of the first subparagraph of Article 2(2), where it meets one of the following descriptions laid down in Annex I, Part two to Council Regulation (EEC) No 2658/87:	
	CN Code	Description
	ex 4403 99	Non-coniferous wood (other than tropical wood specified in subheading note 1 to Chapter 44 or other tropical wood, oak (<i>Quercus</i> spp.), beech (<i>Fagus</i> spp.) or birch (<i>Betula</i> L.)), in the rough, whether or not stripped of bark or sapwood, or roughly squared, not treated with paint, stains, creosote or other preservatives
	ex 4407 99	Non-coniferous wood (other than tropical wood specified in subheading note 1 to Chapter 44 or other tropical wood, oak (<i>Quercus</i> spp.), beech (<i>Fagus</i> spp.), maple (<i>Acer</i> spp.), cherry (<i>Prunus</i> spp.) or ash (<i>Fraxinus</i> spp.)), sawn or chipped lengthwise, sliced or peeled, whether or not planed, sanded or end-jointed, of a thickness exceeding 6 mm

Commission Implementing Decision (UE) 2015/893 targeting *Anoplophora glabripennis* contains requirements to inspect plants and wood of *A. glabripennis* hosts which include *Ulmus* sp.

3.4 Entry, establishment and spread in the EU

3.4.1. Host range

Felt and Joutel (1904) report that *S. tridentata* feeds almost exclusively on white elm (*Ulmus americana*) although they recognise that red elm (*U. rubra*) can also be attacked. Solomon (1995) states that cedar elm (*U. crassifolia*) is also a host. MacRae (1993) reported finding adults of *S. tridentata* on *Ulmus alata* (winged elm, native to south central and south east USA). Whether or not *U. alata* is a host suitable for breeding is unknown.

Table 4: Binomial and common names of key elm species referred to within this pest categorisation and notes related to their occurrence in Europe

<i>Ulmus</i> species	Common name	Host status*	Notes in relation to occurrence in Europe
<i>U. americana</i>	American elm white elm water elm	Major	This species has been introduced in Europe but does not grow well as it is more susceptible to insect foliage damage than native European elms and is susceptible to Dutch elm disease. It grows in European arboreta (Source: Botanic Gardens Conservation International database - https://tools.bgci.org/global_tree_search.php), could be present in private gardens and parks as it is sold in horticultural trade. Abundance and density uncertain
<i>U. crassifolia</i>	cedar elm Texas cedar elm	Minor	Grows in European garden arboreta (Source: Botanic Gardens Conservation International database – https://tools.bgci.org/global_tree_search.php)
<i>U. rubra</i>	slippery elm red elm	Minor	Introduced to Europe in 1830 (White and Moore, 2003)
<i>U. alata</i>	Winged elm	Uncertain; minor host if a host at all	One of three American elm species known to be cultivated in UK as an ornamental in the early 1800s (Main, 1839), now rare. Could be present in private gardens and parks as it is sold in horticultural trade also as a bonsai. Abundance and density uncertain

<i>Ulmus</i> species	Common name	Host status*	Notes in relation to occurrence in Europe
<i>U. glabra</i>	mountain elm wych elm Scots elm Scotch elm	No evidence of being a host	Wide range across most of Europe, from UK to Siberia, including Turkey. Previously widely planted as an ornamental in urban parks and along roadsides but no longer used as such due to its susceptibility to Dutch elm disease. http://www.euforgen.org/species/ulmus-glabra/
<i>U. minor</i>	field elm smooth-leaved English elm (in US?)	No evidence of being a host	Mainly in southern European regions by banks of small streams http://www.euforgen.org/species/ulmus-minor/
<i>U. laevis</i>	European white elm Russian elm	No evidence of being a host	Occurs across Central and Eastern Europe and is relatively rare. http://www.euforgen.org/species/ulmus-laevis/

*: Major = most common host reported in literature. Minor = very few references in the literature.

The literature does not report species of European elm introduced into North America as hosts of *S. tridentata* (Table 4). Felt and Joutel (1904) state that there is no evidence that *S. tridentata* attacks European elms, *U. glabra* or *U. minor*. Campbell et al. (1989) cite Metcalf et al. (1951) when reporting that *S. tridentata* does not attack English elm (*U. minor*) or wych elm (*U. glabra*) two of the three most common elm species in Europe (Caudullo and de Rigo, 2016). The Swedish Unit for Risk Assessment of Plant Pests (Boberg and Björklund, 2018) drafted a short document citing Krischik and Davidson (2013) which reports ‘American elms, slippery elm and other elms’ as host plants. However ‘other elms’ are not identified and it is assumed that Krischik and Davidson (2013) were referring to North American species (listed as the first four in Table 4). No evidence was found that *S. tridentata* attacks the third European elm species (*U. laevis*). Hence, *S. tridentata* literature does not regard European *Ulmus* species as hosts. However, the literature is based on observational evidence. There have been no formal experiments, such as feeding choice studies, or oviposition choice experiments to categorically confirm that *S. tridentata* could, or particularly could not, develop on European elms.

Figure 2 illustrates the number of pieces of literature that name plants as hosts of *S. tridentata*. Out of 304 references about *S. tridentata*, 183 refer to association with a named host. 94% of these associations were with *Ulmus* sp. (elm, *Ulmus* and four American species). Two generic reports refer to Siberian elm (*U. pumila*) introduced into North America.

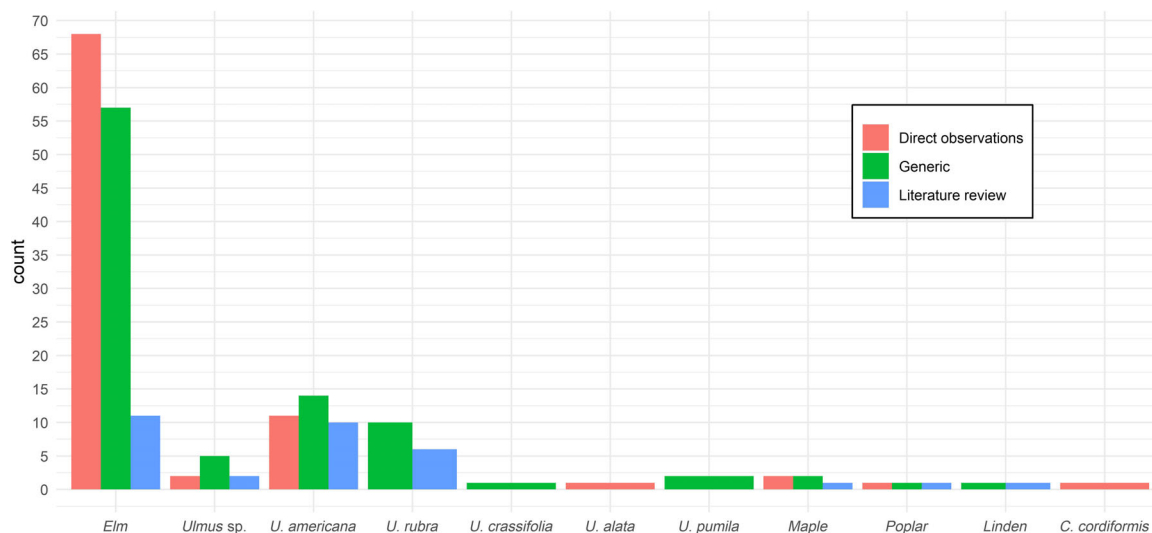


Figure 2: Number of pieces of literature that name plants as hosts of *S. tridentata*. Red: Count of literature with direct observations (e.g. documents reporting *S. tridentata* and its host(s) in open field or under laboratory conditions); Green: literature with generic observations (e.g. manuals and textbooks without supporting references); Blue: literature reviews. Names are quoted as found in the reference (Appendix D). Source: Biodiversity Heritage Library database (<https://www.biodiversitylibrary.org/>), the JSTOR database (<https://www.jstor.org/>), ISI Web of Knowledge. Last access to databases: 21 October 2019

However, five other broad-leafed tree groups were mentioned in association with the pest, i.e. maple (*Acer* sp., n = 2), poplar (*Populus* sp., n = 1), linden (*Tilia* sp., n = 1) and bitternut hickory (*Carya cordiformis*, n = 1) which require particular attention.

Maple: A repeatedly cited observation originally by Harrington (1883) described that he was "...stripping the bark from a large prostrate maple on May 22nd, ... The tree yielded... some pupae of *Saperda tridentata*, Oliv., from which imagos emerged on June 15th". Felt and Joutel (1904) noted (without further reference) that there is a record of *S. tridentata* emerging from maple (i.e. *Acer*). They write that the 'infestation must have been abnormal or else the record was founded on an erroneous observation'. Ehrmann (1897) mentions that on 'June 3. *S. tridentata* is found in numbers on the Elm and Acer' without further description e.g. of distance between the elm and maple specimens, or *S. tridentata* phenological stage (adults or larvae). Hence, the observation by Ehrmann does not constitute a reliable record that *Acer* is a host on which *S. tridentata* development takes place.

Poplar (*Populus*): The only reference is by Washburn (1910) who annexed the following sentence to a chapter on *S. tridentata* on elm: 'We have reared this same borer, *S. tridentata*, from Poplars.' Details about the wood offered, the rearing conditions and the successful development of imagos are lacking.

Linden (*Tilia*): Lugger (1899) recognised that '*S. vestida* Say (*linden borer*), *S. tridentata* Oliv., and *S. lateralis* Fab., occur upon a variety of forest trees, such as linden, poplar and others'. Unfortunately, it remains ambiguous which borer referred to which tree, and whether by 'others' he referred to elm.

Hickory (*Carya cordiformis*): The report of Park (1931) regarding relations of Coleopterans to plants for food and shelter mentions for a mesophytic oak–elm–hickory subclimax that '*Saperda tridentata* Oliv. has been beaten from the foliage of the bitter-nut hickory in numbers on July 17, and this is in the seasonal range for the species as given by Blatchley (1910, p. 1087). It has been repeatedly beaten from elm foliage. The larvae bore into this tree (Felt 1906, I, pp. 67-70)'. Recall that during the day adults shelter amongst foliage or bark (Pechuman, 1940). Hence, the observation by Park (1931) does not constitute a reliable record that hickory is a host on which *S. tridentata* development takes place.

The potential of *S. tridentata* to change host selection preference given host limitation was not reported in literature. Therefore, host range in other species of the genus *Saperda* was addressed for American and non-American species. The reported hosts of the other 14 North American *Saperda* species were compiled into a table (Appendix B). Half of the 14 species are reported to feed on hosts in more than one family. Of the seven remaining species at least five feed on hosts from two or more host genera. Two of the 14 species are recorded as having a single genus as a host. Appendix C lists 22 *Saperda* species from outside North America and records the host plants where known. Most feed on multiple genera. Three species, *S. octomaculata*, *S. scalaris* and *S. subobliterata*, feed on *Ulmus*. In Asia, *S. octomaculata* and *S. scalaris* are reported as feeding on *Ulmus* and other unspecified deciduous trees. *S. subobliterata* is an Asian species only recorded feeding on *Ulmus japonica* and *U. laciniata* (Appendix C). Examining the hosts of other *Saperda* species, four out of five species feeding on *Ulmus* have hosts in other Families too.

3.4.2. Entry

Is the pest able to enter the EU territory? (Yes or No) If yes, identify and list the pathways.

Yes, wood is a pathway, *S. tridentata* has been intercepted in the EU with *U. rubra* wood from USA on seven occasions since records began being centrally collected via Europhyt in 1995.

3.4.2.1. Interceptions

EUROPHYT data indicate that between 1995 and June 2019, there were six interceptions of *S. tridentata* (once in 2016, three times in 2017, once in 2018 and once in 2019) and one interception of *Saperda* sp. All were intercepted in Italy associated with *U. rubra* wood and bark from states close to the Great Lakes in USA (Ohio, Illinois, Iowa).

Prior to this pest categorisation, a 2016 interception report in EUROPHYT reported *S. tridentata* with a consignment of *Ulmus rubra* and of *Juglans nigra* roundwood (logs with bark) which led to *J. nigra* being referenced as a possible host in subsequent literature. A personal communication with the plant protection officer who conducted the original inspection has clarified that the larvae of *S. tridentata* were only found in *U. rubra* logs. The report in EUROPHYT has been clarified to prevent

future misinterpretation. Consequently, the PLH Panel does not consider *J. nigra* as host of *S. tridentata*

Two records of *Saperda sp.* interceptions where no species is provided relate to interceptions of pallets and wood packing material from China to Germany. *S. tridentata* is not known to occur in China. We assume these interceptions were not *S. tridentata* but Asian *Saperda* species.

3.4.2.2. Pathways

S. tridentata could potentially enter the EU within different commodities comprising plant material including wood products (Table 5).

Table 5: Traded wood and wood products that might comprise elm timber. Suggested pathways are listed with legislative measures which may result in *S. tridentata* detection during inspections required for other sanitary reasons

CN Code ^(a)	Description	Regulatory measures
	Solid wood packaging material (SWPM) if constructed using recently felled host timber	Managed by ISPM 15 (need to treat wood materials of a thickness greater than 6 mm, used to ship products between countries)
ex 0602	Plants for planting, other than seeds, in vitro material and naturally or artificially dwarfed woody plants for planting, originating from all third countries	Included in Commission Implementing Regulation EU 2018/2019. <i>Ulmus</i> plants for planting from North America are inspected [...] (2000/29 EC, Annex IV A I 14.).
4401 12 00	Fuel wood, in logs, in billets, in twigs, in faggots or in similar forms. Non-coniferous	Requires inspection (Annex V B)
ex 4401 22 00	Wood in chips or particles. Non-coniferous	Included in Commission Implementing Regulation EU 2018/2019
ex 4401 39 00	Sawdust and wood waste and scrap, agglomerated in logs, briquettes, pellets or similar forms. Others.	Included in Commission Implementing Regulation EU 2018/2019
ex 4403 12 00	Wood in the rough, whether or not stripped of bark or sapwood, or roughly squared. Treated with paint, stains, creosote or other preservatives. Non-coniferous	Included in Commission Implementing Regulation EU 2018/2019
ex 4403 99 00	Wood in the rough, whether or not stripped of bark or sapwood, or roughly squared. Others.	Included in Commission Implementing Regulation EU 2018/2019. Requires inspection (See 2000/29 EC Annex V B Section I 6 b).
4404 20 00	Hoopwood; split poles; piles, pickets and stakes of wood, pointed but not sawn lengthwise; wooden sticks, roughly trimmed but not turned, bent or otherwise worked, suitable for the manufacture of walking sticks, umbrellas, tool handles or the like; chipwood and the like. Non-coniferous	Requires inspection (Annex V B)
4406 12 00	Railway or tramway sleeps (cross-ties) of wood. Not impregnated. Non-coniferous	Requires inspection (Annex V B)
ex 4407 99	Wood sawn or chipped lengthwise, sliced or peeled, whether or not planed, sanded or end-jointed, of a thickness exceeding 6 mm. Other	Included in Commission Implementing Regulation EU 2018/2019. Requires inspection (See 2000/29 EC Annex V B Section I 6 b)
4408 90	Sheets for veneering (including those obtained by slicing laminated wood), for plywood or for similar laminated wood and other wood, sawn lengthwise, sliced or peeled, whether or not planed, sanded, spliced or end-jointed, of a thickness not exceeding 6 mm. Other	No phytosanitary measures required. Highly processed.
4409 29	Wood (including strips and friezes for parquet flooring, not assembled) continuously shaped (tongued, grooved, rebated, chamfered, V-jointed, beaded, moulded, rounded or the like) along any of its edges, ends or faces, whether or not planed, sanded or end-jointed. Non-coniferous. Other	No phytosanitary measures required. Highly processed

CN Code ^(a)	Description	Regulatory measures
4410	Particle board, oriented strand board (OSB) and similar board (e.g. waferboard) of wood or other ligneous materials, whether or not agglomerated with resins or other organic binding substances	No phytosanitary measures required. Highly processed
4411	Fibreboard of wood or other ligneous materials, whether or not bonded with resins or other organic substances	No phytosanitary measures required. Highly processed
4412	Plywood, veneered panels and similar laminated wood	No phytosanitary measures required. Highly processed

(a): Chapter 44. Commission Implementing Regulation (EU) 2018/1602 of 11 October 2018 amending Annex I to Council Regulation (EEC) No 2658/87 on the tariff and statistical nomenclature and on the Common Customs Tariff. Official Journal of the European Union L273, 61, 31 October 2018. (<https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:L:2018:273:FULL&from=ENCN> Code)

3.4.2.3. Elm wood imports

Elm wood is relatively scarce in trade and only a small amount of elm is exported from USA (Cassens, 2007). Nevertheless, rough-wood logs are shipped from North America to Europe.

Elm wood, *Ulmus* spp., is not itemised in trade nomenclature. The international nomenclature and codification system used to record trade statistics are not sufficiently detailed to determine the amount of trade specifically in elm wood. Table 5 details import classifications sub-summing elm wood and derived products. CN 4403 (wood in the rough, whether or not stripped of bark or sapwood, or roughly squared, not treated) recognises subclass CN 4403 99 00 for rough hardwood not itemised and thus would include elm; CN 4407 (Wood sawn or chipped lengthwise, sliced or peeled, whether or not planed, sanded or end-jointed, of a thickness exceeding 6 mm.) recognises a sub-class CN 4407 99 for all sawn non-tropical hardwoods not itemised and thus would include elm.

3.4.2.4. Import volume

Eurostat statistics based on customs records of import do not explicitly itemise elm wood. Estimation thus combines secondary indicators. Luppold and Thomas (1991) estimated the volume of annual exports of individual hardwoods from USA to European countries for the years 1981–1989. The mean volume of elm hardwood was 311 m³ per year (minimum 24 m³; maximum 807 m³). The density of elm wood can be estimated by assuming 12% moisture and is estimated as 593 kg m⁻³ (source: www.americanhardwood.org). Hence, between 1981 and 1989, a mean of 185 tonnes of elm wood was imported annually into the EU (range 14–479 tonnes; Table 6). 75% of US elm exports to the EU went to Italy, 18% to France, 5% to UK and 2% to BENELUX (Luppold and Thomas, 1991) (Table 6).

Table 6: Estimated annual volumes and weight of elm wood imported into EU from USA 1981–1989 (Source: Luppold and Thomas, 1991)

Year	Volume (m ³)	Weight (tonnes)
1981	300	178
1982	404	240
1983	191	113
1984	175	104
1985	807	479
1986	24	14
1987	28	17
1988	300	78
1989	573	340
Annual mean	311	185
Minimum	24	14
Maximum	807	479

In more recent years, the import volume of two main wood categories sub-summing elm wood (CN 4403 99 and 4407 99) is available and is reported by weight (Table 7).

Table 7: Import of rough wood (CN 4403 99) and sawn wood (CN 4407 99) potentially containing *Ulmus* species, from USA 2014 to 2018, into EU members states previously known to import US elm wood, (tonnes). Source: Eurostat

Code/wood type	Importer	2014	2015	Year 2016	2017	2018
CN 4403 99 rough wood	Italy	33,976	39,910	37,627	37,259	34,354
	France	284	102	366	19	0
	UK	345	307	158	213	93
	sum	34,605	40,319	38,151	37,492	34,447
CN 4407 99 sawn wood	Italy	30,091	22,992	21,198	19,787	18,835
	France	24,205	22,963	24,205	7,472	9,162
	UK	777	731	791	409	485
	sum	55,072	46,686	46,194	27,667	28,481
CN 4403 99 + CN 4407 99		89,677	87,005	84,345	65,159	62,928

The two data sources (Tables 6 and 7) were combined using earlier available Eurostat data from 1988. In 1988, a combined total of 148,332 tonnes of 'rough wood, other' (CN 4403 99) and 'sawn wood, other' (CN 4407 99) were imported into Italy, France and UK from USA. In 1989, the figure was 156,245 tonnes. According to Table 6 (Luppold and Thomas, 1991), approximately 178 tonnes of elm wood was imported into the EU (Italy, France and UK) in 1988 and 340 tonnes in 1989. Assuming all elm wood from USA was classified as either CN 4403 99 or CN 4407 99 then in 1988 0.12% (178/148,332) of rough and sawn wood 'other' entering the EU from USA was elm. Similarly, in 1989, approximately 0.22% (340/156,245) may have been elm.

Applying these estimates of 0.12% and 0.22% to the recent imports (Table 8) would suggest that between 63 and almost 180 tonnes of elm wood arrived in the EU each year between 2014 and 2018 from the USA, although the trend is downwards (Table 8).

Table 8: Estimated annual amount of elm wood in tonnes imported from USA into the EU (Italy, France, UK), 2014–2018

Elm wood	Year				
	2014	2015	2016	2017	2018
Combined total of rough wood and sawn wood 'other'	89,677	87,005	84,345	65,159	62,928
Elm estimate assuming 0.12%	90	87	84	65	63
Elm estimate assuming 0.22%	179	174	169	130	126

EU member states were approached by EFSA and asked for information on the amount of elm logs imported annually from North America since 2016 (more information in Appendix F). Results are shown in Table 9.

Table 9: Annual weight in tonnes of elm logs imported into EU member states from North America 2016–2019. (Note that 2019 is not a full year). (Source: replies to EFSA from individual member states, October 2019). Data were rounded to the nearest whole tonne. In some cases, weight was derived assuming a reference density (see Appendix F)

EU member state	2016	2017	2018	2019
Italy	133	113	41	143
Germany	38	62	31	26
Portugal	0	0	5	0
Croatia	0	0	0	0
Cyprus	0	0	0	0
Estonia	0	0	0	0

EU member state	2016	2017	2018	2019
Finland	0	0	0	0
France	0	0	0	0
Latvia	0	0	0	0
Lithuania	0	0	0	0
Malta	0	0	0	0
Poland	0	0	0	0
Spain	0	0	0	0
Sweden	0	0	0	0
The Netherlands	0	0	0	0
UK	0	0	0	0
Sum	171	175	76	169
Denmark*	98	7,827	32	2

(*): Data for Denmark refers to any type of wood of *Ulmus*, not only logs.

From replies received from individual member states, annual imports of elm logs into the EU from North America ranged from 76 to 175 tonnes (Table 9). These figures are similar to the estimates made in Table 8 suggesting between 63 and almost 180 tonnes of elm wood arrived in the EU each year between 2014 and 2018.

Denmark was unable to provide data on the tonnage of logs of *Ulmus* imported but was able to provide data on the imported volume (m³) including all types of wood of *Ulmus* which are under phytosanitary import provisions and have been inspected on import.

3.4.3. Establishment

Is the pest able to become established in the EU territory? (Yes or No)

If European elms and/or maple and poplar species are hosts of *S. tridentata*, establishment is possible.

3.4.3.1. EU distribution of main host plants

Within Europe, there are limited number of arboreta where American species of elm such as *U. americana* and *U. rubra* grow (Table 10). Data of individual stand distributions are not accessible. Arboreta are assumed to be isolated and widely spread out (i.e. distances between arboreta exceed the range of adult flight capacity). There may be other American elms in private gardens and parks, but abundance and density are not known (see e.g. <https://www.gbif.org/species/5361872>). It is suggested that *S. tridentata* is unlikely to be able to establish if American elms are the only hosts. European elm species are more abundant but not known to be hosts. However, it has also not been proven that European elms are not hosts. The argument is valid also with *Acer* and *Populus*. If European elms, *Acer* and *Populus* are genuine hosts (see Section 3.4.1) and *S. tridentata* demonstrated a shift in host preference to European elms, *Acer* (maple) and *Populus* (poplar) in the EU, then hosts would be ubiquitous, and conditions would be conducive to establishment.

Table 10: Number of gardens/arboreta in EU MS that are recorded as having North American elm species. Whether sites have only single specimens or multiple plantings is not known (Source: https://tools.bgci.org/global_tree_search.php)

Country	<i>U. americana</i>	<i>U. rubra</i>	<i>U. crassifolia</i>	<i>U. thomasi</i>	<i>U. serotina</i>	<i>U. alata</i>	Sum
United Kingdom	5	3	2	2	3	3	18
Germany	7	3					10
Belgium	2		1	1			4
Poland	1			1	1	1	4
Finland	2			1			3
France	2		1				3
Sweden	1	2					3

Country	<i>U. americana</i>	<i>U. rubra</i>	<i>U. crassifolia</i>	<i>U. thomasi</i>	<i>U. serotina</i>	<i>U. alata</i>	Sum
Czech Republic	1	1					2
Latvia	1	1					2
Spain	2						2
Denmark	1						1
Estonia	1						1
Sum	26	10	4	5	4	4	53

3.4.3.2. Climatic conditions affecting establishment

The distribution and abundance of an organism that cannot control or regulate its body temperature are largely determined by host distribution and climate.

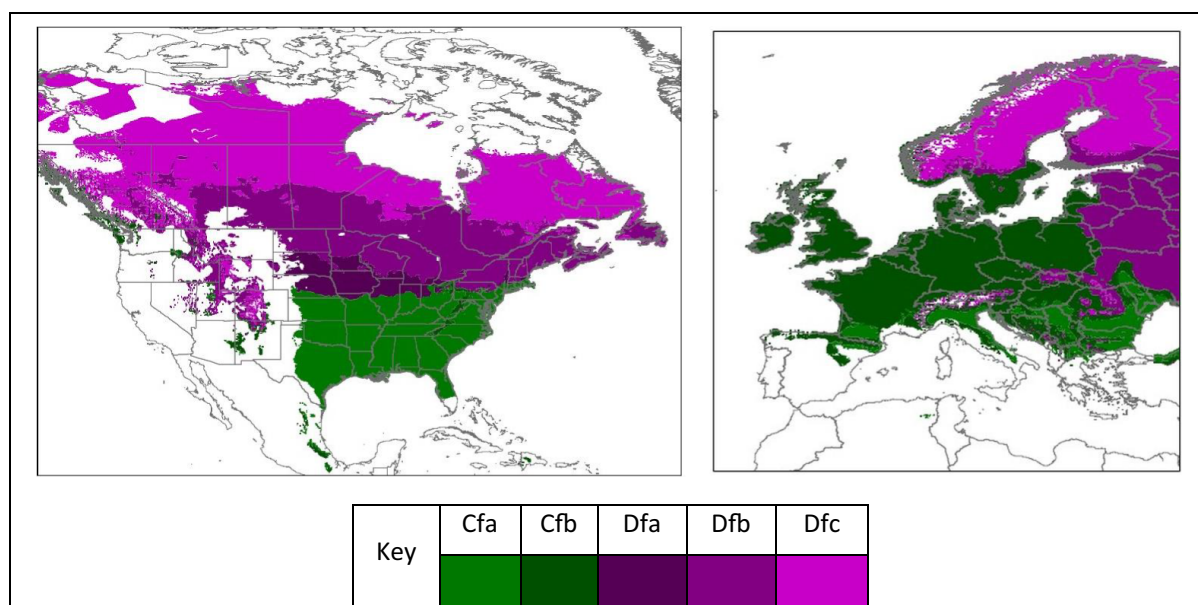


Figure 3: Occurrence of Köppen–Geiger climates (Trewartha and Horn, 1980) in North America (left pane) within which *S. tridentata* occurs and the same climates in Europe (right pane). The pane at the bottom shows the key scheme colour used for the different climates: Cfa = Humid subtropical climate, Cfb = Temperate oceanic climate, Dfa = Hot summer humid continental climate, Dfb = Warm summer humid continental climate, Dfc = Subarctic climate

Comparing climates from the known distribution of an organism with climates in the risk assessment area can inform judgements regarding the potential distribution and abundance of an organism in the risk assessment area (Sutherst and Maywald, 1985; Ehrlén and Morris, 2015). The global Köppen–Geiger climate zone categories, and subsequent modifications made by Trewartha and Horn (1980), describe terrestrial climate in terms of factors such as average minimum winter temperatures and summer maxima, amount of precipitation and seasonality (rainfall pattern) (Trewartha and Horn, 1980; Kottek et al., 2006) and can inform judgements of aspects of establishment during pest categorisation (MacLeod and Korycinska, 2019).

Climate types found in regions of North America where *S. tridentata* occurs are also found in Europe (Figures 1 and 3) suggesting that climate would support the establishment of *S. tridentata* in large parts of the EU.

3.4.4. Spread

Is the pest able to spread within the EU territory following establishment?

Yes. If *S. tridentata* did establish it could spread. The species is a free-living organism, adults can fly.

RNQPs: Is spread mainly via specific plants for planting, rather than via natural spread or via movement of plant products or other objects?

No. *S. tridentata* would not mainly spread via plants for planting.

Adults fly during the night. They tend not to disperse far if hosts are available locally (Hanks, 1999). The dispersal of *S. tridentata*, like that of other cerambycids such as *S. candida* and *S. inornata*, is influenced by the dietary requirements of adults and host requirements of the larvae. Females may oviposit on their natal host if its condition has not declined too greatly; such behaviour results in adults appearing to be relatively sedentary with a disinclination to disperse (Hanks, 1999).

S. tridentata has slowly spread within the USA and Canada. The species was known to occur in the eastern states of the USA and in eastern Canada in the late 1790s and was recorded in Idaho in 2017 (Rice et al., 2017). Whether recorded spread is related to recording effort, natural spread or spread on host plant material, such as infested *Ulmus* wood, is unknown.

3.5. Impacts

Would the pests' introduction have an economic or environmental impact on the EU territory?

The preference for weakened trees might generally limit the potential impact.

No, if *S. tridentata* does not feed on European species of elm impacts would be limited to isolated species of American elm growing in Europe, assuming *S. tridentata* could locate them.

Yes, if weakened trees of elms, poplars, or maples are hosts for *S. tridentata* there is likely to be an impact in the EU territory.

RNQPs: Does the presence of the pest on plants for planting have an economic impact, as regards the intended use of those plants for planting?

Yes. The occurrence of *S. tridentata* on plants for planting could have an economic impact on the intended use of those plants. Infested plants would be introducing a potentially serious pest that could spread and kill other hosts close by. However, the stem size of such plants for planting may limit final development of the pest to the adult stage.

As the pest is not present in the EU impact estimates are based on reports for North America.

S. tridentata prefers trees suffering a lack of nutrients or moisture (Campbell et al., 1989) or are otherwise stressed or weakened. Tucker (1907) reported that there was no evidence that adults oviposit in healthy trees. Hanks (1999) considers *S. tridentata* to be a species that specialises in attacking host plants whose defences have been compromised in some way, such as by chronically poor growing conditions or pathogen infestation. Urban habitats (typical for elm) might make trees more prone to attack by *S. tridentata*. The impact of *S. tridentata* could be to speed up the decline of a weakened tree that was already deteriorating.

Environmental impacts would be confined to already weakened or stressed individual hosts that were located and attacked. Whilst adult feeding damages leaves and twigs, it is the feeding and tunnelling of larvae within the cambium and phloem, inner bark and sapwood, of already weakened or stressed hosts that causes most damage. Infested trees tend to die slowly, a branch at a time (Drooz, 1985) although all parts can be attacked from small branches to the main trunk. The upper branches are usually affected first. Subsequent generations will work down an infected tree. Larval mines can girdle branches killing them; when abundant larval tunnelling can girdle the trunk causing the death of the tree (Hoffmann, 1942; Krischik and Davidson, 2013). Trees can be killed after 2 or 3 years (Packard, 1890). Roots are not attacked (Packard, 1890). Rows of elms in urban areas would gradually be attacked as subsequent generations of adult *S. tridentata* spread from tree to tree.

S. tridentata is more injurious in USA than in Canada (Campbell et al., 1989) perhaps because larvae develop more slowly further north in cooler climates.

Elm is a valued component of the urban forest as a shade provider although Dutch elm disease has greatly reduced the population of elms both in North America and Europe (Allen and Humble, 2002). Historically elm wood was used for barrel hoops and staves, boxes, crates, curved wooden parts of furniture, and panelling, more recently, in areas where the amount of elm wood available has declined (due to Dutch elm disease), it is used for pallets and solid wood packing material (Cassens, 2007). Elm wood is also used to make hockey sticks, veneer, wood pulp and in papermaking (<https://www.wood-database.com/american-elm/>). When sawn, elm is mainly used to make planks 25.4 mm thick.

Extrapolating information on consequences from the native range of the *S. tridentata*, a potential introduction of the organism into the EU territory likely is limited to weakened trees. If *S. tridentata* does neither feed on European species of elm nor on *Acer* or *Populus* impacts would be limited to isolated species of American elm growing in EU, assuming *S. tridentata* could locate them. If, however, *S. tridentata* feed on trees of elms, poplars or maples, there is likely to be an environmental and/or economic impact in the EU territory. Scarce evidence on precise host range of *S. tridentata* in the EU territory does not support any of the impact scenarios over the other.

3.6. Availability and limits of mitigation measures

Are there measures available to prevent the entry into, establishment within or spread of the pest within the EU such that the risk becomes mitigated?

Yes, measures used for *Agrilus planipennis* could be appropriate (Table 2) and those in 3.6.1. However, parameters of mechanical treatment (i.e. removal of 2.5 cm in sapwood) need to be confirmed.

RNQPs: Are there measures available to prevent pest presence on plants for planting such that the risk becomes mitigated?

Yes, plant from planting from pest free areas.

3.6.1. Identification of additional measures

Phytosanitary measures are currently applied to *Ulmus* plants for planting from North America for the control of elm phloem necrosis (see Section 3.3).

Rough wood and sawn wood consignments require inspection (see Section 3.3.2). The existing general requirements are not specific to *S. tridentata* but inhibit the entry of many pests.

3.6.1.1. Additional control measures

Potential additional control measures are listed in Table 11.

Table 11: Selected control measures (a full list is available in EFSA PLH Panel et al., 2018) for pest entry/establishment/spread/impact in relation to currently unregulated hosts and pathways. Control measures are measures that have a direct effect on pest abundance

Information sheet title (with hyperlink to information sheet if available)	Control measure summary	Risk component (entry/establishment/spread/impact)
Chemical treatments on consignments or during processing	Use of chemical compounds that may be applied to plants or to plant products after harvest, during process or packaging operations and storage. The treatments addressed in this information sheet are: a) fumigation; b) spraying/dipping pesticides; c) surface disinfectants; d) process additives; e) protective compounds	Entry. Fumigants available. In principle applicable but challenging to put into practice for large timbers.
Physical treatments on consignments or during processing	This information sheet deals with the following categories of physical treatments: irradiation/ionisation; mechanical cleaning (brushing, washing); sorting and grading, and removal of plant parts (e.g. debarking wood). This information sheet does not address: heat and cold treatment (information sheet 1.14); roughing and pruning (information sheet 1.12)	Entry. Rough wood should be bark free rather than debarked to reduce the likelihood of entry

Information sheet title (with hyperlink to information sheet if available)	Control measure summary	Risk component (entry/establishment/ spread/impact)
Heat and cold treatments	Controlled temperature treatments aimed to kill or inactivate pests without causing any unacceptable prejudice to the treated material itself. The measures addressed in this information sheet are: autoclaving; steam; hot water; hot air; cold treatment	Entry. Equipment available. For large timbers complex in routine practice.
Roguing and pruning of infested brunches	If detected sufficiently early, pruning and burning of infested branches could remove infestations within individual trees	Establishment, Spread.
Felling and burning of infested trees	Felling and burning of infested trees to reduce the spread to neighbouring hosts.	Spread.
Insecticides targeting adults	Insecticides targeting adults could be applied to foliage; insecticides with long-lasting residual activity could be applied to trunks	Spread. Reduce establishment.

3.6.1.2. Additional supporting measures

Potential additional supporting measures are listed in Table 12.

Table 12: Selected supporting measures (a full list is available in EFSA PLH Panel, 2018) in relation to currently unregulated hosts and pathways. Supporting measures are organisational measures or procedures supporting the choice of appropriate risk reduction options that do not directly affect pest abundance.

Information sheet title (with hyperlink to information sheet if available)	Supporting measure summary	Risk component (entry/establishment/ spread/impact)
Inspection and trapping	Inspection is defined as the official visual examination of plants, plant products or other regulated articles to determine if pests are present or to determine compliance with phytosanitary regulations (ISPM 5). The effectiveness of sampling and subsequent inspection to detect pests may be enhanced by including trapping and luring techniques.	Light traps at ports of entry and inland at sites for wood distribution could be used to monitor for adults emerging from imported wood. Establishment
Encourage tree health and vigour	<i>S. tridentata</i> attacks weakened trees therefore practices that encourage tree health and vigour such as site selection, mulching and watering.	Establishment, spread, impact.

3.7. Uncertainty

The precise hosts of *S. tridentata* in the EU are unknown and judgements about the expected establishment and/or spread come with high uncertainty. These critical uncertainties are not expected to lessen by conducting risk assessment.

Host diversity and plasticity of *S. tridentata* are unknown due to inconclusive anecdotal evidence and lack of experimental studies. Indicative reports on diverse species, other than North American elms, are isolated, mostly inconclusive/speculative in biological relevance, and not representative of any situation in the EU. Categorisation of the potential to establish within EU is highly uncertain and driven by assumptions regarding hosts.

Assuming European elms could be hosts of *S. tridentata* in the EU, still the occurrence, density and distribution of European elms in Europe is uncertain. The categorisation of capability to spread is highly uncertain as to whether there are enough hosts at local reach to enable the establishment of *S. tridentata* (i.e. perpetuate for the foreseeable future).

4. Conclusions

Table 13 provides a summary of the conclusions of each part of this pest categorisation.

Table 13: The Panel's conclusions on the pest categorisation criteria defined in Regulation (EU) 2016/2031 on protective measures against pests of plants (the number of the relevant sections of the pest categorisation is shown in brackets in the first column)

Criterion of pest categorisation	Panel's conclusions against criteria in Regulation (EU) 2016/2031 regarding Union quarantine pest	Key uncertainties
Identity of the pests (Section 3.1)	<i>S. tridentata</i> Olivier, (Coleoptera: Cerambycidae) is a well-established and recognised pest	None
Absence/presence of the pest in the EU territory (Section 3.2)	<i>S. tridentata</i> is not known to occur in the EU. The pest occurs in eastern North America (USA and Canada)	A few interceptions have been recorded
Regulatory status (Section 3.3)	<i>S. tridentata</i> is not under official control	
Pest potential for entry, establishment and spread in the EU territory (Section 3.4)	Entry is possible (proven by interceptions). If European elms and/or maple and poplar species are hosts of <i>S. tridentata</i> , then establishment is possible. Spread is possible as <i>S. tridentata</i> is a free-living organism and adults can fly	High uncertainty level. No experimental data; only anecdotal evidence; inadequate information on the precise host range in the EU.
Potential for consequences in the EU territory (Section 3.5)	If <i>S. tridentata</i> does not feed on European species of elm, impacts would be limited to isolated species of American elm growing in Europe, assuming <i>S. tridentata</i> could locate them. The preference for weakened trees might generally limit the potential impact. If European elms, poplars or maples are hosts for <i>S. tridentata</i> , there is likely to be an impact in the EU territory	High uncertainty level. No experimental evidence (e.g. choice experiments) to anticipate behaviour when known hosts (American elms) are scarce.
Available measures (Section 3.6)	Measures for wood-inhabiting beetles with similar biology are available	Efficacy of measures unknown against <i>S. tridentata</i>
Conclusion on pest categorisation (Section 4)	Information on geographical distribution, biology, epidemiology, impact and potential entry pathways of <i>S. tridentata</i> has been evaluated against the criteria for it to qualify as potential Union quarantine pest or as Union regulated non-quarantine pest (RNQP). Since the pest is not reported in EU or plants for planting are not the principal means of spread, it does not meet the criteria assessed by EFSA to qualify as potential Union regulated non-quarantine pest. <i>S. tridentata</i> satisfies the criterion regarding entry into the EU territory. Due to the scarcity of data, the Panel is unable to conclude if <i>S. tridentata</i> meets the post-entry criteria of establishment, spread and potential impact	Uncertainty regarding the precise host range and behaviour in the EU cannot be reduced by any subsequent risk assessment without new experimental evidence in these regards
Aspects of the assessment to focus on/scenarios to address in the future if appropriate	As it is, there is little reason to believe there are hosts on the European continent except those American elms in arboreta, but a host shift cannot be excluded as a possibility. A firm conclusion on all criteria of the categorisation can be achieved through gathering conclusive experimental evidence about the precise host range and behaviour in the EU	

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Glossary

Containment (of a pest)	Application of phytosanitary measures in and around an infested area to prevent spread of a pest (FAO, 1995, 2017)
Control (of a pest)	Suppression, containment or eradication of a pest population (FAO, 1995, 2017)
Entry (of a pest)	Movement of a pest into an area where it is not yet present, or present but not widely distributed and being officially controlled (FAO, 2017)
Eradication (of a pest)	Application of phytosanitary measures to eliminate a pest from an area (FAO, 2017)
Establishment (of a pest)	Perpetuation, for the foreseeable future, of a pest within an area after entry (FAO, 2017)
Impact (of a pest)	The impact of the pest on the crop output and quality and on the environment in the occupied spatial units
Introduction (of a pest)	The entry of a pest resulting in its establishment (FAO, 2017)
Measures	Control (of a pest) is defined in ISPM 5 (FAO 2017) as "Suppression, containment or eradication of a pest population" (FAO, 1995). Control measures are measures that have a direct effect on pest abundance. Supporting measures are organisational measures or procedures supporting the choice of appropriate Risk Reduction Options that do not directly affect pest abundance.
Pathway	Any means that allows the entry or spread of a pest (FAO, 2017)
Phytosanitary measures	Any legislation, regulation or official procedure having the purpose to prevent the introduction or spread of quarantine pests, or to limit the economic impact of regulated non-quarantine pests (FAO, 2017)
Protected zones (PZ)	A Protected zone is an area recognised at EU level to be free from a harmful organism, which is established in one or more other parts of the Union.

Quarantine pest	A pest of potential economic importance to the area endangered thereby and not yet present there, or present but not widely distributed and being officially controlled (FAO, 2017)
Regulated non-quarantine pest	A non-quarantine pest whose presence in plants for planting affects the intended use of those plants with an economically unacceptable impact and which is therefore regulated within the territory of the importing contracting party (FAO, 2017)
Risk reduction option (RRO)	A measure acting on pest introduction and/or pest spread and/or the magnitude of the biological impact of the pest should the pest be present. A RRO may become a phytosanitary measure, action or procedure according to the decision of the risk manager
Spread (of a pest)	Expansion of the geographical distribution of a pest within an area (FAO, 2017)

Abbreviations

EPPO	European and Mediterranean Plant Protection Organization
FAO	Food and Agriculture Organization
IPPC	International Plant Protection Convention
ISPM	International Standards for Phytosanitary Measures
MS	Member State
PLH	EFSA Panel on Plant Health
PZ	Protected Zone
RNQP	regulated non-quarantine pest
TFEU	Treaty on the Functioning of the European Union
ToR	Terms of Reference

Appendices to the Pest Categorisation on *Saperda tridentata*

To further inform decision-making regarding the quarantine status of *S. tridentata* in the EU, the EFSA PLH Panel collected accessible information and observational knowledge supporting conclusions. The outcome is collated within the Appendices (Appendices A–F). The extra information and data were thought useful given the uncertainties about the host range of *S. tridentata* in EU. Nevertheless, interpretation of the data and information requires caution due to the non-systematic collection, patchy accessibility and observational character (data assembled for different purposes).

List of Appendices:

- Appendix A – Detailed *Saperda tridentata* global distribution
- Appendix B – Host plants of North American *Saperda* species, other than *S. tridentata*
- Appendix C – Host plants of non-North American *Saperda* species
- Appendix D – Literature search and review on *S. tridentata* hosts
- Appendix E – Scoping review on the flight capacity of adult *Saperda tridentata* and other Cerambycidae, and analysis of spatial separation of European elm trees in Northern Italy
- Appendix F – *Ulmus* logs imports in Europe.

Appendix A – Detailed *Saperda tridentata* global distribution

Table A.1: *S. tridentata* global distribution according to the online EPPO Global database (<https://gd.eppo.int/>). Last access: 7 November 2019

Continent	Country	Sub-national distribution	Status	
North America	Canada		Present, restricted distribution	
		Manitoba	Present, no details	
		New Brunswick	Present, no details	
		Nova Scotia	Present, no details	
		Ontario	Present, no details	
		Québec	Present, no details	
		Saskatchewan	Present, no details	
	USA			Present, restricted distribution
		Alabama		Present, no details
		Arkansas		Present, no details
		Colorado		Present, no details
		Connecticut		Present, no details
		Florida		Present, restricted distribution
		Georgia		Present, no details
		Idaho		Present, no details
		Illinois		Present, no details
		Indiana		Present, no details
		Iowa		Present, no details
		Kansas		Present, no details
		Kentucky		Present, no details
		Maine		Present, no details
		Maryland		Present, no details
		Massachusetts		Present, no details
		Michigan		Present, no details
		Minnesota		Present, no details
		Mississippi		Present, no details
		Missouri		Present, no details
		Montana		Present, restricted distribution
		Nebraska		Present, no details
		New Hampshire		Present, no details
		New Jersey		Present, no details
		New York		Present, no details
		North Carolina		Present, no details
		North Dakota		Present, no details
		Ohio		Present, no details
Oklahoma		Present, no details		
Pennsylvania		Present, no details		
Rhode Island		Present, no details		
South Carolina		Present, no details		
South Dakota		Present, no details		
Tennessee		Present, no details		
Texas		Present, no details		
Vermont		Present, no details		
West Virginia		Present, no details		
Wisconsin		Present, no details		

Appendix B – Host plants of North American *Saperda* species, other than *S. tridentata*

Table B.1 includes a list of host plants of North American *Saperda* species, other than *S. tridentata* based on Felt and Joutel (1904), Zasada and Phipps (1990), Nord et al. (1972), and the <http://titan.gbif.fr> website.

Table B.1: List of host plants of North American *Saperda* species, other than *S. tridentata* (Sources: a = Felt and Joutel, 1904; b = http://titan.gbif.fr/sel_plantes1.php?numplantes=7140; c = Zasada and Phipps, 1990; d = Nord et al., 1972)

HOST FAMILY Genus species	North American <i>Saperda</i> spp.													
	<i>S.imitans</i>	<i>S.discoidea</i>	<i>S.lateralis</i>	<i>S.vestita</i>	<i>S.candida</i>	<i>S.puncticolis</i>	<i>S.moesta</i>	<i>S.cretata</i>	<i>S.fayi</i>	<i>S.calcarata</i>	<i>S.obliqua</i>	<i>S.inornata</i>	<i>S.horni</i>	<i>S.mutica</i>
ACERACEAE														
<i>Acer</i> sp.				b										
ANACARDIACEAE														
<i>Rhus radicans</i>						a								
<i>Rhus toxicodendron</i>						a								
<i>Toxicodendron radicans</i>						a								
BETULACEAE														
<i>Alnus serrulata</i>											a			
<i>Betula</i> sp.					b						a			
BURCERACEAE														
<i>Cammiphora opobalsamum</i>							a							
CARYOCARACEAE														
<i>Caryocar</i> sp.		a												
CORNACEAE														
<i>Cornus</i> sp.	a													
JUGLANDACEAE														
<i>Carya amara</i>		a												
<i>Carya cordiformis</i>	a		a											
<i>Carya glabra</i>		a	a											
<i>Carya ovata</i>		a												
<i>Juglans nigra</i>		a												
ROSACEAE														
<i>Amelanchier alnifolia</i>					a									
<i>Amelanchier arborea</i>								a						
<i>Amelanchier canadensis</i>					a									
<i>Aronia</i> sp.					a									
<i>Cotoneaster</i> sp.					a									
<i>Crataegus crus-galli</i>									a					
<i>Crataegus oxyacantha</i>									a					
<i>Crataegus phaenopyrum</i>									a					
<i>Crataegus</i> sp.		a	a		a			a						
<i>Crataegus tomentosa</i>									a					
<i>Cydonia oblonga</i>					a									
<i>Malus</i> sp.					a			a	a					
<i>Prunus avium</i>					a									
<i>Prunus domestica</i>					a									

HOST FAMILY Genus species	North American <i>Saperda</i> spp.													
	<i>S. imitans</i>	<i>S. discoidea</i>	<i>S. lateralis</i>	<i>S. vestita</i>	<i>S. candida</i>	<i>S. puncticolis</i>	<i>S. moesta</i>	<i>S. cretata</i>	<i>S. fayi</i>	<i>S. calcarata</i>	<i>S. obliqua</i>	<i>S. inornata</i>	<i>S. horni</i>	<i>S. mutica</i>
<i>Prunus</i> sp.	a													
<i>Pyracantha</i> sp.					a									
<i>Pyrus communis</i>					a									
<i>Sorbus americana</i>					a									
SALICACEAE														
<i>Populus balsamifera</i>							a			c		a		
<i>Populus deltoides</i>										a				
<i>Populus grandidentata</i>												a		
<i>Populus nigra</i>										a				
<i>Populus</i> sp.				a			a							
<i>Populus tremuloides</i>										a		d		
<i>Salix lasiolepis</i>													a	
<i>Salix scouleriana</i>													a	
<i>Salix bebbiana</i>												a		
<i>Salix concolor</i>												a		
<i>Salix discolor</i>												a		
<i>Salix humilis</i>												a		
<i>Salix interior</i>												a		
<i>Salix petiolaris</i>												a		
<i>Salix</i> sp.	a						a			a		a	a	a
TILIACEAE														
<i>Tilia americana</i>				a										
<i>Tilia</i> sp.	a													
ULMACEAE														
<i>Ulmus</i> sp.		a												
<i>Ulmus rubra</i>			a											
VITACEAE														
<i>Parthenocissus engelmannii</i>						a								
<i>Parthenocissus quinquefolia</i>						a								
<i>Vitis</i> sp.						a								
Number of host families	5	4	3	3	2	2	2	1	1	1	1	1	1	1
Number of host genera	5	5	3	3	11	4	3	3	2	2	2	2	1	1

References

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Appendix C – Host plants of non-North American *Saperda* species

Table C.1 includes a list of host plants of non-North American *Saperda* species.

Table C.1: List of host plants of non-North American *Saperda* species

Saperda species	Distribution	Hosts	References
<i>S. alberti</i>	Asia (Japan, North Korea, China, Mongolia, Russia)	Salix Populus	Cherepanov (1991)
<i>S. bacillicornis</i>	China	Salix	Wallin et al. (2017) Tavakilian and Chevillotte (2019)
<i>S. balsamifera</i>	Siberia, NE China, Korea, Japan	Populus alba Salix	Sheng and Hilszczanski (2009) Cherepanov (1991)
<i>S. bilineatocollis</i>	China, Russia	Unknown	Danilevsky (2010) Tavakilian and Chevillotte (2019)
<i>S. carcharias</i>	Europe, northern Asia, China, Korea	Alnus Populus Prunus Quercus Salix	Cherepanov (1991) Tavakilian and Chevillotte (2019)
<i>S. facetula</i>	Vietnam	Unknown -	Holzschuh (1999)
<i>S. gilanense</i>	Iran	Unknown	Tavakilian and Chevillotte (2019)
<i>S. gleneoides</i>	Laos, Vietnam	Unknown	Tavakilian and Chevillotte (2019)
<i>S. interrupta</i>	Siberia, NE China, Korea, Japan	Abies (fir) Picea (spruce) Pinus (pine) other conifers	Cherepanov (1991)
<i>S. kojimai</i>	Taiwan	Unknown	Tavakilian and Chevillotte (2019)
<i>S. maculosa</i>	Iran, Transcaspia (=Azerbaijan, Kazakhstan, Turkmenistan, Uzbekistan)	Unknown	Tavakilian and Chevillotte (2019)
<i>S. octomaculata</i>	Northern Asia, NE China, Korea, Japan	Ulmus others deciduous trees	Cherepanov (1991)
<i>S. octopunctata</i>	Europe, Russia	Unknown	Tavakilian and Chevillotte (2019)
<i>S. ohbayashii</i>	Japan	Unknown	Wikipedia
<i>S. perforata</i>	Europe, northern Asia	Populus tremuloides rarely other Populus spp.. Salix Sorbus	Cherepanov (1991)
<i>Saperda populnea</i>	Europe, North Asia	Populus Salix	Felt and Joutel (1904) Cherepanov (1991)
<i>S. quercus</i>	Europe (Hungary, Greece, Bulgaria, Serbia, Montenegro)	Unknown	Tavakilian and Chevillotte (2019)
<i>S. scalaris</i>	Europe, Siberia, NE China, Korea	Mainly Betula, rarely other deciduous species such as Prunus padus, Salix, Sorbus and Ulmus	Cherepanov (1991)
<i>S. similis</i>	Northern Mongolia, NE China, Korea	Salix	Cherepanov (1991)
<i>S. simulans</i>	China	Unknown	Tavakilian and Chevillotte (2019)
<i>S. subobliterata</i>	China, Japan, Russia	Ulmus japonica Ulmus laciniata	Tavakilian and Chevillotte (2019)
<i>S. viridipennis</i>	China	Unknown	Tavakilian and Chevillotte (2019)

References

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- Felt EM, and Joutel L, 1904. "Monograph of the genus Saperda," New York State Education Dept., Albany.
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- Mao-Ling S, and Hilszczański J, 2009. Two new species of genus Xorides (Hymenoptera: Ichneumonidae) parasitizing Saperda balsamifera Motschulsky and Asias halodendri (Pallas) (Coleoptera: Cerambycidae) in China. Annales Zoologici, 59, 165–170.
- Tavakilian G, and Chevilotte H, 2019. Titan database about Longhorns or Timber-Beetles (Cerambycidae). Available online: http://titan.gbif.fr/accueil_uk.html [Accessed 04 August 2019].
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Appendix D – Literature search and review on *S. tridentata* hosts

A comprehensive literature review was conducted in order to explore the reported host range of *S. tridentata*.

The following databases and platforms were explored (last access: 21 October 2019):

- JSTOR (<https://www.jstor.org>)
- BHL - Biodiversity heritage library (<https://www.biodiversitylibrary.org>)
- WOS - Web of Science (<http://apps.webofknowledge.com>, all databases)

These databases include a variety of documents including among others scientific and technical papers, technical bulletins, governmental reports and documents, conference proceedings, experts' personal reports, manuals, textbooks, field fact sheets. Catalogues of insects (from museums or laboratories) with no indication of host(s) and documents including duplicates of other documents (i.e. not being literature review) were not considered.

The review was focused on retrieving information regarding the hosts of *S. tridentata*, i.e. other information related to the biology of the insect were not considered for this review.

Considering that the literature focusing on the hosts of *S. tridentata* is very poor, and in order to retrieve as much information as possible, the web search comprised the main scientific name and synonyms (Section 3.1.1) of the pest, i.e.:

- "*Saperda tridentata*",
- "*Eutetrappa tridentata*",
- "*Compsidea tridentata*",
- "*Saperda dubiosa*".

The documents considered for the review were assigned to four categories:

- *No information*: documents mentioning *S. tridentata* but not its host.
- *Direct observation*: documents reporting the direct observation of *S. tridentata* and its host(s) (in open field or under laboratory conditions).
- *Generic*: document mentioning *S. tridentata* and its host(s) but neither based on direct observation nor referencing other documents, e.g. manuals, textbooks, technical sheets.
- *Literature review*: documents explicitly refereeing to other documents which mention *S. tridentata* and its host(s).

Table D.1 summarise the total documents found in JSTOR, WOS and BHL, using the four different search key, before removing duplicates and catalogues.

Table D.1: Number of documents found in JSTOR, WOS and BHL, using the four search keys, before removing duplicates and catalogues

Search key	JSTOR	WOS	BHL
" <i>Saperda tridentata</i> "	0	39	416
" <i>Eutetrappa tridentata</i> "	0	2	4
" <i>Compsidea tridentata</i> "	2	0	37
" <i>Saperda dubiosa</i> "	0	0	2

Most of the documents were found in the BHL database; however, many of those documents were duplicates. Table D.2 shows the results of the literature review. After removal of duplicates and insect catalogues, the total number of documents reviewed was 304 of which 121 gathered no information, 78 were generic documents, 22 literature reviews and 83 direct observations.

Table D.2: Documents found in the JSTOR, WOS and BHL database after removal of duplicates and catalogues and their classification according to the source of information and the reported hosts

Reference	Type of source information	Reported hosts
1. Abdullah, M., Abdullah, A. (1966). <i>Saperda</i> Fabricius, 1775 = <i>Eutetrappa</i> Bates, 1884, syn. n. (Coleoptera: Cerambycidae, Lamiinae), with a catalogue, new records, colour variation and a key to the species. In Proceedings of the Royal Entomological Society of London. Series B, Taxonomy, Vol 35(7–8): 87–94	Direct observation	Elm
2. Academy of Natural Sciences of Philadelphia Entomological Section, 1904. "Entomological news and proceedings of the Entomological Section of the Academy of Natural Sciences of Philadelphia" Entomological Rooms of the Academy of Natural Sciences, Philadelphia, Vol 15	Direct observation	Elm
3. Academy of Natural Sciences of Philadelphia Entomological Section, 1902. Entomological news and proceedings of the entomological section of the Academy of Natural Sciences of Philadelphia. Entomological News, Vol 13.	No information	No information
4. Academy of Natural Sciences of Philadelphia Entomological Section, 1915. "Entomological news and proceedings of the Entomological Section of the Academy of Natural Sciences of Philadelphia", Vol 26	No information	No information
5. Adams CC, 1915. "An ecological study of prairie and forest invertebrates," Illinois State Laboratory of Natural History, Urbana, Ill.	No information	No information
6. Alexander C, 1944. "Investigation of materials which promise value in insect control," Annual report of the Massachusetts Agricultural Experimental Station, Rep. No. 0097-6776. Massachusetts Agricultural Experiment Station, Amherst, Mass., No 417	Direct observation	Elm
7. American Association of Economic Entomologists, 1902. "Proceedings of the fourteenth annual meeting of the Association of Economic Entomologists," U.S. Dept. of Agriculture, Division of Entomology, Washington, D.C., Vol 37	Direct observation	Elm
8. American Microscopical Society, 1918. "Transactions of the American Microscopical Society, Organized 1878, Incorporated 1891" Columbus, Ohio, Vol 37	No information	No information
9. Anonymous, 1935. Eleventh National Shade Tree Conference Proceedings (Abstract). Eleventh National Shade Tree Conference Proceedings., 167 pp	No information	No information
10. Atkinson MD, 1992. <i>Betula Pendula</i> Roth (B. <i>Verrucosa</i> Ehrh.) and <i>B. Pubescens</i> Ehrh. Journal of Ecology, 80, 837–870.	No information	No information
11. Bailey LH, and Miller W, 1906. "Cyclopedia of American horticulture, comprising suggestions for cultivation of horticultural plants, descriptions of the species of fruits, vegetables, flowers and ornamental plants sold in the United States and Canada, together with geographical and biographical sketches, and a synopsis of the vegetable kingdom," 4th ed., Ed. Doubleday, Page & Company, New York.	Generic	Elm
12. Baker WC, 1941. Type of wood preferred by Coleoptera commonly found in decadent parts of living elm trees. Journal of Economic Entomology, 34, 475–476.	Direct observation	Elm
13. Baker WL, 1972. "Eastern forest insects - Miscellaneous publication," U.S. Dept. of Agriculture, Forest Service;, Washington, No 1175	Generic	U. americana, U. rubra
14. Banks N, and Henshaw S, 1889. Bibliography of the more important contributions to American economic entomology, Govt. print. off., Washington	No information	No information
15. Barnes J, 1988. "Asa Fitch and the emergence of American entomology". University of the State of New York, State Education Dept., Albany, N.Y., pp 122	No information	No information

Reference	Type of source information	Reported hosts
16. Barnes J, 2003. "Natural History of the Albany Pine Bush: Albany and Schenectady Counties, New York," New York State Museum.	No information	No information
17. Barr M, Rogerson C, Smith S, and Haines J, 1986. "An annotated catalogue of the Pyrenomycetes described by Charles H. Peck," University of the State of New York, State Education Dept., Albany, N.Y.	No information	No information
18. Beutenmüller W, 1891. Bibliographical catalogue of the described transformations of North American Coleoptera. Journal of the New-York Microscopical Society, 7, 1-52.	No information	No information
19. Beutenmuller W, 1896. Food-Habits of North American Cerambycidæ. Journal of the New York Entomological Society, 4, 73-81.	Generic	Elm
20. Blatchley WS, 1910. "An illustrated descriptive catalogue of the Coleoptera or beetles (exclusive of the Rhynchophora) known to occur in Indiana," Nature Pub. Co., Indianapolis.	Generic	U. americana, U. rubra
21. Board of Regents of the University of the State of New York, 1889. "Annual report of the Regents," J.B. Lyon, State Printer, Albany, NY, Vol 43	No information	No information
22. Board of Regents of the University of the State of New York, 1894. "48th Annual report of the Regents of the New York State Museum," J.B. Lyon, State Printer, Albany, NY, Vol 48	Literature review	Elm
23. Board of Regents of the University of the State of New York, 1898. "Annual report of the Regents," J.B. Lyon, State Printer, Albany, NY, Vol 52.	Generic	Elm
24. Board of Regents of the University of the State of New York, 1899. "53d Annual report of the Regents 1899," J.B. Lyon, State Printer, Albany, NY, Vol 53.	Generic	Elm
25. Board of Regents of the University of the State of New York (1900). "Annual report of the Regents," J.B. Lyon, State Printer, Albany, NY, Vol 54	Generic	Elm
26. Board of Regents of the University of the State of New York, 1903. "55th Annual report of the Regents 1901," J.B. Lyon, State Printer, Albany, NY, Vol 55.	Literature review	U. americana
27. Boiteau G, 1983. "The arthropod fauna of potato fields: composition and abundance.," Fredericton, New Brunswick, CA, Contribution 1983-16E.	No information	No information
28. Breuning S, 1952. Revision einiger Gattungen aus der Gruppe der Saperdini Muls. (Col. Cerambycidae). Entomologische Arbeiten aus dem Museum G. Frey Tutzing bei München, 3, 107-213.	No information	No information
29. Britton WE, 1933. "Connecticut State Entomologists thirty-second report 1932," Connecticut Agricultural Experiment Station, New Haven, CT, Vol 349	Direct observation	Elm
30. Britton WE, 1935. "Report of the State Entomologist of Connecticut for the year," New Haven, CT, Vol 383	Direct observation	Elm
31. Britton WE, 1936. "Connecticut state entomologist thirty-sixth report - 1936," New Haven.	Direct observation	Elm
32. Britton WE, 1937. "Connecticut State Entomologist thirty-seven report," New Haven.	No information	No information
33. Britton WE, 1939. "Report of the State Entomologist of Connecticut for the year 1938," New Haven, CT, Vol 428	Direct observation	Elm
34. Britton WE, Clinton G, and Filley W, 1924. "Second report of the Tree Protection Examining Board," Connecticut Agricultural Experiment Station, New Haven, CT.	Generic	Elm

Reference	Type of source information	Reported hosts
35. Bromley SW, 1948. Tests on Control of Elm Scolytus. Journal of Economic Entomology, 41, 327.	No information	No information
36. Bromley SW, 1950. Tests on elm Scolytus 1949. Journal of Economic Entomology, 43, 397–398.	No information	No information
37. Brooklyn Entomological Society, 1937. "Bulletin of the Brooklyn Entomological Society," The Brooklyn Entomological Society, Brooklyn, N.Y., Vol 32–33	Generic	Elm
38. Buchanan WD, and May C, 1942. Technique for artificially feeding Scolytus multistriatus and Saperda tridentata spores of Ceratostoma ulmi and other substances. Phytopathology, 32, 95–97.	No information	No information
39. Buck WR, Heald SV, Holmgren NH, and Zanoni TA, 1996. Index to American Botanical Literature. Brittonia, 48, 124–160.	No information	No information
40. Campbell J, Sarazin M., and Lyons D, 1989. "Canadian beetles (Coleoptera) injurious to crops, ornamentals, stored products, and buildings," Agriculture Canada, Ottawa, Ontario.	Literature review	U. americana, U. rubra
41. Casey TL, 1913. Further studies among the American Longicornia. Memoirs on the coleoptera, 4, 193–388.	No information	No information
42. Chadbourne A, and Savage H, 1883. "The journal of the Boston Zoological Society," The Society, Boston, Vol 2.	No information	No information
43. Clarke J, and Felt EM, 1905. "20th Report of the State Entomologist on injurious and other insects of the State of New York, 1904" New York State Education Dept., Albany, Bulletin 97, Entomology 24.	No information	No information
44. Clarke J, and Felt EM, 1907. "22d Report of the State Entomologist on injurious and other insects of the State of New York, 1906" New York State Education Dept., Albany, Bulletin 110.	No information	No information
45. Clarke J, and Felt EP, 1923. "35th report of the State Entomologist on injurious and other insects of the state of New York, 1921" Weed, Parsons and Co.; University of the State of New York, Albany.	No information	No information
46. Clemens J, and Pettman D, 2004. Public Transport: Jaunting from the Spaceship Nomad to the HSS Tampa. In "Avoiding the Subject", pp. 109–128. Amsterdam University Press.	No information	No information
47. Coleman TW, and Seybold SJ, 2011. Collection History and Comparison of the Interactions of the Goldspotted Oak Borer, Agrilus Auroguttatus Schaeffer (Coleoptera: Buprestidae), with Host Oaks in Southern California and Southeastern Arizona, U.S.A. The Coleopterists Bulletin, 65, 93–108.	No information	No information
48. Collins CW, 1935. Insect vectors of the Dutch Elm disease caused by the fungus Ceratostomella ulmi (Schwarz) Buisman. Proceedings of the National Shade Tree Conference (US), 127–132.	Generic	Elm
49. Collins CW, 1941. Studies of elm insects associated with Dutch elm disease fungus. Journal of Economic Entomology, 34, 369–372.	Direct observation	Elm
50. Collins CW, Buchanan WD, Whitten RR, and Hoffmann CH, 1936. Bark beetles and other possible insect vectors of the Dutch elm disease Ceratostomella ulmi (Schwarz) Buisman. Journal of Economic Entomology, 29, 169–176.	Direct observation	Elm
51. Commissioners of Fisheries, Game and Forest of the State of New York (1900). "Fifth annual report of the Commissioners of Fisheries, Game and Forest of the State of New York," Albany, NY.	Literature review	Elm
52. Committee of the Natural History Society of Montreal, 1860. "The Canadian Naturalist and Geologist and proceedings of the natural history society of Montreal," Dawson & Son, Montreal, CA., Vol 5	No information	No information
53. Committee of the Natural History Society of Montreal, 1861. The Canadian Naturalist and Geologist and proceedings of the natural history society of Montreal. Vol 6.	No information	No information

Reference	Type of source information	Reported hosts
54. Connecticut Agricultural Experiment Station, 1900. "Protection of shade trees in cities and towns" Connecticut Agricultural Experiment Station, New Haven, Connecticut, Bulletin 131	Generic	Elm
55. Craighead FC, 1923. "North American cerambycid larvae : a classification and the biology of North American cerambycid larvae," Bulletin 27 – New Series, Dept. of Agriculture, Ottawa	Generic	Ulmus sp.
56. Craighead FC, 1950. "Insect enemies of eastern forests," U.S. Dept. of Agriculture, Washington, D.C., Vol 657	Generic	Elm
57. Craighead FC, and Middleton W, 1930. "An annotated list of the important North American forest insects," U.S. Dept. of Agriculture, Washington, D. C.	Literature review	Elm
58. Cranshaw W, 2004. Trunk and Branch Borers. In "Garden Insects of North America", pp. 460–499. Princeton University Press.	Generic	U. americana
59. Cranshaw W, and Shetlar D, 2018. Insects associated with large branches and the trunk of trees and shrubs. In "Garden Insects of North America", pp. 424–463. Princeton University Press.	Generic	U. americana
60. Currie RP, 1905. "Catalogue of the exhibit of economic entomology at the Lewis and Clark Centennial Exposition, Portland, Oregon, 1905," U.S. Dept. of Agriculture, Bureau of Entomology, Washington, D.C., Vol 53	Generic	Elm
61. Davenport Academy of Natural Sciences, 1897. "Proceedings of the Davenport Academy of Natural Sciences." Vol 6	No information	No information
62. Davey J, 1914. "Shade Tree Insects, Lesson number ten," Kent, Ohio.	Generic	Elm
63. Daviault L, 1946. Forest Entomology. In Report of the Minister of Lands and Forests of the Province of Quebec for the year ending March 31st, 1945, Redempti Paradis, pp 113–122.	Direct observation	Elm
64. Derek SS, and Reginald PW, 2005. Bioinventory of Rhode Island Coleoptera: 45 New Records. The Coleopterists Bulletin, 59, 311–327.	No information	No information
65. Devereaux W, 1879. Captures of Noctuidæ at Clyde, Wayne Co., N.Y. The Canadian entomologist, 11, 105–110.	No information	No information
66. Dougherty EC, 1951. Evolution of Zoöparasitic Groups in the Phylum Nematoda, with Special Reference to Host-Distribution. The Journal of Parasitology, 37, 353–378.	No information	No information
67. Douglass BW, 1912. "Fourth annual report of the State entomologist of Indiana," W.B. Burford, Indianapolis .	Generic	Elm
68. Downing ER, 1922. "A naturalist in the Great Lakes region," The University of Chicago Press, Chicago, Ill.	No information	No information
69. Drooz A, 1985. "Insects of eastern forests," US Department of Agriculture, Forest Service, Miscellaneous publication No 1426	Generic	U. americana, U. rubra
70. D'Urban WSM, and Bell R, 1860. "Contributions to Canadian natural history" Lovell, Montreal.	No information	No information
71. Ehrmann E, 1897. Coleopterological notes from my brother's diary. Entomological news, and proceedings of the Entomological Section of the Academy of Natural Sciences of Philadelphia, 8, 168–170.	Direct observation	Elm, Maple
72. Elias TS, 1970. The genera of ulmaceae in the southeastern United States. Journal of the Arnold Arboretum, 51, 18–40.	Literature review	Elm
73. Emmons E, 1846. "Agriculture of New York : comprising an account of the classification, composition and distribution of the soils and rocks together with a condensed view of the climate and the agricultural productions of the state," C. Van Benthuyzen, Albany, Vol 5	No Information	No Information
74. Emmons E, 1854. "Coleoptera of the state of New York," C. Van Benthuyzen & Co., Albany, NY.	No Information	No Information

Reference	Type of source information	Reported hosts
75. English LL, 1976. "Illinois trees and shrubs: their insect enemies," 6th print., with revisions, Illinois Natural History Survey, Urbana, Ill.	Generic	Elm
76. Entomological Society of Canada, 1879. "The Canadian entomologist," Entomological Society of Canada, Ottawa, Vol 11	Direct observation	Elm
77. Entomological Society of Canada, 1908. "The Canadian entomologist," Entomological Society of Canada, Ottawa, Vol 40.	Direct observation	Elm
78. Entomological Society of Ontario, 1890. "Twenty-first annual report of the entomological society of Ontario," Entomological Society of Ontario, Toronto, Canada.	Generic	Elm
79. Entomological Society of Ontario, 1897a. "Twenty-seventh annual report of the Entomological Society of Ontario 1896," Entomological Society of Ontario, Toronto.	No information	No information
80. Entomological Society of Ontario, 1897b. "Twenty-eight annual report of the Fruit Growers' Association of Ontario 1896," Fruit Growers' Association of Ontario, Toronto.	No information	No information
81. Entomological Society of Ontario, 1901, Forty-ninth annual report of the Entomological Society of Ontario 1900. The Entomological Society of Ontario, Vol 31.	Literature review	Linden, Poplar
82. Entomological Society of Ontario, 1904. "Thirty-fourth annual report of the Entomological Society of Ontario 1903," Entomological Society of Ontario, Toronto.	Literature review	Elm
83. Entomological Society of Ontario, 1906. "Thirty-sixth annual report of the Entomological Society of Ontario, 1905." Entomological Society of Ontario, Toronto, Vol 36	Generic	Elm
84. Entomological Society of Ontario, 1919. "Forty-ninth annual report of the Entomological Society of Ontario 1918" Entomological Society of Ontario, Toronto.	Direct observation	Elm
85. Entomological Society of Washington, 1905. "Proceedings of the Entomological Society of Washington," Entomological Society of Washington, Washington, Vol 7	Direct observation	Elm
86. Evans AV, 2014. "Beetles of Eastern North America," Princeton University Press.	Generic	Elm
87. Evans AV, and Hogue JN, 2006. Family accounts. In "Field Guide to Beetles of California", pp. 49–278. University of California Press.	No information	No information
88. Fellin DG, 1973. "Weevils attracted to thinned lodgepole pine stands in Montana," Intermountain Forest and Range Experiment Station, Forest Service, U.S. Dept. of Agriculture, [Ogden, Utah]	No information	No information
89. Felt EP, 1898b. "Elm-leaf beetle in New York State," New York State Education Dept., Albany.	Generic	Elm
90. Felt EP, 1898c. "14th Report of the State Entomologist on injurious and other insects of the state of New York". Bulletin of the New York State Museum, University of the State of New York, Albany, NY, Vol 5, No 23	No information	No information
91. Felt EP, 1899a. "Shade tree pests in New York State," New York State Education Dept., Albany.	No information	No information
92. Felt EP, 1899b. "Memorial of life and entomologic work of Joseph Albert Lintner, state entomologist, 1874–98," University of the State of New York, Albany	Literature review	U. americana
93. Felt EP, 1900a. "15th Report of the state entomologist on injurious and other insects of the State of New York," New York State Education Dept., Albany	Direct observation	Elm

Reference	Type of source information	Reported hosts
94. Felt EP, 1900b. Illustrated descriptive catalogue of some of the more important injurious and beneficial insects of New York State. Bulletin of the New York State Museum, Vol 8(37)	Generic	Elm
95. Felt EP, 1901. "16th Report of the state entomologist on injurious and other insects of the State of New York," New York State Education Dept., Albany.	Generic	Elm
96. Felt EP, 1904. "Bulletin of the New York State Museum," New York State Education Dept., Albany, Bulletin 76, Entomology 21	No information	No information
97. Felt EP, 1905. "Insects affecting park and woodland trees," New York State Education Dept., Albany.	Generic	Elm
98. Felt EP, 1930. The economic importance of shade tree insects. Journal of Economic Entomology, 23, 109–113.	No information	No information
99. Felt EP, 1932. Shade Trees Threatened by Insect Pests. The Scientific Monthly, 35, 59–62.	No information	No information
100. Felt EP, and Bromley SW, 1930. Shade tree problems (Abstract). Proceedings of the Annual Meeting of the National Shade Tree Conference, 6, 13–23.	Generic	Elm
101. Felt EP, and Bromley SW, 1937. Scientific Contributions (Abstract). Bulletin of the Bartlett Tree Research Laboratory, 24 pp.	Direct observation	Elm
102. Felt EP, and Joutel L, 1904. "Monograph of the genus Saperda," New York State Education Dept., Albany.	Literature review	U. americana, U. rubra
103. Fiske WF, 1905. Catogenus rufus, a coleopterous parasite. Proceedings of the Entomological Society of Washington, 7, 90–92.	No information	No information
104. Fitch A, 1885. "Fifth report on the noxious and other insects of the State of New York."	Generic	U. rubra
105. Fitch HS, 1965. "Miscellaneous publication - University of Kansas, Museum of Natural History," University of Kansas, Lawrence, KS, Vol 42	No information	No information
106. Forbes SA, 1912a. "Report of the State Entomologist on the noxious and beneficial insects of the state of Illinois," State Entomologist.	Direct observation	U. americana
107. Forbes SA, 1912b. "What is the matter with the elms in Illinois?" Bulletin of the Agricultural Experiment Station of the University of Illinois, Bulletin 154.	Generic	Elm
108. Forbes SA, 1885. "Fourteenth report of the State Entomologist on the noxious and beneficial insects of the state of Illinois," State Entomologist, Springfield, Ill, Vol 14	Direct observation	U. americana
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Reference	Type of source information	Reported hosts
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Reference	Type of source information	Reported hosts
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Reference	Type of source information	Reported hosts
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258. USDA - Bureau of Entomology, 1932a. "The Insect pest survey bulletin" Bureau of Entomology, U.S. Dept. of Agriculture, Washington, D.C., Vol 12.	Direct observation	Elm
259. USDA - Bureau of Entomology, 1932b. "The Insect pest survey bulletin" Bureau of Entomology, U.S. Dept. of Agriculture, Washington, D.C., Vol 12	Direct observation	Ulmus americana
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265. USDA - Bureau of Entomology, 1937. "News letter" Bureau of Entomology and Plant Quarantine, Washington, D.C., Vol 4.	No information	No information
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Reference	Type of source information	Reported hosts
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270. USDA, 1954b. "Cooperative economic insect report" Plant pest control branch, Agricultural Research Service, USDA, Washington, D.C., Vol 4.	No information	No information
271. USDA, 1955. "Cooperative economic insect report" Plant pest control branch, Agricultural Research Service, USDA, Washington, D.C., Vol 5.	Direct observation	Elm
272. USDA, 1955. "Cooperative economic insect report" Plant pest control branch, Agricultural Research Service, USDA, Washington, D.C., Vol 5.	No information	No information
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275. USDA, 1957a. "Cooperative economic insect report" Plant pest control branch, Agricultural Research Service, USDA, Washington, D.C., Vol 7.	No information	No information
276. USDA, 1957b. "Cooperative economic insect report" Plant pest control branch, Agricultural Research Service, USDA, Washington, D.C., Vol 7.	No information	No information
277. USDA, 1957c. "Cooperative economic insect report" Plant pest control branch, Agricultural Research Service, USDA, Washington, D.C., Vol 7.	Direct observation	Elm
278. USDA, 1957d. "Cooperative economic insect report" Plant pest control branch, Agricultural Research Service, USDA, Washington, D.C., Vol 7.	Direct observation	Elm
279. USDA, 1957e. "Cooperative economic insect report" Plant pest control branch, Agricultural Research Service, USDA, Washington, D.C., Vol 7.	Direct observation	Elm
280. USDA (1958a). "Cooperative economic insect report" Plant pest control branch, Agricultural Research Service, USDA, Washington, D.C., Vol 8(27)	No information	No information
281. USDA, 1958a. Cooperative economic insect report. Plant pest control branch, Agricultural Research Service, USDA, Washington, D.C., 8.	Direct observation	Elm
282. USDA, 1958b. "Cooperative economic insect report" Plant pest control branch, Agricultural Research Service, USDA, Washington, D.C., Vol 8.	Direct observation	Elm
283. USDA, 1959a. "Cooperative economic insect report" Plant pest control branch, Agricultural Research Service, USDA, Washington, D.C., Vol 9.	No information	No information

Reference	Type of source information	Reported hosts
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286. USDA, 1963a. "Cooperative economic insect report" Plant pest control branch, Agricultural Research Service, USDA, Washington, D.C., Vol 13.	No information	No information
287. USDA, 1963b. "Cooperative economic insect report" Plant pest control branch, Agricultural Research Service, USDA, Washington, D.C., Vol 13.	No information	No information
288. USDA, 1964a. "Cooperative economic insect report" Plant pest control branch, Agricultural Research Service, USDA, Washington, D.C., Vol 14.	Direct observation	Elm
289. USDA, 1964b. "Cooperative economic insect report" Plant pest control branch, Agricultural Research Service, USDA, Washington, D.C., Vol 14.	Direct observation	Elm
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304. Yanega D, 1996. "Field guide to northeastern longhorn beetles (Coleoptera: Cerambycidae)," Illinois Natural History Survey, Champaign, Ill.	Generic	Elm

Appendix E – Scoping review on the flight capacity of adult *Saperda tridentata* and other Cerambycidae, and analysis of spatial separation of European elm trees in Northern Italy

Scoping review on the flight capacity of adult *S. tridentata* and other Cerambycidae

Adult *S. tridentata* emerge from hosts and quickly mate (Solomon, 1995). However, unless females feed no eggs are laid (Pechuman, 1940). A mated female is, therefore, behaviourally required to locate a suitable host tree for feeding and, subsequently, for egg laying. Since egg laying takes place preferentially on weakened trees, females are likely to respond to cues given off by such trees which suggest they are capable to find suitable hosts even if they are uncommon in the landscape.

No literature reporting experimental studies examining flight distance of *S. tridentata* could be found. We therefore draw on literature describing the flight and dispersal of other cerambycid species feeding on deciduous hosts, including literature on other species of *Saperda*.

Short distance flight is typical of many cerambycids and the natural spread rate of longhorn beetles is generally considered to be quite slow because adults reproduce on, or close to, the natal host (Hack et al., 2010; Rhains et al., 2011). For example, Felt and Joutel (1904) report that *Saperda fayi* usually oviposit on the tree they inhabited as borers and fly only a little, leading to their distribution being considered localised.

Where host density is moderate to high, there is no need for slow-growing cerambycids to spread far. For example, Sawyer et al. (2011) examined the spread of *Anoplophora glabripennis* within US outbreak sites. In areas with abundant hosts, the population remained on a few trees within a few metres of each other for the first few years, e.g. 90% of oviposition sites were within 140 m of the nearest site of emergence and 99% were within 300 m. This contrasted with spread of approximately 3,200 m over 5 years in a region with much lower host density. Hence, the lack of hosts encouraged wider dispersal. Similar distances are reported for *A. glabripennis* in Italy where survey results used in a model suggest 80% of dispersal was within 300 m of the nearest infested hosts although some adults did spread more than 2 km from the nearest infested host (Favaro et al., 2015).

If there is no suitable host in the vicinity, adult *A. glabripennis* can fly several hundred metres or more in a single flight. Lopez et al. (2017) conducted flight mill experiments to measure the dispersal potential of male and female adult *A. glabripennis*. From a study of 162 individuals, the mean flight distance during a 24 hour period was 2,272 m although the maximum distance an individual flew was 13,667 m. However, such experiments do not represent natural conditions and the distances flown in a mill are difficult to relate to those in the natural environment. A similar study carried out on invasive *A. glabripennis* in Europe confirmed that some individuals were capable of flying an accumulated distance of around 14 km during their lifetime (Javal et al. 2018). The authors speculate that the longer flights were prompted by searches for oviposition sites and scarcity of local resources. Analysis of patterns of attack by *A. glabripennis* in a large infestation in Worcester, Massachusetts by Trotter & Hull-Sanders (2015) under different assumed attack scenarios suggested that longer distance dispersal occurred when local resources near natal trees were scarce.

In China, mark–release–recapture studies demonstrated that, although 72% of *A. glabripennis* adults were recaptured within 300 m of release points, some beetles were recaptured up to 2,600 m away (Smith et al., 2004).

There are observations on single flight distances of *Saperda candida* (the round-headed apple tree borer) by Hess (1940). Hess reports capturing adults then releasing them individually from the hand and watching how far they flew in a single flight. Although Hess (1940) reports distances in yards, his estimates are reported in the table below in SI units.

Table E.1: Observed distances of single flights by adult *Saperda candida* (Hess, 1940)

	Number of adults tested	Mean distance (m)	Maximum distance (m)
Males	52	10.1	> 82.3
Female	61	6.4	20.1

Hess (1940) suggested that *S. candida* could spread within North America due to the presence of apple orchards and apples trees in peoples' gardens. However, areas without hosts for 'even a few

miles' would act as natural barriers and prevent spread since without human assistance the species would not be able to cross such barriers. The same is thought to be likely for *S. tridentata*. The distance between hosts will be a key factor influencing whether *S. tridentata* could establish in the EU.

Abiotic environmental conditions such as temperature, humidity, light level and wind speed are factors likely to influence adult flight. However, the specific criteria for initiating flight are unknown for *S. tridentata*. *S. tridentata* most often fly at night and, therefore, host location is more likely to be to olfactory rather than visual cues.

Biotic factors such as the density of individuals on the natal host, and the quality of the remaining host resources are also likely factors that influence whether an adult will fly and disperse from the host it emerged from. Adult *A. glabripennis* disperse in response to the number of beetles that emerge from a tree. The increasing abundance of adults leads to greater migration although they only move a short distance (Bancroft & Smith, 2005).

The Sawyer (2007) study of *A. glabripennis* outbreaks in New Jersey (USA) concluded that there were a few beetles that first established; they remained localised for many years and spread slowly until at some point, the local resources becomes overexploited at which time dispersal increased from a few hundred meters to over 1 km.

If *S. tridentata* is able to utilise European *Ulmus* species, *Acer* or *Populus* as hosts, something similar could be expected for *S. tridentata* in the EU although the likelihood that such trees could become hosts remains highly uncertain.

Spatial separation of European elm trees in Northern Italy

The scarce and ambiguous information regarding the host range of *S. tridentata* hampered firm conclusions on the criteria of the pest categorisation regarding establishment, spread and impact. Nevertheless, arising from the search for scientific or anecdotal evidence about host range, other data were deemed useful to improve the assessment once host range (in EU) was determined.

The observational evidence regarding entry (see Section 3.4.2 in main document) refers to annual interceptions of immature stages of the insect in imported wood through the port of Livorno, Italy. All *S. tridentata* infested wood imports originated from the USA were associated with round or sawn wood of American elm (*Ulmus* sp.). The Panel is uncertain whether the concentration of interceptions at only one port in EU is the matter of fact or due to improved testing procedures at the Livorno location.

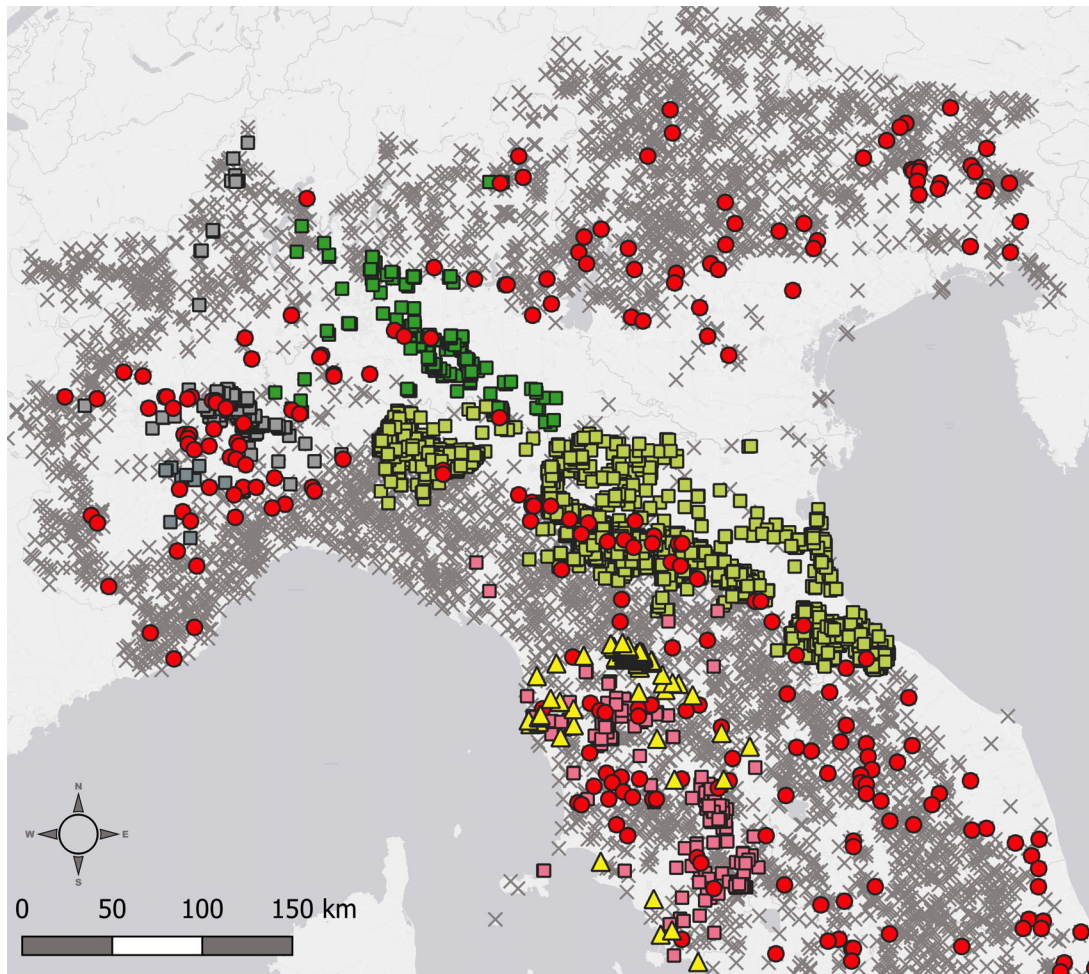
It was deemed informative to consider the spatial separation of elm species in the near vicinity of the Italian ports and the distance profile of elm trees on greater spatial scales. The first proxies the capacity of the regional elm population to provide accessible habitat around Italian ports, while the second provides an indication whether mature beetles translocated to a random elm tree in the area (e.g. anthropogenically mediated) are likely reaching secondary elm trees for future establishment of successive generations by natural flight distance (dispersal mobility).

However, the value of the following considerations remains uncertain because dependent on the unknown host range of *S. tridentata* in the EU possibly anywhere between only American *Ulmus* and any *Acer* + *Populus* trees (see conclusions of the pest categorisation in Table 13).

Stand data of elm trees (*Ulmus* sp)

Northern Italy provides the only example region where *S. tridentata* interceptions are recorded at the port of Livorno (Tuscany Region, Italy), and (at least patchy) retrieval of elm tree stand distributions was possible. For the purposes of these considerations, EU species of elm were assumed to provide a more plausible theoretical host range compared to *Acer* sp. and/or *Populus* sp. while the actual host range of the beetle in EU remains unknown.

EFSA did combine independent data sources to compile the stand distribution shown in Figure E.1. The data sources are heterogeneous regarding geographical coverage, absence reporting and tree size included



Symbols:

Italian Forest Inventory

- Grid cells including *Ulmus* plants
- × Sampled grid cells with no *Ulmus* plants

Regional Forest Inventories - presence of *Ulmus* plants

- Emilia Romagna
- Lombardy
- Piedmont
- Tuscany

Regione Toscana phytosanitary monitoring

- ▲ Monitored *Ulmus* plants

Figure E.1: Data on observed presences and absences of elm trees in Northern Italy. The information compiles different data sources as coloured. Neither of the data sources is deemed comprehensive regarding area coverage or observed absences. Additionally, the stem diameter of recognised tree presences is not equal across data sources and might comprise small trees not representing habitat for reproduction of the beetle (establishment). Symbols related to the Italian Forest Inventory represent the south-west corners of 1 km × 1 km grid cells including (red circles) or not (grey crosses) *Ulmus* plants. Squares indicate centroids of polygons (Emilia Romagna, Lombardy, Piedmont) or grid cells (Tuscany) with records of the presence of *Ulmus* plants. Yellow triangles represent *Ulmus* plants inspected within the Tuscany phytosanitary monitoring program

Distance spread from the point of entry

Usual flight distances reported for cerambycids in laboratory and field studies were around a few hundred meters. In situations of host scarcity, however, mobility distance was reported to increase substantially. Extreme flight distances reported for cerambycid species suggest capacity under host limitations of up to 3 km (see above): 3,200 m over 5 years; more than 2 km; up to 2,600 m; over 1 km; laboratory 13,667 m).

The following map visually combines the tree stand data of Figure E.2 with the hypothetical mobility range of the elm borer. Concentric rings illustrate the chance of reaching an elm tree if a mature beetle starts from either port in the mapped region. Whether finding the tree allows the beetle to reproduce remains uncertain due to unknown host range of *S. tridentata* in the EU.

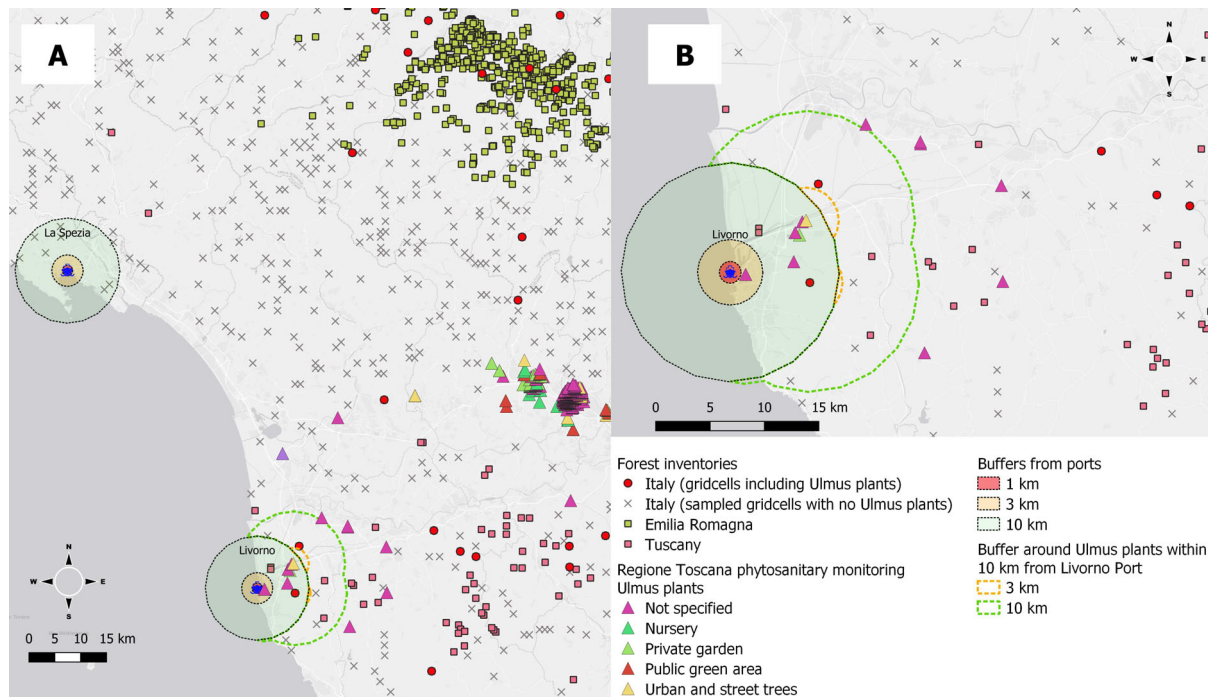


Figure E.2: Panel A: Spatial distribution of elm trees (*Ulmus* sp.) of unknown stem diameter in the vicinity of Northern Italian ports of La Spezia and Livorno (blue stars) being locations of plausible pest interception. Different assumptions of flight capability are represented by radial distance of 1 km (red area), 3 km (orange area) and 10 km (green area) to the port of La Spezia (left top) and Livorno (middle bottom). Additionally, in Panel B, secondary distances are encircled by dotted lines representing the available host for further spread once established on any elm in the surroundings of the two ports. Symbols related to the Italian Forest Inventory represent the south-west corners of 1 km x 1 km grid cells including (red circles) or not (grey crosses) *Ulmus* plants. Squares indicate centroids of polygons (Emilia Romagna) or grid cells (Tuscany) with records of the presence of *Ulmus* plants. Triangles represent *Ulmus* plants inspected within the Tuscany phytosanitary monitoring programme

If theoretically *S. tridentata* can utilise European *Ulmus* species as host, the maps reveal repeated extreme dispersal flights are required following entry to reach first trees and subsequent spatial expansion. However, with *Acer* or *Populus* as hosts, ubiquitous availability would alter the picture, although the likelihood that such trees could become hosts in the EU remains uncertain.

Distance spread from a random location of establishment

Neat scenario assumes that the mature insect was translocated to a random elm tree in Northern Italy (e.g. by transportation of infested wood out of a port). Allowing for natural spread the insect needs to search for and locate secondary tree stands for exploitation. The problem of interest is the expected distance a dispersing beetle might be confronted with when starting from its tree of larval

development. Such patterns usually inform about colonisation potential of a species in an environment of patchy habitat. The shown distance distributions make the unreasonable assumption that the beetle could locate any near neighbour tree in a straight-line flight. Insects, however, are deemed to search only locally using chemical cues while larger scale movement is driven by ecological pattern recognitions or chance search (Webster and Cardé, 2017). Hence, the distance between any elm tree and its nearest neighbour (next-neighbour distance distribution) is an optimistic proxy for the capability of the beetles to colonise other trees (Figure E.3).

Maximising the geographic coverage of the analysis, only the data of the Italian forest inventory were used. The advantage of the data is the 1 km scale and the sample locations i.e. absence locations are of value. Substantial uncertainty remains whether the sample-based approach inherently may exclude close neighbour patches i.e. trees in the distance range of up to 3 km which is the most interesting distance according to the flight distance data collected above.

Distance (km) among nearest *Ulmus* plants neighbours

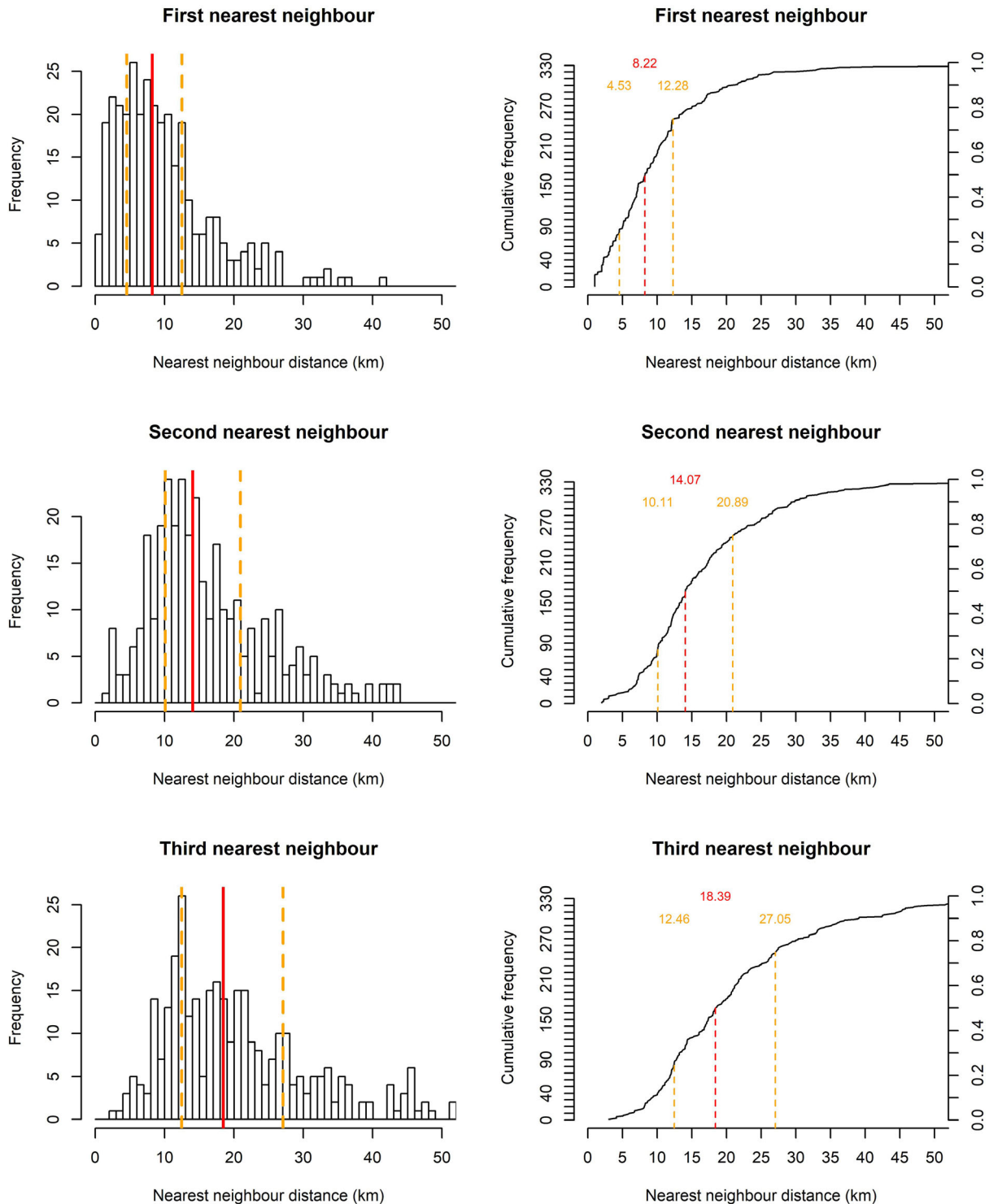


Figure E.3: Nearest, second and third nearest neighbour distribution for the elm tree stands reported in the Italian Forest Inventory data from Northern Italy. Same data are presented as absolute frequencies (left column) and as cumulative frequencies (right column). The median of the distribution and the respective distance value are marked in red. In yellow, the respective 25 and 75 percentiles are highlighted

About 47 of the 330 recorded grid cells containing *Ulmus* trees (first three frequency values) have a neighbouring grid cell within 3 km distance. To find a new tree with ~25% chance (lower yellow line), beetle should be able to cover flight distances up to 4,530 m assuming straight flight without deviation. Beetles may miss the ideal direction to the nearest tree (chance usually determined by the angle segment the beetle could search while moving away of the tree, unknown for this species). Starting on 12 (only one) grid cell beetles may still find a potential host, second (third) nearest neighbour, within 3 km distance if choosing the respective angle segment for the search.

If *S. tridentata* can utilise European *Ulmus* species, *Acer* and *Populus* as hosts in the EU, there would be widespread availability of trees to colonise. The actual possible host range in the EU, however, remains uncertain.

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Appendix F – *Ulmus* logs imports in Europe

Member States were contacted by EFSA to have data about import of *Ulmus* logs in the respective countries from 2016 to 2019.

Table F.1: *Ulmus* logs Import data from North America to European countries from 2016 to 2019. Derived variable was calculated using as a reference the density of *U. rubra* wood: 600 kg m⁻³ (source: <https://www.wood-database.com/>)

Country	Port	Year	Imported			Inspected			Derived variable
			Containers (#)	Weight (tonnes)	Volume (m ³)	Containers (#)	Weight (tonnes)	Volume (m ³)	
Italy	Livorno	2016	8	61.63	102.71	4	45.17	75.29	weight
Italy	Livorno	2017	16	113.57	189.29	14	106.40	177.33	weight
Italy	Livorno	2018	5	40.63	67.71	3	31.27	52.12	weight
Italy	Livorno	2019	1	10.83	18.05	1	10.83	18.05	weight
Italy	La Spezia	2016	4	71.00	118.00	4	4.00	118.00	volume
Italy	La Spezia	2017	0	0.00	0.00	0	0.00	0.00	volume
Italy	La Spezia	2018	0.00	0.00	0.00	0.00	0.00	0.00	volume
Italy	La Spezia	2019	7.00	132.00	220.00	7.00	132.00	220.00	volume
Italy	Napoli	2016	0.00	0.00	0.00	0.00	0.00	0.00	–
Italy	Napoli	2017	0.00	0.00	0.00	0.00	0.00	0.00	–
Italy	Napoli	2018	0.00	0.00	0.00	0.00	0.00	0.00	–
Italy	Napoli	2019	0.00	0.00	0.00	0.00	0.00	0.00	–
Italy	Venezia	2016	0.00	0.00	0.00	0.00	0.00	0.00	–
Italy	Venezia	2017	0.00	0.00	0.00	0.00	0.00	0.00	–
Italy	Venezia	2018	0.00	0.00	0.00	0.00	0.00	0.00	–
Italy	Venezia	2019	0.00	0.00	0.00	0.00	0.00	0.00	–
Estonia	na	2016	0.00	0.00	0.00	0.00	0.00	0.00	–
Estonia	na	2017	0.00	0.00	0.00	0.00	0.00	0.00	–
Estonia	na	2018	0.00	0.00	0.00	0.00	0.00	0.00	–
Estonia	na	2019	0.00	0.00	0.00	0.00	0.00	0.00	–
Germany	na	2016	na	37.67	62.78	na	37.67	62.78	weight
Germany	na	2017	na	61.54	102.57	na	51.63	86.06	weight
Germany	na	2018	na	30.88	51.47	na	30.35	50.58	weight
Germany	na	2019	na	26.10	43.51	na	26.10	43.51	weight
Spain	Barcelona	2016	0.00	0.00	0.00	0.00	0.00	0.00	–

Country	Port	Year	Imported			Inspected			Derived variable
			Containers (#)	Weight (tonnes)	Volume (m ³)	Containers (#)	Weight (tonnes)	Volume (m ³)	
Spain	Barcelona	2017	0.00	0.00	0.00	0.00	0.00	0.00	–
Spain	Barcelona	2018	0.00	0.00	0.00	0.00	0.00	0.00	–
Spain	Barcelona	2019	0.00	0.00	0.00	0.00	0.00	0.00	–
Spain	Valencia	2016	0.00	0.00	0.00	0.00	0.00	0.00	–
Spain	Valencia	2017	0.00	0.00	0.00	0.00	0.00	0.00	–
Spain	Valencia	2018	0.00	0.00	0.00	0.00	0.00	0.00	–
Spain	Valencia	2019	0.00	0.00	0.00	0.00	0.00	0.00	–
Spain	Bilbao	2016	0.00	0.00	0.00	0.00	0.00	0.00	–
Spain	Bilbao	2017	0.00	0.00	0.00	0.00	0.00	0.00	–
Spain	Bilbao	2018	0.00	0.00	0.00	0.00	0.00	0.00	–
Spain	Bilbao	2019	0.00	0.00	0.00	0.00	0.00	0.00	–
Finland	na	2016	0.00	0.00	0.00	0.00	0.00	0.00	–
Finland	na	2017	0.00	0.00	0.00	0.00	0.00	0.00	–
Finland	na	2018	0.00	0.00	0.00	0.00	0.00	0.00	–
Finland	na	2019	0.00	0.00	0.00	0.00	0.00	0.00	–
Portugal	Leixões	2016	0.00	0.00	0.00	na	na	na	–
Portugal	Leixões	2017	0.00	0.00	0.00	na	na	na	–
Portugal	Leixões	2018	0.00	4.65	7.76	na	na	na	volume
Portugal	Leixões	2019	0.00	0.00	0.00	na	na	na	–
Latvia	na	2016	0.00	0.00	0.00	0.00	0.00	0.00	–
Latvia	na	2017	0.00	0.00	0.00	0.00	0.00	0.00	–
Latvia	na	2018	0.00	0.00	0.00	0.00	0.00	0.00	–
Latvia	na	2019	0.00	0.00	0.00	0.00	0.00	0.00	–
Cyprus	na	2016	0.00	0.00	0.00	0.00	0.00	0.00	–
Cyprus	na	2017	0.00	0.00	0.00	0.00	0.00	0.00	–
Cyprus	na	2018	0.00	0.00	0.00	0.00	0.00	0.00	–
Cyprus	na	2019	0.00	0.00	0.00	0.00	0.00	0.00	–
Lithuania	na	2016	0.00	0.00	0.00	0.00	0.00	0.00	–
Lithuania	na	2017	0.00	0.00	0.00	0.00	0.00	0.00	–
Lithuania	na	2018	0.00	0.00	0.00	0.00	0.00	0.00	–

Country	Port	Year	Imported			Inspected			Derived variable
			Containers (#)	Weight (tonnes)	Volume (m ³)	Containers (#)	Weight (tonnes)	Volume (m ³)	
Lithuania	na	2019	0.00	0.00	0.00	0.00	0.00	0.00	–
Croatia	na	2016	0.00	0.00	0.00	0.00	0.00	0.00	–
Croatia	na	2017	0.00	0.00	0.00	0.00	0.00	0.00	–
Croatia	na	2018	0.00	0.00	0.00	0.00	0.00	0.00	–
Croatia	na	2019	0.00	0.00	0.00	0.00	0.00	0.00	–
UK	na	2016	0.00	0.00	0.00	0.00	0.00	0.00	–
UK	na	2017	0.00	0.00	0.00	0.00	0.00	0.00	–
UK	na	2018	0.00	0.00	0.00	0.00	0.00	0.00	–
UK	na	2019	0.00	0.00	0.00	0.00	0.00	0.00	–
Denmark	na	2016	na	97.80	163.00	na	97.80	163.00	weight
Denmark	na	2017	na	7827.00	13045.00	na	7827.00	13045.00	weight
Denmark	na	2018	na	31.80	53.00	na	31.80	53.00	weight
Denmark	na	2019	na	2.40	4.00	na	2.40	4.00	weight
The Netherlands	na	2016	0.00	0.00	0.00	0.00	0.00	0.00	–
The Netherlands	na	2017	0.00	0.00	0.00	0.00	0.00	0.00	–
The Netherlands	na	2018	0.00	0.00	0.00	0.00	0.00	0.00	–
The Netherlands	na	2019	0.00	0.00	0.00	0.00	0.00	0.00	–
France	na	2016	0.00	0.00	0.00	0.00	0.00	0.00	–
France	na	2017	0.00	0.00	0.00	0.00	0.00	0.00	–
France	na	2018	0.00	0.00	0.00	0.00	0.00	0.00	–
France	na	2019	0.00	0.00	0.00	0.00	0.00	0.00	–
Sweden	na	2016	0.00	0.00	0.00	0.00	0.00	0.00	–
Sweden	na	2017	0.00	0.00	0.00	0.00	0.00	0.00	–
Sweden	na	2018	0.00	0.00	0.00	0.00	0.00	0.00	–
Sweden	na	2019	0.00	0.00	0.00	0.00	0.00	0.00	–
Poland	na	2016	0.00	0.00	0.00	0.00	0.00	0.00	–
Poland	na	2017	0.00	0.00	0.00	0.00	0.00	0.00	–
Poland	na	2018	0.00	0.00	0.00	0.00	0.00	0.00	–
Poland	na	2019	0.00	0.00	0.00	0.00	0.00	0.00	–
Malta	na	2016	0.00	0.00	0.00	0.00	0.00	0.00	–

Country	Port	Year	Imported			Inspected			Derived variable
			Containers (#)	Weight (tonnes)	Volume (m ³)	Containers (#)	Weight (tonnes)	Volume (m ³)	
Malta	na	2017	0.00	0.00	0.00	0.00	0.00	0.00	–
Malta	na	2018	0.00	0.00	0.00	0.00	0.00	0.00	–
Malta	na	2019	0.00	0.00	0.00	0.00	0.00	0.00	–

na: not available