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

Pest Risk Analysis for

Orgyia leucostigma (Lepidoptera: Erebidae)

Larva (John Ghent, Bugwood.org)

EPPO Technical Document No. 1082
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The risk assessment follows EPPO standard PM 5/5(1) *Decision-Support Scheme for an Express Pest Risk Analysis* (available at http://archives.eppo.int/EPPOStandards/pra.htm), as recommended by the Panel on Phytosanitary Measures. Pest risk management (detailed in ANNEX 1) was conducted according to the EPPO Decision-support scheme for quarantine pests PM 5/3(5). The risk assessment uses the terminology defined in ISPM 5 *Glossary of Phytosanitary Terms* (available at https://www.ippc.int/index.php).

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Based on this PRA, *Orgyia leucostigma* was added to the EPPO A1 List of pests recommended for regulation as quarantine pests in 2021. Measures for main woody host species of plants for planting, cut branches (incl. Christmas trees), round wood with bark, sawn wood with bark, and isolated bark are recommended.

Pest Risk Analysis for *Orgyia leucostigma* (Lepidoptera: Erebidae)

PRA area: EPPO region
Prepared by: Expert Working Group (EWG) on *Orgyia leucostigma*
Date: 23-26 March and 6-8 April 2021 (online meetings). The text was further reviewed and amended following comments by EPPO core members and the EPPO Panel on Phytosanitary Measures (see below).

Composition of the Expert Working Group (EWG)

Johanna Boberg	Swedish University of Agricultural Sciences, Uppsala, Sweden
Olfa Ezzine	Institut National de Recherches en Génie Rural, Eaux et Forêts (INRGREF), Ariana, Tunisia
Jose Maria Guitian Castrillon	Tecnologias y Servicios Agrarios, TRAGSATEC, Madrid, Spain.
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Fabienne Grousset	Consultant for EPPO, Lejre, Denmark

The first draft of the PRA was prepared by the Nordic PRA Network: Mariela Marinova-Todorova, Niklas Björklund, Johanna Boberg, Daniel Flø, Juha Tuomola, Micael Wendell & Salla Hannunen.

Personal communications in this PRA were obtained in December 2020 to April 2021 from: Alejandro Barro (University of Havana, Cuba), Rayner Nuñez (main author of Nuñez & Barro, 2011); Ville Welling (Finnish Food Authority, Pest Laboratory); Boyan Zlatkov (National Museum of Natural History, Bulgarian Academy of Science).

The draft PRA was commented upon before the meeting by Helen Anderson and Duncan Allen (Department for Environment, Food and Rural Affairs, UK).

The Nordic PRA Network and the EPPO Secretariat thank Martin Damus (Canadian Food Inspection Agency) for providing some publications before the meeting.

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

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

Following the EWG, the PRA was further reviewed by the following core members: N. Avendaño Garcia, F. Petter, C. Picard, G. Schrader, M. Suffert, R. Tanner, D.J. van der Gaag.

The PRA, in particular the section on risk management, was reviewed and amended by the EPPO Panel on Phytosanitary Measures on 2021-05, with the participation of two members of the EPPO Panel on Quarantine Pests for Forestry. EPPO Working Party on Phytosanitary Regulation and Council agreed that *Orgyia leucostigma* should be added to the A1 Lists of pests recommended for regulation as quarantine pests in 2021. The Working Party also recommended that measures for plants for planting are further discussed at the Panel on Phytosanitary Measures in order to make a distinction between main hosts and other hosts. The Panel met on 2021-10 and suggested some modifications, which were approved in a consultation of the Working Party by email on 2021-12.

CONTENTS

Summary of the Pest Risk Analysis for *Orgyia leucostigma* (Lepidoptera: Erebidae)
PRA area: EPPO region (Albania, Algeria, Austria, Azerbaijan, Belarus, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Georgia, Germany, Greece, Guernsey, Hungary, Ireland, Israel, Italy, Jersey, Jordan, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Luxembourg, Macedonia, Malta, Moldova, Montenegro, Morocco, Netherlands, Norway, Poland, Portugal, Romania, Russia, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Tunisia, Turkey, Ukraine, United Kingdom, Uzbekistan)
Describe the endangered area: Eastern and Northern parts of the PRA area, where the climatic conditions are similar to those in northern USA and Canada where outbreaks are mostly reported. There are some uncertainties attached to the area of potential establishment and the endangered area.
Main conclusions: *O. leucostigma* is a North American species with a wide distribution in the eastern part of the USA and Canada. *O. leucostigma* is a polyphagous species recorded on more than 160 hosts, including deciduous and coniferous trees, as well as bushes and herbaceous plants including weeds. Outbreaks of *O. leucostigma* can last 1-4 years and are periodic, with major outbreaks every 20 years. Severe outbreaks have been reported mostly in northeastern USA and eastern Canada, where defoliation of large areas of deciduous and coniferous trees has occurred. Defoliation over several years may result in economic and environmental impact (wood loss, tree death). Impacts have been reported in forests in both the USA and Canada, in Christmas tree plantations (*Abies balsamea*) in Canada, and occasionally in fruit crops. *O. leucostigma* appears to be a minor pest in parts of its range. Furthermore, larvae may cause social impact by dispersing, and dropping frass and their allergenic hairs. In its native range, *O. leucostigma* is regulated by a complex of natural enemies, but control methods are sometimes applied. For the purpose of the assessment, the EWG considered all host plants and categorised them into 'main hosts'[1] and 'other hosts'. The likelihood of entry was rated as high for plants for planting (except seeds, bulbs, corms, tubers, rhizomes, tissue cultures, pollen) of main hosts (except *Fragaria*, *Zea mays*, *Triticum*). It was rated moderate for plants for planting of other hosts and for round wood with bark of main hosts. The likelihood of entry on cut branches (incl. Christmas trees), sawn wood with bark, bark of main hosts, and round wood with bark of other hosts was assessed to be low, and on all other pathways was assessed as very low. A moderate uncertainty was associated with most ratings of likelihood. For most pathways, transfer to a suitable host was the main constraint for entry. Hosts are widespread in the EPPO region, and suitable climatic conditions exist in a large part of the EPPO region. The likelihood of establishment outdoors was rated as high, with a low uncertainty. The magnitude of spread was rated as moderate with a moderate uncertainty. Females are flightless, and dispersal occurs primarily by ballooning of young larvae. Human-assisted spread would be the main mode of long-distance spread. Nevertheless, if new infestations are detected early, measures may be put in place and would limit further spread. Impact in North America was assessed as moderate with a moderate uncertainty. Outbreaks of economic significance are periodical and there can be many years between severe outbreaks. In addition, populations causing economically-significant damage have not been documented throughout the current range, although *O. leucostigma* is still considered a pest throughout North America. If considering only Canada and only outbreak years, impact is higher. The potential impact (for the endangered area) in the EPPO region was assessed to be moderate with a high uncertainty. Many potentially suitable hosts and climates are present in the EPPO region. *O. leucostigma* could cause defoliation in various habitats (such as forests, Christmas trees plantations, amenity trees, private gardens, fruit orchards). In forests, both economic and environmental impacts would be expected. As in North America, there may be fluctuation in impact depending on locations and years. Although natural enemies are present in the EPPO region, it is not known whether they would regulate populations of *O. leucostigma*. The

[1] In the literature, these host plants are mentioned as common or preferred hosts or hosts for which impacts have been recorded.

same natural enemy complex that exists in North America and regulates populations does not occur in the EPPO region.			
Phytosanitary risk for the *<u>endangered area</u>* (*Individual ratings for likelihood of entry and establishment, and for magnitude of spread and impact are provided in the document*)	High	Moderate X	Low ☐
Level of uncertainty of assessment *(see Q 17 for the justification of the rating. Individual ratings of uncertainty of entry, establishment, spread and impact are provided in the document)*	High ☐	Moderate X	Low ☐
Other recommendations: The EWG noted a number of research topics (detailed in section 18) that would help solve some uncertainties raised in this PRA.			

Stage 1. Initiation

Reason for performing the PRA:
Orgyia leucostigma was identified as a potential threat to Nordic coniferous forests when screening for potential pests associated with trade of ornamental plants (Marinova-Todorova et al., 2020). The pest was assessed to potentially fulfil the criteria to become regulated as a quarantine pest in the EU and Norway. In a German express PRA (initiated due to an application for movement and use of the organism for research and breeding purposes) the phytosanitary risk of *O. leucostigma* for EU member states was considered high with high certainty (Wilstermann & Schrader, 2018). In an assessment of the risk of North American and Eastern Asian insects to European chestnuts, *O. leucostigma* was included in the low-risk category (Peverieri et al., 2017). Based on a proposal by the Nordic PRA Network, *O. leucostigma* was added to the EPPO Alert List in March 2020. The Panel on Phytosanitary Measures (PPM) selected *O. leucostigma* as a possible priority for PRA in 2020, and the Working Party on Phytosanitary Measures selected it for PRA in June 2020.

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

PRA area: EPPO region in 2021 (map at https://www.eppo.int/ABOUT_EPPO/eppo_members)

Stage 2. Pest risk assessment

1. Taxonomy

Taxonomic classification
Kingdom: Animalia / Phylum: Arthropoda / Subphylum: Hexapoda / Class: Insecta / Order: Lepidoptera / Family: Erebidae / Genus: *Orgyia* Ochsenheimer, 1810 / Species: *Orgyia leucostigma* (J.E. Smith, 1797).

Scientific names
Preferred scientific name: *Orgyia leucostigma* (J.E. Smith, 1797).

Subspecies: Several geographical populations of *O. leucostigma* exist and they are sometimes treated as subspecies (Ferguson, 1978; Wallner & McManus, 1989; Pohl et al., 2018):

- *Orgyia leucostigma leucostigma* (Smith, 1797)
- *Orgyia leucostigma intermedia* Fitch, 1856
- *Orgyia leucostigma plagiata* (Walker, 1855)
- *Orgyia leucostigma oslari* Barnes, 1900
- *Orgyia leucostigma sablensis* Neil, 1979.

Note: The PRA is done at the species level, i.e. *Orgyia leucostigma*, but when the information in the literature refers to a specific subspecies (geographical population), that is specified in the text hereafter.

Other scientific names

Species / subspecies	**Synonyms (from Ferguson, 1978)**
Orgyia leucostigma	*Hemerocampa leucostigma* (J.E Smith, 1797); *Orgyia libera* Strecker, 1900;
Orgyia leucostigma leucostigma (Smith, 1797)	*Cladophora leucographa* Geyer, 1832; *Orgyia meridionalis* Riotte, 1974; *Phalaena leucostigma* J.E Smith, 1797
Orgyia leucostigma intermedia Fitch, 1856	*Orgyia leucographa* var. *obliviosa* Henry Edwards, 1886 *Orgyia leucostigma* var. *borealis* Fitch, 1856
Orgyia leucostigma plagiata	*Acyphas plagiata* Walker, 1855; *Orgyia wardi* Riotte, 1971;
Orgyia leucostigma oslari	*Orgyia oslari* Barnes, 1900
Orgyia leucostigma sablensis	

International common names
English: white-marked tussock moth
French: chenille à houppes blanches, hémérocampe marquée de blanc (EPPO, 2020)

EPPO code
HEMELE

2. Pest overview

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

2.1 Morphology

An overview of the morphology of the different life stages of *O. leucostigma* is provided in Table 1. The life stages are illustrated in ANNEX 2.

The eggs are deposited in a foamy white egg mass on the surface or near the empty cocoons of the female pupae (Webster, 1916; Wilson, 1991; Ontario Apple IPM, 2009; Hall & Buss, 2014 and references therein; Schowalter, 2018 and references therein).

Newly hatched larvae are small and brown, with a mean length of around 2.5–4 mm (Riley, 1888; Isaacs & van Timmeren, 2008; 2009). Mature larvae are 25–37 mm long and have a reddish-orange head and hairy body. They are characterized by two light yellow lines running along the body's length, a black mid-dorsal stripe, four brush-like tufts of light tan hairs on the back (top of the first four abdominal segments) and red dorsal glandular structures on abdominal segments six and seven. A pair of longer tufts (pencils) of black hairs rises forward from the prothorax, and dorsal hair pencils of black setae extending backward on the eighth abdominal segment (Wagner et al., 1997; Ontario Apple IPM, 2009; Hall & Buss, 2014 and references therein; Schowalter, 2018 and references therein; Natural Resources Canada, 2020a).

Before pupation, the larvae spin their cream- or tan-coloured cocoons of silk and body hairs which are the size of the adult (Barnard & Dixon, 1983; Hall & Buss, 2014 and references therein; Schowalter, 2018 and references therein).

Pupae appear hairy and have patches of dorsal spatulate setae ("vesicles" according to Mosher, 1916) on abdominal segments 1–3. The female pupae are much larger than the male (Riley, 1888). Male pupae have longer wings and longer and broader antennae than female pupae. The wings of male pupae extend nearly to the posterior margin of the fourth abdominal segment while those of the females only slightly reach beyond the anterior margin of the segment (Mosher, 1916; Hall & Buss, 2014 and references therein).

Adults are dimorphic. Males are small, ash grey with prominent bipectinate antennae and a wingspan of 25–30 mm. Their forewings have darker wavy bands and a conspicuous white spot near the anal angle. The wings of newly emerged males have a purplish tint. At rest, they hold their first pair of legs in an outstretched position. **Females are creamy white to grey, hairy and about 12 mm long. The literature often describes females as being wingless. However, they are short-winged (brachypterous) and cannot fly** (Hall & Buss, 2014 and references therein; Baker, 2017; Schowalter, 2018 and references therein).

2.2 Life cycle

The development times of *O. leucostigma* life stages are summarized in Table 1.

Orgyia leucostigma overwinters as eggs within a frothy mass laid on or near the empty cocoon of the female pupae, which are found on host plants (on branches, boles, in dry leafs) or on other objects (see further down) (Howard, 1896; Thurston, 2002; Wagner, 2005; Foltz, 2006; Baker, 2017). Ferguson (1978) suggested that *O. leucostigma* subsp. *intermedia* might also overwinter as larvae since in northern New England, New York and Ontario adults were observed early in the summer (July). Furthermore, in Florida adults have been observed in the winter and early spring (from March to June and from September to January). According to Riley (1888), although occasionally living pupae may be found during the winter, this is uncommon and the different climatic conditions do not seem to alter the normal mode of hibernation, i.e. overwintering as eggs. **In this PRA, it is considered that *O. leucostigma* overwinters mostly as eggs, but it is not excluded that in some locations larvae, pupae or adults may be present during the winter (Ferguson, 1978; Riley, 1888).**

The period of larval emergence depends on the geographical location (e.g. latitude, climatic conditions) (Foltz, 2006; Isaacs & van Timmeren, 2009; Ontario Apple IPM, 2009) and is typically in close timing with the availability of new host plant foliage. For tussock moths in Florida (including *O. leucostigma*), Foltz (2006) note that larval emergence starts at about the time when oak trees begin to produce new foliage. This is also known for other species such as *O. trigotephras* (Ezzine et al. 2010) or *Lymantria dispar* (Mnara *et al.*, 2005). The degree-days required for development are provided in section 9.1. In Florida, the tussock moths (including *O. leucostigma*) start to hatch in late February and early March to early April (Foltz, 2006). In Canada (Ontario), eggs hatch from late June to early July (Ontario Apple IPM, 2009). Isaacs & Van Timmeren (2009) reported that hatched larvae remained clustered on egg masses for several days before dispersing throughout the host plant. Initially, larvae feed on the remains of the egg mass and later migrate to leaves or needles, often by spinning down on silk threads and floating on the breeze ('ballooning') (Thurston, 2002) and feed on the surface of leaves, causing skeletonization. Larvae are going through five instars and mature in 5–6 weeks (Schowalter, 2018 and references therein).

When disturbed/threatened, larvae may drop from the plant; however young larvae may be suspended in a silk thread; larger larvae may be able to grab onto foliage and crawl back (Howard, 1896; Castellanos et al., 2011; Ontario Ministry of Agriculture, Food and Rural Affairs, 2019). In a study by Castellanos et al. (2011), some larvae dropped from a leaf were able to grasp a leaf or branch underneath the leaf they were feeding on, while most of them landed on the ground but were able to return to the host (sometimes after spending >2 h on the ground).

The last instar larvae spin nymphal cocoons in bark crevices, on the exposed bark of the bole, in crevices on the bole formed by pruning wounds, under and between twigs and branches, beneath limbs, in branch crotches and under loose bark (Embree et al., 1984; Wilson, 1991; Hall & Buss, 2014 and references therein; Schowalter, 2018 and references therein). In blueberry fields, the egg mass may occur inside a dry leaf (Isaacs & Van Timmeren, 2008). In high larval density, larvae may use other substrates, such as herbaceous plants (L. Roscoe, pers comm.). *O. leucostigma* may also spin cocoons on other substrates, such as fences, houses, logs, outdoor furniture, stored boats etc. (Embree et al., 1984; Foltz, 2006; Hall & Buss, 2014 - the last two refer to several tussock moth pecies). Such substrates appear to be used mostly in cases of abundant populations (Howard, 1896; Foltz, 2006). Howard (1896) indicated that though cocoons can be found upon objects near the trees on which the larvae have been feeding, the vast majority are found upon the trunks.

The pupal stage lasts 2–3 weeks (Wilson, 1991). **Upon emerging, flightless females attract males to their cocoons by a sex pheromone (Grant et al., 2003). After mating, the females lay 150–200 (up to 500) eggs in a single froth-covered egg mass on the surface or near their empty pupal cocoons** (Webster, 1916; Belton, 1988; Wilson, 1991; Hall & Buss, 2014 and references therein). In Kansas, Riley (1888) counted 786 eggs on a single egg mass. **After the oviposition, the females die and fall to the ground** (Thurston & MacGregor, 2003; Schowalter, 2018 and references therein). Grant et al. (2003) found that the male flight begins close to sunset and the peak flight occurs in the latter half of the night. They are attracted to artificial lights (Riley, 1888; Hancock, 1893). **Neither adult females nor males feed and thus rarely live longer than a week (Tammaru et al., 2002).**

***Orgyia leucostigma* has 1–3 generations per year, depending on the geographical location and climate** (Ferguson, 1978; Drooz, 1985; Thurston, 2002; Grant et al., 2003; Wagner, 2005; Foltz, 2006; Reynolds et al., 2007; Isaacs & van Timmeren, 2009). **Reynolds et al. (2007) noted in studies in New Hampshire, northeast USA, that the pest is facultatively bivoltine in warm years and univoltine in cooler years. In eastern Canada, Thurston (2002) reported one generation per year, with a partial second generation in some years.** Isaacs & van Timmeren (2009) noted two generations per year in the Great Lakes region, southwest Michigan USA. Using 12.8ºC as a base threshold temperature, they calculated that 2000 growing degree-days (GDD) are needed for the development of two generations of larvae (Isaacs & van Timmeren, 2009). In Washington DC (USA), Riley (1888) noted that the species has two generations. Adults of the first generation appear in early June, those of the second generation in September/October, but on several occasions some of the larvae from the same egg mass were still feeding while the rest had already transformed to adults. This delay and irregularity in development means that larvae may be found continuously throughout the season (from June to October) and no distinct dividing line between the two generations is observed. In Florida, *O. leucostigma* is bivoltine (Hall & Buss, 2014 and references therein).

Ferguson (1978) reported two or more generations for *O. leucostigma* subsp. *leucostigma* in the southern USA, from April to June and from September to December; two generations for *O. leucostigma* subsp. *intermedia* in eastern and central USA and southern Canada, from July to October and one generation for *O. leucostigma* subsp. *plagiata* in eastern Canada, from mid-August to early-September (see ANNEX 3).

The flight season of *O. leucostigma* males varies between geographical locations (Ferguson, 1978; Neil, 1979; Foltz, 2006; Hall & Buss, 2014 – see also Figure 1). In Florida, the adult tussock moths (three *Orgyia* species, including *O. leucostigma*) emerge from mid-April to early May (with a second emergence period for *O. leucostigma* later) (Foltz, 2006; Hall & Buss, 2014). *Orgyia leucostigma* subsp. *leucostigma*, which is present in southern USA (see ANNEX 3), has two flight periods from April to June and from September to December (Ferguson, 1978). The flight period of *O. leucostigma* subsp. *intermedia*, which is present in eastern and central USA and southern Canada, ranges from July to October, and the flight period of *O. leucostigma* subsp. *plagiata*, which is present in eastern Canada, ranges from mid-August to early-September (Ferguson, 1978). However, according to Neil (1979) the flight period of *O. leucostigma* subsp. *plagiata* in mainland Nova Scotia, Canada, ranges from late July to mid-September, and it corresponds to the flight period of *O. leucostigma* subsp. *sablensis*, present in Sable Island, Nova Scotia. Male adult specimens of *O. leucostigma* subsp. *oslari*, present in the Rocky Mountain Colorado USA, have only been found in August (Ferguson, 1978).

Figure 1. Flight period of *O. leucostigma* according to Ferguson (1978)* and Neil (1979)[%]
When the period within a month is indicated (e.g. start May), this is illustrated, otherwise the whole month is marked

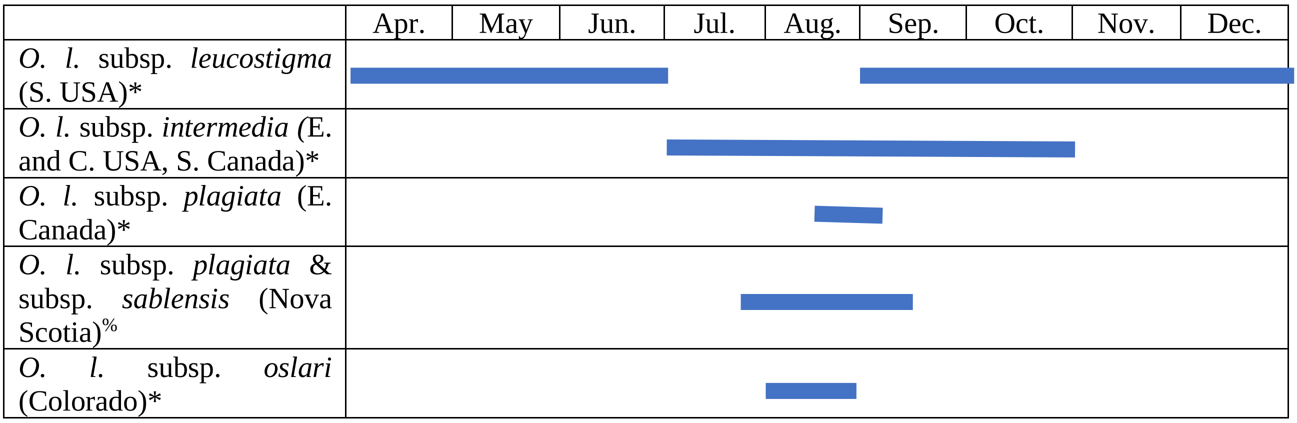


Table 1. Details on the morphology and development times of *Orgyia leucostigma. Photos of life stages are provided in ANNEX 2*

Stage	Colour/shape	Size	Duration
Egg mass/Eggs	The egg mass is foamy white Eggs are perfectly round, cream-white	1–2 mm diameter	Overwintering stage. No figure found when *O. leucostigma* is multivoltine
Larvae	Newly emerged larvae: - dull whitish-grey colour - the under side paler, the upper side covered with long hairs and tufts of a dark-brown colour Mature larvae: - reddish-orange head	Larvae grow from around 2.5–4 mm to 25–37 mm	5–6 weeks

Stage	Colour/shape	Size	Duration
	- white or yellow line on each side of the dark mid-dorsal line - four brush-like tufts of light tan hairs on the back (first four abdominal segments) - red dorsal glandular structures on abdominal segments six and seven		
Pupae/Cocoon	Pupae are protected in a cream- or tan-coloured cocoon: -the male pupae have longer wings and longer and broader antennae than female pupae. -the wings of male pupae extend nearly to the posterior margin of the fourth abdominal segment -the wings of female pupae only slightly reach beyond the anterior margin of the segment	Size of an adult, female pupae are larger than male pupae	2 weeks
Adult male	Ash grey; the forewings have darker wavy bands and a conspicuous white spot near the anal angle	26–30 mm wingspan	< 1 week
Adult female	Creamy white to grey; short-winged (brachypterous)	12 mm long	< 1 week

2.3 Temperature (or climatic) requirements

Isaacs & van Timmeren (2009) studied the development of *Orgyia leucostigma* in the Great Lakes region (southwest Michigan, USA) on northern highbush blueberry (*Vaccinium corymbosum*). In laboratory conditions (in environmental chambers) under a photoperiod of 16:8 (L:D) h, they found the lower threshold for development to be 12.3ºC and the optimal temperatures for development to be between 18°C and 28°C. **They reported that the larval developmental rate increased significantly with temperatures from 16°C to 28°C, while temperatures below 10°C and above 35°C prevented development.** In field experiments, egg hatching was best predicted using a base threshold temperature of 12.8°C.

2.4 Natural enemies

***Orgyia leucostigma* has various natural enemies and its populations can be regulated by pathogens, parasitoids and predators** (Ontario Apple IPM, 2009; Embree *et al.*, 1984; Thurston, 2002). Natural enemies of *O. leucostigma* identified in the literature are listed in ANNEX 4. The entomopathogenic fungus *Entomophaga aulicae* and nucleopolyhedrosis virus were found to be the most important mortality factors of *O. leucostigma* in Nova Scotia, Canada (Thurston, 2002; van Frankenhuyzen *et al.*, 2002). Two strains of nucleopolyhedrosis viruses, one specific to *O. leucostigma* and the other to *O. pseudotsugata*, have been found to cause widespread mortality in populations of *O. leucostigma* and are being developed as possible biological control agents in Christmas tree plantations (balsam fir, *Abies balsamea*) in eastern Canada (Thurston, 2002). **In Canada, a nuclear polyhedrosis virus has been registered for use against *O. pseudotsugata*, but to date none are registered for use against *O. leucostigma* (L. Roscoe, pers. comm.).**

2.5 Dispersal capacity

Orgyia leucostigma natural dispersal is a consequence of ballooning and crawling but humans can also mediate dispersal by moving infested plant material to new areas (Belton, 1988).

2.5.1 Ballooning

***Orgyia leucostigma* females cannot fly (Hall & Buss, 2014 and references therein; Baker, 2017; Schowalter, 2018 and references therein). The dispersal of the pest occurs mainly when the first instar larvae spin a long silken thread and are carried off by air currents (‘ballooning’) (Thurston & MacGregor, 2003).** During outbreaks, swarms of ballooning larvae can be so dense that they appear as a grey mist (Embree *et al.*, 1984). Larvae often die due to failure to find a suitable host during ballooning dispersal (Medina & Barbosa, 2002; Schowalter 2018, and references therein). At least in the closely related species *O. pseudotsugata*, older instars also disperse, but they only constitute about 4% of the dispersing larvae and their spread is localized within the host plant or to closely adjacent host plants (Mitchell, 1979).

No information was available on the triggers of ballooning specifically for *O. leucostigma*. For another *Orgyia* species, *O. vetusta*, it was found that larvae ballooned frequently when located on dead hosts while rates of ballooning was very low on live hosts (Harrison, 1997). For other Lepidoptera species, host plant suitability has been identified as a factor (*Ostrinia nubilalis*, Crambidae; Goldstein et al., 2010).

Drooz (1985) states that ballooning larvae can be transported "considerable distances by the wind", but **exact information about ballooning distances specific to *O. leucostigma* was not found.** The settling rate of the first instar larvae of a closely related and ecologically similar species, *O. pseudotsugata* was investigated under laboratory conditions by Mitchell (1979). This was done by measuring the time that it takes for the larva to fall a given distance to the floor in still and moving air, and with different lengths of the silken thread. Extrapolation of the results showed that larvae released at 10-meter height into constant wind would be able to drift downwind approximately 160 meters (Table 2). **The results, which also include field experiments, suggest that most larvae of *O. pseudotsugata* do not disperse far from their source trees. According to Mitchell (1979) "Even larvae with very long threads, dispersing from trees 30 m tall into the strongest winds recorded during dispersal, would not have the buoyancy to travel downwind much farther than 500 m. Since larvae usually disperse from smaller trees in the morning when winds are lightest, most larvae would probably disperse no farther than 200 m".**

Table 2. Calculated lateral distance that unfed first instar larvae of *O. pseudotsugata* with variable silk thread lengths are expected to drift downwind when released at 10 m height into constant wind (Mitchell, 1979). The dispersal distance was estimated by the following equation: $\boldsymbol{D = U*h/s}$, where $\boldsymbol{D}$ is the horizontal distance travelled downwind, $\boldsymbol{U}$ is the windspeed, $\boldsymbol{h}$ is the height of release (or take-off) and $\boldsymbol{s}$ is the settling rate (Mitchell, 1979; Pasek, 1988).

	Distance travelled (m) in wind speed		
Length of silk thread (m)	**0.5 m/sec**	**1.0 m/sec**	**2.0 m/sec**
0	5.7	11.5	23.0
1.0	17.2	34.5	69.0
2.0	31.3	62.5	125.0
Max*	39.7	79.4	158.8

** Thread lengths approaching asymptotic settling rate of 0.126 m/sec*

Another species in the subfamily Lymantriinae where females also are incapable of flight, is the European gypsy moth (*Lymantria dispar* subsp. *dispar*), which is invasive in the USA. Most females of *L. dispar* are believed to oviposit only a few meters from the emergence site (Odell & Mastro, 1980). The range expansion of *L. dispar* due to larval ballooning alone was calculated to be 2–3 km per year (Liebhold *et al*., 1992), and the actual spread rate of *L. dispar* is much higher due to stratified dispersal (Sharov & Liebhold, 1998). Liebhold et al. (1992) based their calculations on data from Mason & McManus (1981) according to which the majority of *L. dispar* larvae appear to not balloon further than 180 m.

In this PRA, it is expected that the ballooning distance by *O. leucostigma* might be similar to that of *O. pseudotsugata* (i.e. most larvae would generally not disperse more than 200 m). The EWG consequently considered that the natural spread of *O. leucostigma* is likely to be less than 1 km per year (see section 11). In relation to discussions on the distance needed between a pest free area and the closest area where the pest is known to be present, the EWG noted that no specific data were available, but that this distance might be rather short. The Panel on Phytosanitary Measures considered that 1 km was an appropriate distance for the size of buffer zones around pest free areas, pest free places of production and pest free production sites (section 16.1 and ANNEX 1).

2.5.2 Crawling

Mature larvae in search of sites to pupate are often observed crawling on understory vegetation, on walls of structures and on the ground (Howard, 1896; Drooz, 1985; Hall & Buss, 2014 and references therein; Schowalter 2018). According to Howard (1896), the nearly fully grown larvae are "great travellers, crawling down the trunk of the tree upon which they were hatched and across a considerable stretch of ground, to ascend another tree". The pest can also crawl up on, or drop onto, vehicles and they may thereby reach new areas (Howard, 1896). For another *Orgyia* species, *O. trigotephras*, the high mobility of the larvae allows them to feed on different host plants over the course of the larval stages and older larvae are able to walk as single individuals quickly to other plants (Ezzine *et al*., 2015). In a study of larval dispersal in open areas surrounded by woodland, larvae of *Lymantria dispar* were observed to cover over 100 m (Doane & Leonard, 1975). **Young**

larvae can presumably also crawl, but the distance is expected to be rather short. Exact information about the maximum crawling distances of *O. leucostigma* was not found.

2.6 Nature of the damage

The damage caused by *O. leucostigma* to plants is a result of larval defoliation. The young larvae feed on the surface of the leaves and chew holes. The old larvae consume entire leaves except for the main veins and petiole (Drooz, 1985; Ontario Apple IPM, 2009; Hall & Buss, 2014 and references therein). Entire trees and shrubs may be defoliated in case of high larval density (Webster, 1916). Outbreaks of *O. leucostigma* can last 1-4 years and repeated years of defoliation might cause tree mortality and wood loss (Ontario Apple IPM, 2009). In Atlantic Canada, minor outbreaks occur about every 9 years, with major outbreaks every 20 years (Thurston, 2002). Tree mortality mainly occurs in association with other abiotic or biotic factors, such as drought or secondary pest infestations (Ezzine, 2016). However, a single heavy defoliation can reduce tree growth and subject trees to attack by secondary insects and diseases (Wilson, 1991). **On conifer hosts, larvae feed also on the bark of twigs, causing the twigs to curl and branches to deform** (Dedes, 2014).

In forests, *O. leucostigma* is primarily a pest of broad-leaved trees but, when the population density is high, it also attacks coniferous species (Natural resources Canada, 2020a). In mixed-tree hardwood forests this insect is seldom abundant, but it can cause severe defoliation in monoculture hardwood forests, cities, and parks (Wilson, 1991 and references therein).

According to Belton (1988) feeding also occurs in fruit seen as shallow irregular areas, which cause calloused blemishes. It is unclear which fruit this refers to and how common this is. No other mention of larvae feeding on fruit was found in the literature. **In the absence of more information, the EWG considered that feeding on fruit is unlikely for such a defoliator.**

2.7 Detection and identification methods

Symptoms

Numerous holes appearing in young leaves are usually the first sign of an *O. leucostigma* infestation, with larvae highly visible on the leaves. Later, skeletonized (defoliated) shoots and bare stems indicate the presence of larger larvae. During winter, *O. leucostigma* can be detected by the presence of egg-masses characterized by a froth protective covering (Webster, 1916) and described by Riley (1888) as glistening white masses glued on a cocoon of dirty gray colour on bare twigs, inside a dry leaf (Isaacs & van Timmeren 2008), in bark crevices, and on other non-living object. **The pest and its symptoms are usually visible to the naked eye** (CABI, 2020a)**.**

Monitoring

The adult males can be trapped using pheromone traps baited with *O. leucostigma* pheromone [(Z,Z)-6,9-heneicosadien-11-one] (Grant *et al.*, 2003; Isaacs & van Timmeren, 2009) and the pheromone of *O. pseudotsugata* (Daterman *et al.*, 1977). In field experiments on blueberry (*Vaccinium corymbosum*), Isaacs & van Timmeren (2009) found that **large plastic delta traps (Scentry Biologicals Inc., Billings, MT) were the most effective at trapping adult male moths**, capturing more than three times the number of moths than the next most effective trap, the wing trap. The small and large diamond traps were less effective. They suggest placing large plastic delta traps at the perimeter of blueberry fields adjacent to woodlands with no need of replacing pheromone lures during the season.

Identification

Identification at the species level is based on morphological and molecular characterisation.

***Orgyia leucostigma* can be distinguished from most *Orgyia* species, including those that are present in the PRA area, by external morphological characteristics of males.** Due to colour polymorphism, and if male specimens are damaged (as this is common for trapped specimen), *O. leucostigma* may in some cases only reliably be distinguished from all other *Orgyia* species by the male genitalia (Ferguson, 1978; Boyan Zlatkov, pers. comm.; Ville Welling, pers. comm.). Daterman *et al.* (1977) present a summary of the key identifying characteristics (external morphology and male genitalia) for four *Orgyia* species males that may be found in traps with *O. pseudotsugata* pheromone in North America, including *O. leucostigma* and *O. antiqua*, a species native to the PRA area. Ferguson *et al.* (1978) provides a key to last instar larvae of *O. antiqua, O. leuschneri, O. definita, O. falcata, O. leucostigma, O. detrita, O. pseudotsugata* and *O. vetusta*.

In New Zealand, a molecular diagnostic system based on PCR-RFLP of nuclear ribosomal DNA for seven species of tussock moths (including *O. leucostigma*) was used to identify the egg masses intercepted on imported used vehicles (Armstrong *et al.*, 2003). Later, more advanced approaches for identification of species of the family Lymantriidae and two subspecies of *Orgyia trigotephras* using DNA barcoding of the *cox1* gene were tested and proved successful by Armstrong & Ball (2005), Ball & Armstrong (2006) and Ezzine *et al.* (2014).

3. Is the pest a vector?

Yes ☐ No ▣

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

Yes ☐ No ▣

5. Regulatory status of the pest

Orgyia leucostigma is not listed as a quarantine pest by any EPPO country according to EPPO Global Database (EPPO, 2020). It was added to the EPPO Alert List in 2020 (EPPO, 2020).

Information about the regulatory status of *O. leucostigma* elsewhere in the world was sought but the information consulted is not exhaustive and it may thus be regulated in more countries. *Orgyia leucostigma* is regulated at the species level in China (under the name *Hemerocampa leucostigma* (Smith)), New Zealand, Japan and Mexico (IPPC, 2020) as well as in India (Anonymous, 2020). Further, the genus *Orgyia* is regulated in Argentina and USA (IPPC, 2020). Interstate regulations targeting *O. leucostigma* may be in place in several US states. *O. leucostigma* is regulated as a quarantine pest at least in California (University of California, 2021).

6. Distribution

***Orgyia leucostigma* is distributed throughout the eastern part of North America (Table 3 and Figure 2). The southern distribution boundary lies between Texas and Florida. In the west it is known to be present up to New Mexico and Colorado (USA), and Manitoba (Canada).**

There is also a record in Cuba. The pest is mentioned in a list of Cuban Lepidoptera (Núñez & Barro, 2012) based on re-examination of specimens in a museum collection (3 specimens collected in the 1980s in Western Cuba; R. Núñez, pers. comm.). *O. leucostigma* is also mentioned in a book on Cuban Lepidoptera (Barro & Núñez, 2011) based on a recent record on *Rhizophora mangle* (red mangrove). The specimens available originate from one locality, Batabano mangrove forest in Western Cuba; *O leucostigma* has not been detected in other localities or on other hosts, and is not a pest on Cuba (A. Barro, pers. comm.). There is no information on whether *O. leucostigma* is native or introduced in Cuba. In addition, *O. leucostigma plagiata* is mentioned in Waller *et al.* (2007) amongst 'less important defoliators' of coffee in Cuba, citing Bruner *et al.* (1975) (not available). This record is considered erroneous in this PRA, and coffee is also not mentioned amongst host plants in Annex 5. Bruner et al. (1975) referred to *Hemerocampa plagiata* (Walker) based on original collection specimens of *Agrotis grandirena*, which is now *Tiracola grandirena*. It has since been confirmed in other publications that those original specimen were *Tiracola grandirena,* and had been misidentified in the past as *Tiracola (Hemerocampa) plagiata* (Núñez & Barro, 2012, Becker, 2002).

Table 3. Distribution of *Orgyia leucostigma*.

Continent	Distribution	Comments	References
North America	**Canada** (Manitoba, New Brunswick, Newfoundland, Nova Scotia, Ontario, Prince Edward Island, Quebec)	Present, native	MacNay & Creelman, 1958; Rose *et al.*, 2000;

			Pohl *et al.*, 2018; EPPO, 2020
	USA (Alabama, Arkansas, Colorado, Connecticut, Delaware, Florida, Georgia, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, Nebraska, New Hampshire, New Jersey, New Mexico, New York, North Carolina, Ohio, Oklahoma, Pennsylvania, Rhode Island, South Carolina, Tennessee, Texas, Vermont, Virginia, West Virginia, Wisconsin)	Present, native	Hall & Buss, 2014 and references therein; Lotts & Naberhaus, 2017; EPPO, 2020; Mississippi State University, 2020
Carribean	**Cuba**	From collection specimens and few findings*	Barro & Núñez, 2011; Núñez & Barro, 2012

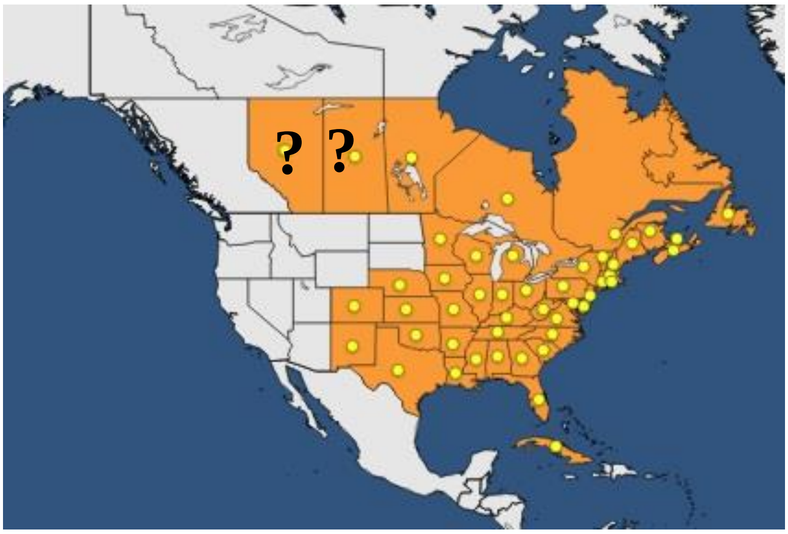


Figure 2. Distribution of *Orgyia leucostigma* in provinces/states of Canada and the USA from EPPO Global Database (EPPO, 2020).

Uncertain or invalid records (not included in Table 3):

- Canada: Saskatchewan and Alberta. Pohl *et al.* (2010) noted that the species was reported as far west as Langham in central Saskatchewan (Canada) (citing Prentice, 1962; Ferguson, 1978; Ives & Wong, 1988). However, according to Pohl *et al.* (2018) records from western Canada are confused with *Orgyia antiqua*, and there are no verified observations west of Manitoba (Canada). There are nevertheless reports of the pest for Saskatchewan and Alberta in Natural Resources Canada (2020a).
- USA (Arizona, California, Montana): There are records of *O. leucostigma* in GBIF.org (*Orgyia leucostigma* (J.E. Smith, 1797) in GBIF Secretariat 2019). In Arizona and California, the records are represented by preserved specimens from university or museum collections dated between 1939–1977 or with date unknown. The pest is regulated as a quarantine pest in California. Records from Montana are found in a report by the U.S. Department of Agriculture (1976) and in iNaturalist database (iNaturalist, 2020). It is uncertain whether these records represent established populations in these states.
- Mexico: There are some observation points of *O. leucostigma* recorded in the iNaturalist database from Mexico (iNaturalist, 2020, to Veracruz in the South). These observations are supported by pictures of mature larvae or male moths. However, the species identities have not been verified by experts and the observations were therefore not considered reliable.

7. Host plants and their distribution in the PRA area

***Orgyia leucostigma* has more than 160 host plants from 122 genera belonging to 59 families (ANNEX 5, Table 1). Its host plants include deciduous and coniferous woody trees and bushes, as well as herbaceous**

plants, however most damages are recorded on trees and bushes (see section 12). The host species with most significant damage seem to differ between areas, subspecies and years (ANNEX 5, Table 2; section 12).

There may be differences in host preference and host suitability for younger and later larval instars, with the range of suitable host plants being more restricted for younger larvae than for later larval instars. This is the case in other species such as *O. trigotephras* (Ezzine *et al.*, 2010; 2015). However, no information was available for *O. leucostigma* and no distinction is made between hosts of young and mature larvae in this PRA. In forests, *O. leucostigma* is primarily a pest of deciduous trees but coniferous species are also attacked when population density is high (Natural Resources Canada, 2020a).

It is considered in this PRA that *O. leucostigma* is more likely to be associated with woody plants than with herbaceous ones (see section 2.2). The host plants of *O. leucostigma* occur throughout the PRA area as native or introduced species, in different environments including orchards and gardens (fruit trees and ornamentals), urban areas (ornamentals), forests and plantations, in the wild and as weeds.

ANNEX 5, Table 1 provides a complete host list (with references) and outlines the presence and status of host species in the PRA area. Some host plants are listed at genus level as there is no information on which species the pest was recorded. Further details on host species and genera in the PRA area are given in section 9.2 and ANNEX 6.
For the purpose of this PRA, two categories of hosts were considered:

- **Main hosts**. In the literature, these host plants are mentioned as common or preferred hosts or hosts for which impacts have been recorded (indicated in green in ANNEX 5, Table 1). This classification is based on information in ANNEX 5, Table 2. This category includes some herbaceous plants (*Fragaria*, *Zea mays*, *Triticum*) for which only one publication was found, but that supports damage.
- **Other hosts.** In the literature, the pest is reported on these hosts without further details (indicated in white in ANNEX 5, Table 1).

Belton (1988) reported damage on “vegetables” but the plant species were not specified. Therefore, vegetables were not taken into account in this PRA.

8. Pathways for entry

The following pathways for entry of *O. leucostigma* were discussed in this PRA. Pathways in bold are described in detail and evaluated in section 8.1 while the other pathways are described in section 8.2.

- **Host plants for planting (except seeds, bulbs, corms, tubers, rhizomes, tissue cultures, pollen) (Table 4)**
- **Cut branches (incl. Christmas trees) of host plants (Table 5)**
- **Round wood and sawn wood of host plants with or without bark (Table 6)**
- **Wood chips, hogwood, processing wood residues (except sawdust and shavings) of host plants (Table 7)**
- **Bark of host plants (Table 8)**
- **Contaminated commodities: pests associated with commodities of non-hosts, wood packaging material and containers, conveyances (vehicles and machinery), and commodities made of any material likely to be stored outside (Table 9)**
- *Fragaria* plants for planting
- Cut flowers of host plants
- Cut foliage of host plants
- Fruit of *Vaccinium* and of other host plants
- Seeds, bulbs, corms, tubers, rhizomes, tissue cultures and pollen of host plants
- Furniture and other articles made of wood of host plants
- Soil and other growing media (on its own or associated with plants for planting of non-hosts)
- Intentional human assisted movement of individuals, e.g. exchange or trade by collectors and researchers
- Natural spread

The following pathways from the EPPO Secretariat's tree of pathways have no relevance for *O. leucostigma*: leaf vegetables (incl. herbs) (see also section 7); stored plant products/dried plant parts (incl. grain); underground plant parts; soil and growing medium; animals.

8.1 Pathways investigated in detail

Information on import prohibitions and phytosanitary measures is not provided for all countries in the PRA area.

It is noted that confirmed records of *O. leucostigma* in Cuba appear to relate to one locality, a mangrove forest in the western part of the country. Entry from Cuba was not studied in detail below. The likelihood of association with pathways from Cuba is lower because the distribution is restricted, and the likelihood of entry, is considered lower than from Canada and the USA.

8.1.1 Host plants for planting (except seeds, bulbs, corms, tubers, rhizomes, tissue cultures, pollen)

Table 4. Host plants for planting (except seeds, bulbs, corms, tubers, rhizomes, tissue cultures, pollen)

Pathway 1	**Host plants for planting (except seeds, bulbs, corms, tubers, rhizomes, tissue cultures, pollen)**
Coverage	• The pathway includes plants for planting in pots or similar (including bonsais), plants with bare roots, cuttings, scions of host plants. • It includes plants with or without soil or growing medium attached • Seeds, bulbs, corms, tubers, rhizomes, tissue cultures and pollen are excluded, because the pest is not associated with these categories of plant material (added to section 8.2). • The likelihood of entry on *Fragaria* plants for planting (only herbaceous main host that is likely to be traded as plants for planting) was rated as very low with a low uncertainty, and the pathway was therefore transferred to section 8.2. This pathway covers commercial trade, including Internet trade by private persons. **Travellers carrying plants for planting from areas where the pest occurs.** Travellers may carry plants for planting in their luggage. Although subject to phytosanitary requirements, at least in some EPPO countries, such material may escape import controls, and individuals may not be aware of the rules. There is no specific information indicating that transport in travellers' luggage is especially of concern for the host plants from North America. Plants carried in luggage are most likely individually handled, larvae initially present are expected to drop when disturbed and any cocoon or symptoms of larval feeding present on plants (small enough to fit into travellers' luggage) are more likely to be observed than in plant consignments traded in containers. No data is available for Internet trade and plants for planting carried by travellers, and they are therefore not assessed separately.
Plants covered	All host plants (main hosts or other hosts – see ANNEX 5) likely to be traded as plants for planting. Amongst main hosts: *Abies balsamea*, *Acer negundo*, *Acer platanoides*, *Acer saccharinum*, *Aesculus hippocastanum*, *Albizia julibrissin*, *Alnus* sp., *Alnus incana* subsp. *rugosa*, *Betula alleghaniensis*, *Betula papyrifera*, *Betula* sp., *Catalpa* sp., *Cercis canadensis*, *Fagus* sp., *Juglans nigra*, *Larix laricina*, *Larix* sp., *Malus domestica*, *Malus* sp., *Myrica pensylvanica*, *Picea* sp., *Picea glauca*, *Picea mariana*, *Pinus strobus*, *Platanus occidentalis*, *Platanus* sp., *Populus deltoides*, *Populus* sp., *Prunus* sp., *Prunus cerasus*, *Prunus domestica*, *Pyracantha coccinea*, *Pyrus communis*, *Quercus alba*, *Quercus laurifoli*, *Quercus nigra*, *Quercus rubra*, *Quercus* sp., *Quercus virginiana*, *Rubus* sp., *Salix* sp., *Tamarix gallica*, *Tilia americana*, *Tsuga canadensis*, *Tsuga* sp., *Ulmus* sp., *Ulmus americana*, *Vaccinium corymbosum*, *Vaccinium* sp. *Triticum* sp. and *Zea mays* are main hosts but are unlikely to be traded as plants for planting. (*Fragaria* was transferred to section 8.2).
Pathway prohibited in the PRA area?	Partly. In the EU, the following host plants genera are listed on the provisional list of 'high risk plants': *Acer, Albizia, Alnus, Berberis, Betula, Castanea, Cornus, Corylus, Crataegus, Diospyros, Fagus, Ficus, Fraxinus, Hamamelis, Jasminum, Juglans, Ligustrum, Lonicera, Malus, Persea, Populus, Prunus, Quercus, Robinia, Salix, Taxus, Tilia* and *Ulmus.* The introduction into the EU of plants for planting originating from all third countries and belonging to these genera is **prohibited** pending a risk assessment (Annex I of (EU) 2018/2019 (EU, 2018)). In addition, the introduction into the EU of plants belonging to the following host plant genera is **prohibited** from certain third countries, including Canada and USA (Annex VI of (EU) 2019/2072 (EU, 2019)):

Pathway 1	Host plants for planting (except seeds, bulbs, corms, tubers, rhizomes, tissue cultures, pollen)
	• Plants of *Abies*, *Chamaecyparis*, *Juniperus*, *Larix*, *Picea*, *Pinus* and *Tsuga*. • Plants with leaves of *Castanea*, *Populus* and *Quercus*. • Plants for planting of the family Poaceae, other than plants of ornamental perennial grasses of the subfamilies Bambusoideae and Panicoideae and of the genera *Buchloe*, *Bouteloua*, *Calamagrostis*, *Cortaderia*, *Glyceria*, *Hakonechloa*, *Hystrix*, *Molinia*, *Phalaris*, *Shibataea*, *Spartina*, *Stipa* and *Uniola*, other than seeds. • Plants for planting, other than dormant plants free from leaves, flowers and fruits of *Crataegus*, *Cydonia*, *Malus*, *Prunus*, *Pyrus* and *Rosa*. • Plants for planting of *Photinia*, other than dormant plants free from leaves, flowers and fruits (**not prohibited from Canada**).
Pathway subject to phytosanitary measures, including inspection at import?	Partly. In the EU, **some** plants for planting originating from the USA and Canada are covered by various phytosanitary requirements (summarized below the table) and **all** plants for planting (excluding seeds) must be accompanied by a Phytosanitary Certificate ((EU) 2016/2031 (EU, 2016); (EU) 2019/2072 (EU, 2019)). The Phytosanitary Certificate requirement also applies to plants for planting transported by travellers (travellers' luggage). All consignments of plants for planting, other than seeds, must be inspected at import and after import, physical checks should be carried out on plants for planting other than seeds that have been introduced at a dormant stage (Commission Implementing Regulation (EU) 2020/887, article 1 point 4). These requirements are likely to reduce the association of the pest with the commodity, as they imply some inspection before export and at import which increase the chance of detection.
Pest already intercepted?	No interceptions reported through EUROPHYT for the EU on this pathway and no interceptions reported to EPPO for other EPPO countries. It is noted that one publication mentions transport of egg masses of *O. leucostigma* with young trees (probably within North America; Belton, 1988).
Most likely stages that may be associated	**All life stages** can be present on the aboveground parts of the host plant.
Important factors for association with the pathway	**Larvae** can be present on the foliage, but also on branches and stem of the host plant. However, young larvae would be present only if the plants have foliage, i.e. not on dormant deciduous trees. **Egg masses and pupae** together with the cocoon can be present between branches, beneath limbs, in branch crotches, tree cavities, under loose bark, protected sites in bark crevices, in crevices on the bole formed by pruning wounds. **Adults** are less likely to be associated. **Adult females** can be present on or near their own cocoons and can thereby be present as listed above. However, the adult females die shortly after laying their eggs. **Adult males** can be present as free flying specimens if they emerged during transport. Adult males are attracted to the female cocoons only for mating. General factors affecting the association with the pathway at the point(s) of origin: • The pest is more likely to be associated with main hosts than other hosts. This is because higher densities of the pest are expected on main hosts. It is also more likely to be associated with woody hosts than herbaceous hosts (see section 2.2). • The seasonal presence of the different life stages varies between locations. Eggs are the most common overwintering stage and are present on the host plants, or on other sites selected by the female, from autumn to spring/early summer. However, in the southern parts of the current range the pest has 2–3 generations and hence eggs can be present also during the summer. In southern parts also other life stages may be found during

Pathway 1	Host plants for planting (except seeds, bulbs, corms, tubers, rhizomes, tissue cultures, pollen)
	winter. In the northern parts of its distribution range, larvae are generally present on the host plants from June to August, but in the southern parts of the current range, they might be present from February to November. Pupae are present during a couple of weeks (e.g. from August to September in the northern parts). Dormant plants would not carry larvae. • During outbreak years (usually lasting 1-4 years) larvae density is high and so is egg mass density, increasing the likelihood of the pest being associated with different commodities. • It is unclear how common *O. leucostigma* occurs as a pest in plant nurseries. No documentation of damages in ornamental or forest nurseries were found. Nevertheless, *O. leucostigma* is included in a list of common pests and diseases of nursery crops with recommended management practices (Ontario Ministry of Agriculture, Food and Rural Affairs, 2019). Finally, no records of infestations in protected conditions in the native range were found. Factors limiting the association of the pest with the pathway are: • Larvae may drop from the plant when disturbed/threatened (Howard, 1896; Castellanos *et al.*, 2011). • If plants are treated to control other insect pests (e.g. using chemical treatments), these should be effective also against *O. leucostigma* (Ontario Apple IPM, 2009; Hall & Buss, 2014 and references therein). • None of the life stages of *O. leucostigma* is associated with soil or growing media. • Cuttings may be rooted or unrooted and are expected to be rather small in size. The main life stage potentially associated would be larvae. However, any larvae present on the cuttings when taken from hosts may drop from plants when disturbed. Cuttings traded as rooted may have been maintained in protected conditions reducing the likelihood of association. Factors affecting the likelihood of detecting the organism during inspection or testing at the point(s) of origin: • Symptoms of larval feeding are conspicuous, such as numerous holes appearing in young leaves and skeletonized shoots and bare stems. • Larger larvae skeletonized shoots and bare stems and are highly visible on the leaves, but may hide on the underside of leaves and in dense, shady parts of plants (Isaacs & van Timmeren, 2008). • Newly hatched larvae are very small, with a mean larval length of around 2.5–4 mm (Isaacs & van Timmeren, 2009). • Cocoons with pupae or egg masses are visible on bare twigs of, e.g. dormant deciduous shrubs and trees but may be more difficult to see on ever-green plants. Egg masses are conspicuous and characterized by a white protective covering (Webster, 1916), but species identification may require DNA based diagnostic methods (Armstrong *et al.*, 2003).
Survival during transport and storage	Plants for planting are often transported in refrigerated containers, but temperatures vary depending on the product (e.g. GDV, 2021). All life stages are expected to survive standard trade temperatures. Larvae would continue their development if conditions are favourable and foliage of the host plant is available. Mature larvae could spin their cocoon on suitable locations, e.g. on the packaging. Adults do not feed and 'rarely live longer than a week'.
Trade	There is no updated detailed data at genus or species level for import of plants for planting in the EPPO region. Information on trade of plants for planting was obtained from the database used in Eschen *et al.* (2017), in which data is provided for 14 countries in the PRA area for the period

<table>
<tr><th>Pathway 1</th><th>Host plants for planting (except seeds, bulbs, corms, tubers, rhizomes, tissue cultures, pollen)</th></tr>
<tr><td></td><td>2000–2012. During that time, in total 76 416 pieces of plants for planting of host species/genera (except Fragaria) was traded from Canada (ANNEX 7 A). The respective import from USA was 1 147 965 pieces.

EUROSTAT data of imports of plants for planting from Canada and USA into the EU in 2015–2019 is provided in ANNEX 7 A and a summary is presented below (Data is mainly available for large categories and there is no information for individual plant species).
Import from Canada and USA to EU in 2015–2019 (EUROSTAT, 2020).
<table>
<tr><th></th><th>Canada, tonnes</th><th>USA, tonnes</th></tr>
<tr><td>Unrooted cuttings and slips (excl. vines) (CN 06021090)</td><td>1.1</td><td>96.3</td></tr>
<tr><td>Outdoor rooted cuttings and young plants of trees, shrubs and bushes (excl. fruit, nut and forest trees) (CN 06029045)</td><td>0.8</td><td>57.8</td></tr>
<tr><td>Trees, shrubs and bushes of kinds which bear edible fruit or nuts (CN 06022090, 06022020 and 06022080)</td><td>47.9</td><td>5448.5</td></tr>
<tr><td>Outdoor trees, shrubs and bushes (excl. cuttings, slips and young plants, and fruit, nut and forest trees) (CN 06029046, 06029048 and 06029047)</td><td>0.4</td><td>600.2</td></tr>
<tr><td>Live forest trees (CN 06029041)</td><td></td><td>12.1</td></tr>
<tr><td>Rhododendrons and azaleas (CN 06023000)</td><td></td><td>2.3</td></tr>
<tr><td>Roses (CN 06024000)</td><td>0.8</td><td>4.6</td></tr>
<tr><td>Total</td><td>51</td><td>6221.8</td></tr>
</table></td></tr>
<tr><td>Transfer to a host</td><td>Arrival of a single egg-mass (up to 500 eggs/egg mass) or a fertilized female in the PRA area may be sufficient to facilitate transfer to a host, if it ends up in a site with high density of suitable host plants. Plants for planting are normally planted during favourable conditions for their further development. Those conditions are likely to be favourable for pest development as well. Eggs, larvae and potentially also pre-pupae, may continue their development once at destination. Newly-emerged females would already be on a suitable host (for the offspring) but for mating to occur also male pupae should be arriving at the same time point. Young larvae may be able to transfer to suitable hosts by ‘ballooning’. Yet, they may die due to failure to find a suitable host during ballooning dispersal. If larvae have developed to later stages, they may also crawl to a host. Presumably young larvae could also crawl but the distance is not known, and expected to be rather short.

The pest is very polyphagous and about 54 host genera/species reported as common hosts in the native range also occur in the EPPO region and some of them are widespread (Section 9.2, table 10). Based on the broad host range it is also assumed likely that the pest could transfer from a commodity to new hosts in the EPPO region, e.g. species of genera known to contain hosts.</td></tr>
<tr><td>Likelihood of entry and uncertainty</td><td>The EWG rated separately main hosts and other hosts because the likelihood of association with these two categories differ.
Main elements for the likelihood ratings:
• one egg mass is sufficient for entry of the pest.
• cocoons with pupae or egg masses may be overlooked when hidden.
• one publication mentions transport of egg masses with young trees (Belton 1988)</td></tr>
</table>

<table>
<tr><th>Pathway 1</th><th>Host plants for planting (except seeds, bulbs, corms, tubers, rhizomes, tissue cultures, pollen)</th></tr>
<tr><td></td><td>

there is a trade, at least to part of the EPPO region
for other hosts, lesser association.

The EWG did not rate cuttings and scions of host separately, but considered that the likelihood of entry would be lower (see ‘Important factors for association with the pathway’).
Uncertainties: whether O. leucostigma is commonly present in nurseries and whether treatments applied control it; which life stages may be associated with nursery plants; trade volumes to the EPPO region. For other hosts, whether O. leucostigma is frequently associated.
<table>
<tr><th></th><th>Likelihood</th><th>Uncertainty</th></tr>
<tr><td>Plants for planting (except seeds, bulbs, corms, tubers, rhizomes, tissue cultures, pollen) of main hosts* (except Fragaria, Zea mays, Triticum)</td><td>High</td><td>Moderate</td></tr>
<tr><td>Plants for planting (except seeds, bulbs, corms, tubers, rhizomes, tissue cultures, pollen) of other hosts*</td><td>Moderate</td><td>Moderate</td></tr>
</table>
In countries where there is a prohibition or some requirements are in place, the likelihood of entry will be lower for the hosts concerned.
* Main hosts and other hosts are listed in ANNEX 5.
</td></tr>
</table>

Excerpt of EU requirements
Following the EU legislation (Annex VII of (EU) 2019/2072 (EU, 2019)): • Some of the special requirements (i.e. grown in nurseries; free from plant debris, flowers and fruits; have been inspected at appropriate times and prior to export; plants found to be free from signs or symptoms of harmful insects, or have been subjected to appropriate treatment to eliminate such organisms) potentially have impact for the following host plants: o Annual and biennial plants for planting o Herbaceous perennial plants for planting, other than seeds, of the Rosaceae family o Trees and shrubs, intended for planting • The special requirement ‘dormant and free from leaves’ potentially has an impact for the following host plants: o Deciduous trees and shrubs intended for planting (other than seeds and plants in tissue culture) • Some of the special requirements (e.g. official inspections carried out at the place of production for relevant quarantine pests; the plants are subject to an inspection for relevant quarantine pests immediately prior to export) potentially have impact for the following host plant: o Plants of *Castanea*, *Quercus* and *Populus* (only without leaves) o Plants for planting of *Platanus* (from USA) o Plants for planting of *Cydonia*, *Ribes* and *Rubus* o All plants for planting (for *Thrips palmi* in areas where it is present - restricted distribution in North America, only reported in Florida (EPPO, 2021)) o Plants for planting of *Amelanchier*, *Cydonia*, *Pyracantha* and *Vaccinium* • Special requirements for ‘Naturally or artificially dwarfed plants for planting other than seeds‘(e.g. plants kept in officially registered nurseries and subjected to officially supervised control regime for at least two years prior to dispatch, have been officially inspected for and ensured to be free from union quarantine pests, packed in closed containers).
A number of emergency measures make requirements that would apply for some hosts from the USA and Canada, such as for *Anoplophora glabripennis* (Commission Implementing Decision 2015/893), Rose rosette virus (Decision 2019/1739), *Phytophthora ramorum* (Decision (EU) 2002/757), *Xylella fastidiosa* (Commission Implementing Regulation (EU) 2020/1201), *Fusarium circinatum* (Commission Implementing Decision 2019/2032)

8.1.2 Cut branches (including Christmas trees) of host plants

Table 5. Cut branches (incl. Christmas trees) of host plants

Pathway 2	Cut branches (incl. Christmas trees) of host plants
Coverage	• The pathway includes Christmas trees and other cut branches of hosts.
Plants covered	All host plants (main hosts or other hosts – see ANNEX 5) that may be used in this form. However, many hosts are unlikely to be used, and therefore traded, as Christmas trees and cut branches. Amongst main hosts: *Abies balsamea*, *Acer negundo*, *Acer platanoides*, *Acer saccharinum*, *Aesculus hippocastanum*, *Albizia julibrissin*, *Alnus* sp., *Alnus incana* subsp. *rugosa*, *Betula alleghaniensis*, *Betula papyrifera*, *Betula* sp., *Catalpa* sp., *Cercis canadensis*, *Fagus* sp., *Juglans nigra*, *Larix laricina*, *Larix* sp., *Malus domestica*, *Malus* sp., *Myrica pensylvanica*, *Picea* sp., *Picea glauca*, *Picea mariana*, *Pinus strobus*, *Platanus occidentalis*, *Platanus* sp., *Populus deltoides*, *Populus* sp., *Prunus* sp., *Prunus cerasus*, *Prunus domestica*, *Pyracantha coccinea*, *Pyrus communis*, *Quercus alba*, *Quercus laurifoli*, *Quercus nigra*, *Quercus rubra*, *Quercus* sp., *Quercus virginiana*, *Salix* sp., *Tamarix gallica*, *Tilia americana*, *Tsuga canadensis*, *Tsuga* sp., *Ulmus* sp., *Ulmus americana*, *Vaccinium* sp.
Pathway prohibited in the PRA area?	Partly. In the EU, the introduction of parts of plants belonging to the following host plant genera is **prohibited** from certain third countries, including Canada and USA (Annex VI of (EU) 2019/2072 (EU, 2019)): • Plants of *Abies*, *Chamaecyparis*, *Juniperus*, *Larix*, *Picea*, *Pinus* and *Tsuga*. • Plants with leaves of *Castanea*, *Populus* and *Quercus*.
Pathway subject to phytosanitary measures, including inspection at import?	Partly. In the EU, Phytosanitary certificates are required for all fresh parts of plants for their introduction into the Union territory from third countries (other than Switzerland) (Annex XI of (EU) 2019/2072 (EU, 2019).
Pest already intercepted?	No interceptions reported through EUROPHYT for the EU on this pathway and no interceptions reported to EPPO for other EPPO countries.
Most likely stages that may be associated	**All life stages** can be present on the aboveground parts of the host plant.
Important factors for association with the pathway	**Larvae** can be present on the foliage, but also on branches and stem of the host plant. However, young larvae would be present only if the plants have foliage. **Egg masses and pupae** can be present in branch crotches, protected sites in bark crevices. Christmas trees would provide more places for egg masses and pupae than other cut branches. **Adult females** can be present on or near their own pupal cocoons and can thereby be present as listed above. However, the adult females die shortly after laying their eggs. **Adult males** can be present if they emerged during transport as free flying specimens. Adult males are attracted to the female cocoons only for mating.

	General factors affecting the association with the pathway at the point(s) of origin: • The pest is more likely to be associated with main hosts than other hosts. • During outbreak years (usually lasting 1-4 years) larvae density is high and so is egg mass density, increasing the likelihood of the pest being associated with different commodities. • The pest is found in Christmas tree plantations (Thurston, 2002; Sutherland, 2008). Factors limiting the association with the pathway are: • Larvae may drop from the cut branches when disturbed/threatened (Howard, 1896; Castellanos *et al.*, 2011). • If plants are treated to control other insect pests (e.g. using chemical treatment), these should be effective also against *O. leucostigma* (Ontario Apple IPM, 2009; Hall & Buss, 2014 and references therein). • Harvesting, packing and transport may affect the likelihood of the pest remaining on the commodity, especially larvae. Factors affecting the likelihood of detecting the organism during inspection or testing at the point(s) of origin: • Symptoms of larval feeding are conspicuous, such as numerous holes appearing in young leaves and skeletonized shoots and bare stems. Such symptoms would also prevent the commodity from being traded for ornamental purposes because of the quality requirements. • Larger larvae skeletonized shoots and bare stems and are highly visible on the leaves, but may hide on the underside of leaves (Isaacs & van Timmeren, 2008). • Newly hatched larvae are very small, with a mean larval length of around 2.5 mm (Isaacs & van Timmeren, 2009). • Cocoons with pupae or egg masses are visible on bare twigs of, e.g. above-ground fresh parts of dormant deciduous shrubs and trees but may be more difficult to see on ever-green plants. • Eggs masses are conspicuous and characterized by a white protective covering (Webster, 1916), but species identification may require DNA based diagnostic methods (Armstrong *et al.*, 2003).
Survival during transport and storage	All life stages are expected to survive during transport and storage. Larvae would continue their development if foliage of the host plant were available. Mature larvae could spin their cocoon on suitable locations, e.g. on the packaging. Adults do not feed and 'rarely live longer than a week'.

<table>
<tr><td>Trade</td><td>EUROSTAT data of imports of above ground fresh plant parts from Canada and USA into the EU in 2015–2019 is provided in ANNEX 7 B and a summary of that data is presented below. (Data is mainly available for large categories and there is no information for individual plant species.)
Import from Canada and USA to EU in 2015–2019 (EUROSTAT, 2020). Zeros indicate that there has been import but its annual amount has been below 100 kg.
<table>
<tr><th></th><th>Canada, tonnes</th><th>USA, tonnes</th></tr>
<tr><td>Fresh Christmas trees (CN 06042020)</td><td></td><td>0</td></tr>
<tr><td>Fresh conifer branches, suitable for bouquets or ornamental purposes (CN 06042040)</td><td></td><td>8.7</td></tr>
<tr><td>Foliage, branches and other parts of plants, without flowers or flower buds, and grasses, fresh, suitable for bouquets or ornamental purposes (excl. Christmas trees and conifer branches) (CN 06042090)</td><td>3 737.7</td><td>87 042.5</td></tr>
</table></td></tr>
<tr><td>Transfer to a host</td><td>Arrival of a single egg-mass (up to 500 eggs/egg mass) in the PRA area may be sufficient to facilitate transfer to a host, if it ends up in a site with high density of suitable host plants. Eggs would continue their development once at destination. Larvae are the only life stage able to ensure transfer to a host by ‘ballooning’ for younger larvae or by crawling if larvae have developed to later stages on the cut branches. Young larvae often die due to failure to find a suitable host during ballooning dispersal. Presumably young larvae could also crawl but the distance is not known, and expected to be rather short.
The pest is very polyphagous and about 54 host genera/species reported as common hosts in the native range also occur in the EPPO region and some of them are widespread (Section 9.2, table 10). Based on the broad host range it is also assumed likely that the pest could transfer from a commodity to new hosts in the EPPO region, e.g. species of genera known to contain hosts.
The likelihood of transfer is higher if Christmas trees or cut branches are used outdoors, or possibly if they are discarded outdoors after use. The likelihood of transfer from cut branches used in bouquets used indoors is expected to be lower. If the commodity arrives at nurseries or garden centres, transfer to other hosts may be more likely.</td></tr>
<tr><td>Likelihood of entry and uncertainty (ratings: e.g. very low, low, moderate, high, very high)</td><td>The EWG rated separately main hosts and other hosts because the likelihood of association with these two categories differs.
Main elements for the likelihood ratings:
- one egg mass is sufficient for entry of the pest.
- cocoons with pupae or egg masses may be overlooked when hidden
- such plants parts have a limited life time, and would then become unsuitable to support larvae life stages.
- transfer is the limiting step (only possible if used or discarded outdoors, and such material is often used indoors).
- the likelihood may be higher for Christmas trees than other cut branches, because they provide more places for egg masses and those could remain on the material until hatching. It is noted that there is no trade of Christmas trees into the EU at the moment.
- for other hosts, lower association.
- if large volumes of a host are imported, this may change the ratings.</td></tr>
</table>

	Uncertainties: whether cut branches of hosts are traded to the EPPO region. Whether life stages would be associated with such material. Trade volumes to the EPPO region, whether transfer is possible. For other hosts, whether *O. leucostigma* is frequently associated with them. Trade volume to the EPPO countries.

	Likelihood	Uncertainty
Cut branches (incl. Christmas trees) of main hosts*	Low	Moderate
Cut branches (incl. Christmas trees) of other hosts* (consequently listed in section 8.2)	Very low	Moderate

* Main hosts and other hosts are listed in ANNEX 5.

8.1.3 Round wood and sawn wood of hosts with or without bark

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

Pathway 3	**Round wood and sawn wood of hosts with or without bark**
Coverage	This pathway intends to cover all types of round wood and sawn wood, including with or without bark. The understanding of sawn wood is as per definition in ISPM 5, i.e. wood sawn longitudinally, with or without its natural rounded surface with or without bark (FAO, 2018a). Round wood includes logs, but also other types of material. Whole trees including branches, twigs, possibly stumps, may be harvested (e.g. as fuel wood). In addition, part of the commodity described in the EPPO Study on wood commodities (EPPO, 2015a) as 'harvesting residues' is a type of round wood when in the form of tops of trees, branches, twigs etc. - *composition:* Consignments of round wood (as logs) and sawn wood would generally be of one species. Harvesting residues (in the form of round wood) arise from the harvest of logs and may initially be from one tree species, but it is not known if they would be grouped with other tree species from other origins when traded (e.g. as fuel wood). Round wood intended for other purposes (e.g. fuel wood, production of chips) may contain a mixture of species. - *presence of bark:* round wood (as logs) and sawn wood may be traded with or without bark. Other types of round wood may also have bark attached. - *intended use:* Such commodities may be used for construction, furniture, long poles, energy purposes or processed (such as chips, pulp, fibreboard etc.).
Plants covered	All host plants (main hosts and other hosts – see ANNEX 5) that are trees. Some of them are widely used for wood and may be traded as round or sawn wood, while others may be present more incidentally in consignments, e.g. for energy purposes. Major tree hosts are listed below. The ones that are not in the Working List of Commercial Timber Tree Species (Mark *et al.*, 2014) are indicated with *. All those listed below at genus level have some species in Mark *et al.* (2014). *Abies balsamea*, *Acer negundo*, *Acer platanoides**, *Acer saccharinum*, *Aesculus hippocastanum*, *Albizia julibrissin**, *Alnus* sp., *Alnus incana* subsp. *rugosa**, *Betula alleghaniensis*, *Betula papyrifera*, *Betula* sp., *Catalpa* sp., *Fagus* sp., *Juglans nigra*, *Larix laricina*, *Larix* sp., *Malus domestica*, *Malus* sp., *Picea* sp., *Picea glauca*, *Picea mariana*, *Pinus strobus*, *Platanus occidentalis*, *Platanus* sp., *Populus deltoides*, *Populus* sp., *Prunus* sp., *Prunus cerasus**, *Prunus domestica**, *Pyrus communis*, *Quercus alba*, *Quercus laurifoli**, *Quercus nigra**, *Quercus rubra*, *Quercus* sp., *Quercus virginiana*, *Salix* sp., *Tilia americana*, *Tsuga canadensis*, *Tsuga* sp., *Ulmus* sp., *Ulmus americana*
Pathway prohibited in the PRA area?	No
Pathway subject to phytosanitary measures, including	Partly. In the EU, a number of **special requirements** directed against other pests are placed on round and sawn wood, e.g. heat treatment, fumigation, kiln-dried, removal of bark, outer sapwood removed, pest-free area etc. **Phytosanitary certificates** are required for some specific wood commodities, and **emergency measures** are in place (see details below the table).

inspection at import?	
Pest already intercepted?	No interceptions reported through EUROPHYT for the EU on this pathway and no interceptions reported to EPPO for other EPPO countries.
Most likely stages that may be associated	Egg masses and pupae. Mature larvae or adults may also be present.
Important factors for association with the pathway	Egg masses and pupae are the most likely stages to be associated. Cocoons are often found in bark crevices, under loose bark, etc. Other stages may be associated but it is less likely: - Mature larvae can be present when crawling and searching for suitable sites to spin their cocoon, although expected to be during a short time period. The mature larvae crawl in search for protected sites to spin their cocoon and pupate. - Adult females can be present on or near their own cocoons. However, females die shortly after laying their eggs. Adult males can be present if they emerged during transport as free flying specimens. General factors affecting the association with the pathway at the point(s) of origin: • The pest is more likely to be associated with main hosts than other hosts • During outbreak years (usually lasting 1-4 years) larvae density is high and so is egg mass density, increasing the likelihood of the pest being associated with different commodities. Factors limiting affecting the association with the pathway at the point(s) of origin: • If bark is removed, the cocoon with pupae, adult females or egg masses are likely to also be removed. Therefore, wood without bark is less likely to be infested. • Common pest management options for wood: for example, heat treatment, irradiation and removal of bark against regulated pests in the EPPO region. Heat treatment and ionizing radiation are expected to be efficient against wood related insects for round and sawn wood (EPPO, 2009a; 2009b). The efficiency of the latter treatment would, however, depend on the radiation dose (Rossmoore and Hoffman 1971). Removal of bark would effectively remove the cocoon (with the pupae) and egg masses, but debarked wood stored in open air may be infested by larvae seeking sites to pupate. Embree et al. (1984) mentions logs as a site for cocoons but it is not known whether these were with or without bark. However, the treatment options or removal of bark do not apply to all host trees, nor to all EPPO countries, and were therefore not taken into account in the ratings. • Processing into sawn wood would destroy or dislodge some life stages, but some life stages may remain on sawn wood with bark. Factors affecting the likelihood of detecting the organism during inspection or testing at the point(s) of origin:

	• Cocoons with pupae, females or egg masses would be visible but could be overlooked if hidden, e.g. in protected sites on stems with bark. Species identification of egg masses may require DNA based diagnostic methods (Armstrong *et al.*, 2003). Could be overlooked in large wood consignments.
Survival during transport and storage	Eggs and pupae are likely to survive during transport. • Desiccation of wood is not likely to affect *O. leucostigma* since no life stage is xylophagous.
Trade	Many known hosts are in the Working List of Commercial Timber Tree Species (Mark *et al.*, 2014). FAOSTAT provides data of imports into the PRA area for large categories of plants and no information is available for individual host species or genera (ANNEX 7 C). In 2014–2017, 484 692 m^3 of roundwood (coniferous and non-coniferous, non-tropical) was imported to the PRA area from Canada, and 6 746 613 m^3 from USA (FAOSTAT, 2020). For the same period, the amount of sawn wood (coniferous and non-coniferous, non-tropical) imported to the PRA area from Canada was 8 463 977 m^3, and 2 062 815 m^3 from USA (FAOSTAT, 2020). EUROSTAT provides data of imports into the EU separately for some genera that have *O. leugostigma* host plants (ANNEX 7 C). In 2015–2019, at least* 331 tonnes of wood in the rough of *Abies*, *Betula*, *Fagus*, *Picea*, *Pinus*, *Populus* and *Quercus* was imported into the EU from Canada, and 38 585 tonnes form USA (EUROSTAT 2020). In the same period, at least* 98 tonnes of sawnwood of *Abies*, *Betula*, *Fagus*, *Picea*, *Pinus*, and *Quercus* was imported into EU from Canada, and 4 874 tonnes from USA (EUROSTAT, 2020). **Because of how the CN codes are determined, the true amount of imports of wood cannot be calculated.*
Transfer to a host	Arrival of a single egg-mass (up to 500 eggs/egg mass) in the PRA area may be sufficient for successful transfer to a host, if it ends up in a site with high density of suitable host plants. Wood is often stored outdoors and close to forests or trees, so transfer is considered possible. If egg masses or pupae are present on the wood, larvae or adults could emerge. If the pest arrives as eggs, emerging larvae would need to find a suitable host plant to feed. This is not unlikely as the pest has a very wide host range of shrubs, forest, ornamental and fruit trees. However, by 'ballooning' from piles of wood, the pest would probably be able to disperse only over rather short distances, and larvae may die due to failure to find a suitable host. Presumably young larvae could also crawl but the distance is not known, and expected to be rather short. Several individuals should arrive together at about the same development stage, so that the emerging adults can eventually mate. If the pest arrives as pupae, since the emerging female adults cannot fly, the pest transfer would require certain circumstances, i.e. the female and male pupae need to arrive at the same time at same destination to mate. The laid eggs must be able to develop and larvae emerge at an appropriate time for survival and the wood needs to be kept or used outdoors at the destination.
Likelihood of entry and uncertainty (ratings: e.g. very low, low,	The EWG rated separately round wood with bark and sawn wood with bark. As for other pathways, main hosts and other hosts were rated separately. Round wood and sawn wood without bark were rated separately. *Main elements for the likelihood ratings*: - one egg mass is sufficient for entry of the pest. - cocoons with pupae or egg masses may be overlooked when hidden.

moderate, high, very high)	- Transfer is the limiting step because life stages would have to reach suitable hosts. The EWG rated a situation where wood is stored outdoors close to suitable host plants. - for sawn wood, the likelihood of association is lower as more life stages would be killed during processing. - for other hosts, lower association. - there is a trade of wood of hosts, at least to the EU *Uncertainties*: whether ballooning or other transfer from log piles would be more difficult than from plants for planting. Where logs arrive, and whether they would frequently be very close to suitable host plants. For other hosts, whether *O. leucostigma* is frequently associated with them.

	Likelihood	Uncertainty
Round wood with bark of main hosts*	Moderate	Moderate
Round wood with bark of other hosts*	Low	Moderate
Sawn wood with bark of main hosts	Low	Moderate
Sawn wood with bark of other hosts (consequently listed in 8.2)	Very low	Low
Round wood and sawn wood without bark (consequently listed in 8.2)	Very low	Low

* Main hosts and other hosts are listed in ANNEX 5.

Excerpt of EU requirements for round wood and sawn wood of various host genera
Annex VII of Commission Implementing Regulation (EU) 2019/2072. Special requirements directed against other pests are placed on round and sawn wood, e.g. heat treatment, fumigation, kiln-dried, removal of bark, outer sapwood removed, pest-free area of the following species or genera: • Conifers (Pinales), *Acer saccharum*, *Fraxinus, Juglans ailantifolia, Juglans mandshurica, Ulmus davidiana and Pterocarya rhoifolia, Betula, Amelanchier, Aronia, Cotoneaster, Crataegus, Cydonia, Malus, Pyracantha, Pyrus, Prunus* and *Sorbus,* from Canada and USA • *Juglans, Pterocarya, Platanus* and *Quercus* from USA. • *Populus* from the Americas.
Phytosanitary certificates are required for some specific wood commodities of (Annex XI of (EU) 2019/2072 (EU, 2019)): • Conifers (Pinales), *Acer saccharum, Betula, Fraxinus, Juglans, Pterocarya and Ulmus davidiana, Amelanchier, Aronia, Cotoneaster, Crataegus, Cydonia, Malus, Pyracantha, Pyrus, Sorbus* and *Prunus* from USA and Canada. • *Quercus, Platanus, Acer macrophyllum, Aesculus californica, Lithocarpus densiflorus* and *Taxus brevifolia* from USA. • *Populus* from the Americas. • *Acer, Aesculus, Alnus, Betula, Carpinus, Cercidiphyllum, Corylus, Fagus, Fraxinus*, *Koelreuteria, Platanus, Populus, Salix, Tilia* and *Ulmus* from third countries where *Anoplophora glabripennis* is known to be present (which includes USA and possibly Canada where the pest has been eradicated and is now absent according to EPPO (2020)).
A number of emergency measures make requirements that would apply for some hosts from the USA and Canada, such as for: • *Anoplophora glabripennnis* (Commission Implementing Decision 2015/893) • *Phytophthora ramorum* (Decision EU 2002/757) • *Fusarium circinatum* (Commission Implementing Decision 2019/2032).

8.1.4 Wood chips, hogwood, processing wood residues (except sawdust and shavings) of host plants

Table 7. Wood chips, hogwood, processing wood residues (except sawdust and shavings) of host plants

Pathway 4	**Wood chips, hogwood, processing wood residues (except sawdust and shavings) of host plants**
Coverage	*Note '(except sawdust and shavings)' is not repeated below to simplify but is intended throughout this pathway.* Where harvesting residues are in another form than round wood (e.g. residues from squaring), the EPPO Study on wood commodities (EPPO, 2015a) considers that they would either be left on-site or transformed on-site, in which case they become another commodity (e.g. wood chips, hogwood). - *composition:* depending on the intended use, wood chips are produced from one or a mixture of species. This is not known for the other commodities but would presumably be the same. - *presence of bark:* wood chips or hogwood may be produced from different types of initial material (e.g. wood with or without bark, post-consumer scrap wood etc.). Processing wood residues are residues from round and sawn wood, e.g. made from off-cuts, and may have bark attached. Consequently, at least part of these commodities may include some bark. - *size:* wood chips are produced through a shredder using a round-hole sieve that defines the dimension of chips (e.g. <2.5 cm) on two sides (not the third). The European Standard on solid fuel (CEN, 2014) identifies ten classes of wood chips [cut with sharp tools; typical particle size 5-100 mm] and hog fuel [crushed with blunt tools; varying size] according to the dimensions of the particles. In the class with the largest predefined size of particles, a minimum of 60 weight-percentage (w-%) should consist of particles with a height and a width in the range of 3.15-200 mm and a max length of ≤ 400 mm, and a coarse fraction constituting ≤ 10 w-% which can have a height or width of > 250mm and a max length of particles of 400 mm. There is also one larger size class (60 w-% with a height and a width in the range of 3.15 – 300 mm) where the criteria for the coarse fraction and the max length are not predefined but "to be specified". In the class that most closely relate to the typical wood chips size (5-100 cm), 60% of wood chips should be comprised in the range 3.15–100 mm, and 10% can measure 150-350 mm. As a consequence, both wood chips and hogwood can be quite large. - *intended use*: All these commodities may be used for different purposes, such as pulp, fibreboard production, energy purposes, mulch.
Plants covered	As for wood.
Pathway prohibited in the PRA area?	Partly. The introduction into the EU of 'Wood chips, particles, sawdust, shavings, wood waste and scrap obtained in whole or in part from *Betula*' should be accompanied with an 'Official statement that the wood originates in a country known to be free of *Agrilus anxius.* Since, *A. anxius* is present in Canada and USA import of *deciduous wood chips containing Betula* is not allowed.
Pathway subject to phytosanitary measures, including inspection at import?	Partly. In the EU, a number of **special requirements** directed against other pests are placed on wood chips etc., e.g. heat treatment, fumigation, kiln-dried, and removal of bark, on the following genera or species (Annex VII of (EU) 2019/2072 (EU, 2019)): • Conifers (Pinales), *Acer saccharum*, *Populus*, *Amelanchier*, *Aronia*, *Cotoneaster*, *Crataegus*, *Cydonia*, *Malus*, *Pyracantha*, *Pyrus*, *Prunus* and *Sorbus* from Canada and USA • *Juglans*, *Pterocarya* and *Quercus* from USA

	In the EU, the requirements for **phytosanitary certificates** of this commodity are the same as for wood.
Pest already intercepted?	No interceptions reported through EUROPHYT for the EU on this pathway and no interceptions reported to EPPO for other EPPO countries.
Most likely stages that may be associated	Egg masses and pupae. Adults may also be present.
Important factors for association with the pathway	**Egg masses** and **pupae** are the most likely stages to be associated if they were present on the wood before processing. Cocoons are often found in bark crevices and under loose bark, etc. However, some would be destroyed at processing, especially if the particles are smaller than 2.5×2.5 cm in two dimensions. But the mulch may contain eggs even out of the froth protective covering. **Adults** may emerge from pupal cocoons during transport. General factors affecting the association with the pathway at the point(s) of origin: • The pest is more likely to be associated with main hosts than other hosts. A wider variety of hosts is expected to be used for wood chips etc. than round wood and sawn wood (Ward & Orlinski, 2016). • During outbreak years (usually lasting 1-4 years) larvae density is high and so is egg mass density, increasing the likelihood of the pest being associated with different commodities. Factors limiting the association with the pathway at the point(s) of origin: • For some host species existing requirements (e.g. in the EU) based on size, i.e. that chips should be below 2.5×2.5 cm in two dimensions, would decrease the survival rate of the eggs and pupae compared to wood. However, the third dimension can be of any size and this requirement does not apply to all hosts or commodities. Factors affecting the likelihood of detecting the organism during inspection or testing at the point(s) of origin: • Cocoons with pupae, females or egg masses would be visible but presumably very difficult to detect among wood chips etc.
Survival during transport and storage	As for wood. • In addition, this commodity is often stored in large piles and due to composting processes, the temperatures may become high in the core. Depending on the material, moisture content and storage conditions, the temperature in some parts of the pile may reach up to 55°C or higher (McCullough *et al.*, 2007). But the temperature in other parts of the pile may be much lower and not lethal for the pest. • There is limited information on the heat tolerance of *O. leucostigma*. It is known that temperatures above 35°C prevent larval development (Isaacs & van Timmeren, 2009).
Trade	FAOSTAT provides data for most EPPO countries, grouping coniferous and non-coniferous wood chips (ANNEX 7 D). In 2014–2017, 1 611 292 m^3 of wood chips and particles were imported to the PRA area from Canada, and 8 750 657 m^3 from USA (FAOSTAT, 2020).
Transfer to a host	As for wood.

<table>
<tr><td></td><td>Transfer is possible only if the commodity is used (e.g. as ground cover, mulch) or stored outdoors (prior to processing). The probability of transfer is lower than for wood as dispersal by ‘ballooning’ would be possible only from the outermost layer of the commodity. Also, ‘ballooning’ distances would be very restricted from piles of chips, etc. and especially from mulch spread on the ground. Thus, young larvae would often die due to failure to find a suitable host. Products for ground cover (mulch) likely constitute to a small part of imports.</td></tr>
<tr><td>Likelihood of entry and uncertainty
(ratings: e.g. very low, low, moderate, high, very high)</td><td>Main elements for the likelihood ratings:
- one egg mass is sufficient for entry of the pest.
- cocoons with pupae or egg masses may be overlooked when hidden.
- processing would kill or dislodge some individuals.
- survival would be more difficult than on round wood
- transfer would be difficult.
- information on trade is lacking, i.e. if hosts are commonly traded in this form.
- a general rating was given, also including mixed consignments. The rating may need to be reconsidered if countries wish to assess consignments composed of one species, and more data on association to this species and trade is available.
<table><tr><td></td><td>Likelihood</td><td>Uncertainty</td></tr><tr><td>Wood chips, hogwood, processing wood residues (except sawdust and shavings) of hosts</td><td>Low</td><td>Low</td></tr></table></td></tr>
</table>

8.1.5 Bark of host plants

Table 8. Bark of host plants

Pathway 5	**Bark of host plants**
Coverage	• Bark of host plants traded on its own.
Plants covered	All host plants (main hosts and other hosts) that have bark. No data was found on which bark may be used and traded internationally. Plants that are common hosts or for which damage has been recorded and potentially traded as bark (section 7; ANNEX 5): *Abies balsamea*, *Acer negundo*, *Acer platanoides*, *Acer saccharinum*, *Aesculus hippocastanum*, *Albizia julibrissin*, *Alnus* sp., *Alnus incana* subsp. *rugosa*, *Betula alleghaniensis*, *Betula papyrifera*, *Betula* sp., *Catalpa* sp., *Fagus* sp., *Juglans nigra*, *Larix laricina*, *Larix* sp., *Malus domestica*, *Malus* sp., *Picea* sp., *Picea glauca*, *Picea mariana*, *Pinus strobus*, *Platanus occidentalis*, *Platanus* sp., *Populus deltoides*, *Populus* sp., *Prunus sp.*, *Prunus cerasus*, *Prunus domestica*, *Pyrus communis*, *Quercus alba*, *Quercus laurifoli*, *Quercus nigra*, *Quercus rubra*, *Quercus* sp., *Quercus virginiana*, *Salix* sp., *Tilia americana*, *Tsuga canadensis*, *Tsuga* sp., *Ulmus* sp., *Ulmus americana*
Pathway prohibited in the PRA area?	Partly. The introduction into the EU of isolated bark belonging to the following host plant genera is **prohibited** from certain third countries, including Canada and USA (Annex VI of (EU) 2019/2072 (EU, 2019)): *Castanea*, *Quercus* (other than *Q. suber*), *Acer saccharum* and *Populus*. The introduction into the EU of isolated bark of *Acer macrophyllum, Aesculus californica, Lithocarpus densiflorus, Quercus* and *Taxus brevifolia* from USA is prohibited (2002/757/EC (EU, 2002)).
Pathway subject to phytosanitary measures, including inspection at import?	Partly. In the EU, a number of **special requirements** directed against other pests are placed on isolated bark, e.g. heat treatment, fumigation, pest free area etc. **Phytosanitary certificates** are required for some specific wood commodities, and **emergency measures** are in place (see details below the table).
Pest already intercepted?	No interceptions reported through EUROPHYT for the EU on this pathway and no interceptions reported to EPPO for other EPPO countries.
Most likely stages that may be associated	Egg masses and pupae. Adult females may also be present
Important factors for association with the pathway	**Egg masses**, pupae and **adult females** may remain attached to the removed bark. **Adult females** can be present on or near their own pupal cocoons. However, females die shortly after laying eggs. General factors affecting the association with the pathway at the point(s) of origin: • The pest is more likely to be associated with main hosts than other hosts.

	• During outbreak years (usually lasting 1-4 years) larvae density is high and so is egg mass density, increasing the likelihood of the pest being associated with different commodities. Factors limiting affecting the association with the pathway at the point(s) of origin: • Harvesting and processing of the bark is likely to affect the survival of all life stages that may be present. • The EWG noted that bark may be of different size for different uses. Processing into small pieces would destroy or dislodge many individuals, while if large sections of bark are collected from the trees and not chopped into pieces, more individuals could remain associated. The EWG did not know if this was a usual practice for some host species. • Heat treatment and fumigation are common pest management options for isolated bark against regulated pests in the EPPO region. Heat treatment is expected to be efficient against wood related insects at least for round and sawn wood (EPPO, 2009a). The effect of fumigation on *O. leucostigma* is uncertain. The treatment options may not be required for all host trees, nor to all EPPO countries, and were therefore not taken into account in the ratings. Factors affecting the likelihood of detecting the organism during inspection or testing at the point(s) of origin: • Cocoons with pupae, females or egg masses would be visible but presumably very difficult to detect among pieces of bark. Species identification of egg masses may require DNA based diagnostic methods (Armstrong *et al.*, 2003).
Survival during transport and storage	Eggs and pupae might survive during transport. However, bark is often stored in large piles and due to composting processes, the temperatures may become high in the core. Depending on the material, moisture content and storage conditions, the temperature in some parts of the pile may reach up to around 60–70°C (Zoch *et al.*, 1982; Routa *et al.*, 2020). The temperature in other parts of the pile may be much lower and not lethal for the pest.
Trade	No information on trade of isolated bark was found.
Transfer to a host	Arrival of a single egg-mass (up to 500 eggs/egg mass) in the PRA area may be sufficient to facilitate transfer to a host, if it ends up in a site with high density of suitable host plants. If the pest arrives as eggs, emerging larvae would need to find a suitable host plant to feed. This is not unlikely as the pest has a very wide host range of shrubs, forest, ornamental and fruit trees. However, by ‘ballooning’ from piles of bark especially from bark spread on the ground as mulch, the pest would probably be able to disperse only over rather short distances. Larvae may die due to failure to find a suitable host. Presumably young larvae could also crawl but the distance is not known, and expected to be rather short. Several individuals should arrive together at about the same development stage, so that the emerging adults can eventually mate. Transfer would require certain circumstances, i.e. that the bark is kept or used outdoors at an appropriate time for larvae emergence and survival. If the bark is stored or used outdoors, available hosts are expected to be present in the surroundings since host plants are widely distributed in the PRA area. If the pest arrives as pupae, since the emerging female adults cannot fly, the pest transfer would require certain circumstances, i.e. the female and male pupae need to arrive at the same time at the same destination to mate. The laid eggs must be able to develop and larvae emerge at an appropriate time for survival and the bark need to be kept or used outdoors at the destination.
Likelihood of entry and uncertainty	As for other pathways, main hosts and other hosts were rated separately. *Main elements for the likelihood ratings*: - one egg mass is sufficient for entry of the pest.

	- cocoons with pupae or egg masses may be overlooked when hidden. - processing would kill or dislodge some individuals, especially for smaller pieces of bark. - survival would be lower than on round wood - transfer would be difficult. - for other hosts, lower association. *Uncertainty*. information on trade is lacking, i.e. whether the bark of some hosts is commonly traded, whether transfer is possible; whether the bark of some hosts is traded as very large pieces (i.e. only collected from the tree and not chopped). Bark of main hosts* — Low — High Bark of other hosts* (consequently listed in section 8.2) — Very low — High If specific bark is traded as large sections collected from the tree and not chopped into pieces, the likelihood may be higher. * Main hosts and other hosts are listed in ANNEX 5.

Bark of main hosts*	Low	High
Bark of other hosts* (consequently listed in section 8.2)	Very low	High

Excerpt of EU requirements for isolated bark of various host genera
Annex VII of (EU) 2019/2072 (EU, 2019). Special requirements directed against other pests are placed on isolated bark, e.g. heat treatment, fumigation, pest free area etc. from the following genera or species: • conifers (Pinales) originating in Canada and USA. • *Juglans* and *Pterocarya* originating in USA. • *Fraxinus, Juglans ailantifolia, Juglans mandshurica, Ulmus davidiana* and *Pterocarya rhoifolia* originating in Canada and USA (isolated bark and objects made of bark)
Phytosanitary certificates are required for some isolated bark from Canada and USA of (Annex XI of (EU) 2019/2072 (EU, 2019)): Conifers (Pinales), *Quercus suber*, *Fraxinus*, *Juglans*, *Pterocarya, Ulmus davidiana* and *Betula.*
A number of emergency measures make requirements that would apply for some hosts from the USA and Canada, such as for: • *Anoplophora glabripennnis* (Commission Implementing Decision 2015/893). • *Phytophthora ramorum* (Decision EU 2002/757). • *Fusarium circinatum* (Commission Implementing Decision 2019/2032).

8.1.6 Contaminated commodities

Table 9. Contaminated commodities

Pathway 6	**Contaminated commodities: pests associated with commodities of non-hosts, wood packaging material and containers, conveyances (vehicles and machinery), and commodities made of any material likely to be stored outside.**
Coverage	All commodities made of any material likely to be stored outside prior to export e.g.: • Plants for planting, cut branches and wood of non-hosts. • Pallets, dunnage, containers etc. moving in trade. • New or used vehicles and machinery traded as such.
Plants covered	All non-host plant species that may carry the pest as a contaminating pest in the commodities wood, plants for planting and cut branches if produced/stored within crawling distance of the mature larvae. Not relevant for the other commodities.
Pathway prohibited in the PRA area?	No.
Pathway subject to phytosanitary measures, including inspection at import?	Partly. For example, in the EU, general requirements for plants for planting and cut branches of all plant species apply also here (see pathways 1 and 2). To non-host species, other requirements that affect the likelihood of the pest being associated with commodity and detection of the pest may apply. In international trade, wood packaging material must be treated according to ISPM 15 (FAO, 2018b). In the EU, consignments are inspected randomly to check compliance with ISPM 15. However, as the ISPM 15 treatments are applied only once, re-infestation is possible. Machinery and vehicles which have been operated for agricultural or forestry purposes from Canada and USA are required to carry a Phytosanitary certificate and an official statement that machinery or vehicles are cleaned and free from soil and plant debris when introduced into the EU (Annex VII of (EU) 2019/2072 (EU, 2019)).
Pest already intercepted?	No. No interceptions reported for the EU on this pathway. Egg masses of the related species *Orgyia thyellina* have been intercepted at the border of New Zealand on imported used vehicles (Armstrong *et al.*, 2003; MAF Biosecurity New Zealand, 2008). *O. thyellina* has both flight-capable and flightless females depending on the season (i.e. photoperiod). Larvae of flightless females are reported to more commonly spin their cocoons (and after pupation lay the eggs on the cocoon) on inanimate objects, while flight-capable females more commonly spin their cocoons on foliage (Kimura & Masaki, 1977; MAF Biosecurity New Zealand, 2008).
Most likely stages that may be associated	Egg masses, pupae and adults.

Important factors for association with the pathway	**Egg masses and pupae** can be present in protected sites of the commodities, especially in case of high larval density (see section 2.2), since mature larvae crawl in search of protected sites to spin their cocoons and pupate. Young larvae may end up on non-host commodities due to ballooning but are not expected to remain associated. **Adult females** can be present on or near their own pupal cocoons. However, females die shortly after laying eggs and the adult males are attracted to the female cocoons only for mating. Spinning on other substrates than plants is expected to happen more in case of high larval density or low host availability. It is unknown how common this is and whether the pest is more likely to be associated with some of these other substrates. Factors affecting the association with the pathway at the point(s) of origin: • The pest can be associated with the pathway when commodities are stored outdoors close to infested host plants at the time when mature larvae crawl and search for sites to spin their cocoons and pupate. Cocoons have been reported from furniture stored outside, stored boats, houses etc. The commodity must be within crawling distance of the mature larvae, which is not known. • Pupae are present for a couple of weeks. Should a female emerge and mate, eggs could be present together with the cocoon. • Spinning cocoons on such materials is more related to abundant populations. Factors affecting the likelihood of detecting the organism during inspection or testing at the point(s) of origin: • Cocoons with pupae, females or egg masses would be visible but presumably difficult to detect if present in a protected site of the commodities. Species identification of egg masses may require DNA based diagnostic methods (Armstrong *et al.*, 2003).
Survival during transport and storage	Eggs and pupae would survive during the transport provided the substrate is not subject to further treatment.
Trade	No trade data was sought, but very large quantities of wood packaging material and other commodities are expected to be moving in trade from Canada and USA.
Transfer to a host	Arrival of a single egg-mass (up to 500 eggs/egg mass) in the PRA area may be sufficient to facilitate transfer to a host, if it ends up in a site with high density of suitable host plants. Transfer would require certain circumstances, i.e. that the commodities are kept outdoors in an area where host plants are present and during a time period when conditions are suitable for egg development and host foliage is available. Hatched larvae would use 'ballooning' to disperse, but only if located on the outside of the commodity, and hosts are widely distributed in the PRA area. Despite that, young larvae might often die due to failure to find a suitable host. Presumably young larvae could also crawl but the distance is not known, and expected to be rather short. Several individuals should arrive together at about the same development stage, so that the emerging adults can eventually mate. If the pest arrives as pupae, since the emerging female adults cannot fly, the pest transfer would require certain circumstances, i.e. the female and male pupae need to arrive at the same time at the same destination to mate. The laid eggs must be able to develop and larvae emerge at an appropriate time for survival and be able to further balloon to suitable hosts. In places where used wood packaging material is collected in large quantities (e.g. for recycling), the probability of having several infested items is increased. If pupae are present and adults emerge, this would increase the likelihood of females being mated and laying eggs.

Likelihood of entry and uncertainty	The EWG concluded that there is not enough information to rate this pathway, nor to identify some commodities that may be present a higher likelihood of association. The EWG noted that the likelihood of entry would be highest from areas where the pest density is high.

8.2 Unlikely pathways: very low likelihood of entry

For the pathways below, uncertainty is low except if otherwise specified.

- **Pathways rated with a very low likelihood of entry in section 8.1** (see details in tables): sawn wood with bark of other hosts (low uncertainty); round wood and sawn wood without bark (low uncertainty), cut branches (incl. Christmas trees) of other hosts (moderate uncertainty); isolated bark of other hosts (high uncertainty).
- ***Fragaria* plants for planting.** *Fragaria* is listed amongst main hosts, because outbreaks of *O. leucostigma* have been reported from commercial strawberry productions according to Belton (1988). *O. leucostigma* is more likely to be associated with woody hosts than herbaceous hosts. In addition, larvae are the most likely stage to be associated, because the pest normally does not spin cocoons on herbaceous plants. Plants for planting of strawberries are often transported and stored as 'frigo plants' at temperatures of –2°C to 2°C (EFSA, 2014) and most of the foliage of the plants are commonly removed prior to the cold storage (Lieten *et al.*, 2005). The latter greatly reduces the likelihood of larvae being present on the plants. In addition, if cocoons were present on the plants, they are unlikely to be on the part of stem that is retained, i.e. very close to the ground.It is unknown if strawberry plants are always transported without foliage. Nevertheless, if foliage is present, only larvae may be present and may be detected.
  Uncertainty: moderate (whether strawberry plants are always transported without foliage).
- **Cut flowers of host plants.** Some plant species used for cut flowers are listed amongst other hosts, e.g. *Iris* sp. and *Rosa* sp. (ANNEX 5, Table 1). Larvae are the most likely life stage associated with cut flowers, but the high quality standard makes it less likely that flowers with feeding damage or larvae present would be dispatched. Larvae are also likely to drop from the cut flowers during sorting and packing and transfer would be difficult if used indoors.
- **Cut foliage of host plants.** Cut foliage originates from non-woody plants (EPPO 2020). Some hosts are herbaceous (amongst 'other hosts') and may be used as cut foliage. The pest is less likely to be associated with herbaceous plants than with woody plants. Larvae are the most likely life stage associated. They are likely to drop from the cut foliage during sorting and packing. Cut foliage is likely to be used indoors, and transfer would be difficult.
- **Fruit of *Vaccinium* and of other hosts.** Larvae are normally unlikely to remain on blueberries, but may accidentally be collected together with fruits. Such association has been reported to occur during mechanical harvesting of blueberries when larval population density is high (Isaacs & van Timmeren, 2008; 2009). The high quality requirements for blueberries would affect the likelihood of larvae remaining after sorting and packing. Any young larvae still associated with the fruits are unlikely to survive. There is no evidence that they could survive feeding on fruit. Mature larvae are more likely to be detected (due to their large size) but may spin their cocoon on packaging material. Other life stages are not associated. Although there are fruit trees on the host list, there is no evidence for association with the fruit.
- **Seeds, bulbs, corms, tubers, rhizomes, tissue cultures and pollen of host plants.** None of the life stages of *O. leucostigma* is associated with these organs.
- **Furniture and other articles made of wood of host plants.** The processing of the wood would in most cases involve removing the bark and will efficiently remove any cocoons present. It is considered unlikely that unpacked furniture made of wood is stored outside prior to export.
- **Soil and other growing media (on its own or associated with plants for planting of non-hosts).** None of the life stages of *O. leucostigma* is associated with soil or growing media.
- **Intentional human assisted movement of individuals, e.g. exchange or trade by collectors and researchers.** Specimens of *O. leucostigma* may be traded between hobby entomologists, but presumably once dead. Live insects for research purposes may be circulated (Wilstermann & Schrader, 2018), but are likely to be studied only in laboratories in conditions that prevent transfer. It may be interesting to note that laboratory reared specimens of *O. leucostigma* can be ordered for research purposes from the Canadian Forest Service (https://www.nrcan.gc.ca/science-and-data/research-centres-and-labs/forestry-research-centres/great-lakes-forestry-centre/insect-production-and-quarantine-laboratories/13467).
- **Natural spread.** The occurrence of *Orgyia leucostigma* is limited to North America and it cannot spread naturally to the PRA area.

8.3 Overall rating of the likelihood of entry

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

9. Likelihood of establishment outdoors in the PRA area

Orgyia leucostigma is an endemic species in the eastern part of North America. The pest has not been recorded as being established outside of North America. Within its native range the pest occurs in different types of climates and environments feeding on many different plant species including both deciduous and coniferous trees and bushes, herbaceous plants and weeds.

9.1 Climatic requirements

***Orgyia leucostigma* has one to three generations per year, depending on the geographical location and climate variation (see section 2.2).**

Isaacs and van Timmeren (2009) determined that about 2000 GDD (growing degree-days for a base of 12.8 °C) were needed for the development of two generations of larvae in the Great Lakes region, southwest Michigan USA, during 2005, 2006 and 2007, with a 1 March start date. The first-generation larvae were observed in the two first weeks of May emerged from overwintering egg masses at 205.7 ± 2.8 GDD and second-generation larvae were observed in the two last weeks of July emerging at 1157.0 ± 52.3 GDD for a base of 12.8 °C. Wilson (1991) detected a single generation in southwestern Michigan from 1978 to 1981. The voltinism of *O. leucostigma* may vary within a small geographic area due to the variation in GDD accumulation with proximity to Lake Michigan. In the PRA area, 2000 GDD is only achieved in the southernmost areas based on temperature data for 1960–1990 (ANNEX 8, Figure 1). Note that based on the same temperature data 2000 GDD is not achieved in Michigan or in eastern USA and southern Canada where *O. leucostigma* subsp. *intermedia* has been reported to have two generations (Ferguson, 1978).

Comparing the maps of degree days for North America and Europe (1960-1990), there are areas in the EPPO region with similar annual GDD than where *O. leucostigma* completes at least one generation in North America (e.g. Nova Scotia, in the range 400-600 GDD and above) (ANNEX 8, Figure 1). The specific factors influencing multivoltinism are currently unknown for *O. leucostigma*.

There are 18 Köppen-Geiger climatic types in the USA states and Canadian provinces where *O. leucostigma* is reported to be present (ANNEX 8, Figure 2). These climate types also cover most of the PRA area (ANNEX 8, Figure 1). However, in some of the USA states (e.g. Colorado, Kansas, Nebraska and New Mexico) and in the Canadian provinces, the distribution of *O. leucostigma* is localized and hence the pest is not likely to occur in all the climate types present in these regions.

In the iNaturalist database (iNaturalist 2020), *O. leucostigma* is reported from specific locations, within the USA states and Canadian provinces where it is known to be present, from the following seven Köppen-Geiger climatic types: Am, Aw, Cfa, Cfb, Dfa, Dfb, Dfc (ANNEX 8, Figure 3). Of these, five occur in the PRA area, with Cfb prevailing in western and central Europe, and Dfb and Dfc prevailing in Scandinavia and Russia (except Russian Far East) (ANNEX 8, Figure 3). None of the climate types occur in the southernmost Europe, in North African countries or in most of Central Asia (ANNEX 8, Figure 3). It should also be noted that only a few of the iNaturalist occurrence records were from areas with the climate types Am, Aw and Dfc (ANNEX 8, Figure 3).

There are 12 plant hardiness zones (1–12) in the USA states and Canadian provinces where *O. leucostigma* is reported to be present (ANNEX 8, Figure 4). These zones cover most of the PRA area (ANNEX 8, Figure 3). All observation points of *O. leucostigma*, within the USA states and Canadian provinces where *O. leucostigma* is known to be present, recorded in the iNaturalist database (iNaturalist, 2020), occur in plant hardiness zones

2–11 (ANNEX 8, Figure 5). In the PRA area, these zones occur throughout Europe, North Africa and Central Asia, but not in the Asian part of Russia (ANNEX 8, Figure 5).

No information was found on the cold tolerance of *O. leucostigma* or the effect of humidity and other climatic factors on the development of the pest. Because *O. leucostigma* is highly polyphagous and suitable host plants occur throughout North America, the distribution limits of the pest may be related to unsuitable climatic conditions or other environmental factors rather than to the lack of host plants. Various environmental factors including humidity may influence the range of *O. leucostigma*.

In summary, the climatic conditions appear to be suitable for *O. leucostigma* in a large part of the PRA area at least from temperate oceanic Europe to Russia (ANNEX 8. Figure 3). Due to lack of information on cold tolerance, there is some uncertainty regarding the northern limit of the potential establishment of the pest in Scandinavia and northern Russia. There is also an uncertainty regarding the effect of humidity on the development of the pest, and whether dry areas of the EPPO region (Mediterranean area and southern part of the region) would be suitable. The number of generations the pest could have in different parts of the PRA area is unknown.

9.2 Host plants in the PRA area

***Orgyia leucostigma* is a highly polyphagous pest recorded on more than 160 plant species from 122 genera belonging to 59 families (section 7; ANNEX 5, Table 1). Its host plants include both deciduous and coniferous trees, as well as bushes and herbaceous plants.** The high diversity of host species appears to be linked to a tolerance to various defensive compounds of plants (Schowalter, 2018 and references therein).

The host plants of *O. leucostigma* occur throughout the PRA area as native or introduced species, in different environments including orchards and gardens (fruit trees and ornamentals), urban areas (ornamentals), forests and plantations, in the wild and as weeds. All the host plants on which *O. leucostigma* is commonly found in its native range and which also occur in the PRA area are listed in Table 10. Some of these, such as *Acer platanoides*, *Malus domestica*, *Prunus cerasus*, *Prunus domestica*, *Pyrus communis* and *Quercus rubra* are widespread in the PRA area (ANNEX 6).

Because *O. leucostigma* is highly polyphagous and tolerant to various defensive compounds, it might be able to find other suitable hosts in the PRA area. Particularly Eurasian plant species from genera that include suitable hosts for the pest in North America could potentially become hosts in the PRA area. The pest could find suitable hosts e.g. in the genera *Acer*, *Alnus*, *Betula*, *Fagus*, *Larix*, *Picea*, *Pinus*, *Populus*, *Prunus*, *Quercus*, *Rosa*, *Rubus*, *Salix*, *Tilia*, *Ulmus* and *Vaccinium*, which are all widespread in the PRA area. Nevertheless, not all plants are expected to be a source of suitable food. Tallamy *et al.* (2010) reared larvae of *O. leucostigma* in the laboratory on 20 non-native species of plants and found no surviving larvae on 10 of them.

Table 10. Plants that are common hosts of *Orgyia leucostigma* or for which impact has been recorded in its native range and that occur in the PRA area as native or introduced species (ANNEX 5, Table 1).

Host plant	Status in the PRA area	Habitat or use in PRA area
Abies balsamea	introduced, cultivated	ornamental
Acer negundo	introduced, cultivated	ornamental
Acer platanoides	native in most of Europe, introduced and naturalized in some areas	forest, ornamental
Acer saccharinum	introduced, naturalized, cultivated	ornamental
Aesculus hippocastanum	native in Balkan peninsula, introduced in other areas, naturalized in some parts of Europe, cultivated (large scale in Eastern Europe)	forest, ornamental
Albizia julibrissin	native in Azerbaijan, introduced in some areas	ornamental
Alnus[1]	native	forest, ornamental
Alnus incana subsp. *rugosa*	introduced	ornamental
Betula[1]	native	forest, wood, ornamental
Betula alleghaniensis	introduced	ornamental
Betula papyrifera	introduced	ornamental

Host plant	Status in the PRA area	Habitat or use in PRA area
Catalpa[1]	introduced, naturalized	ornamental
Cercis canadensis	introduced	ornamental
Fagus[1]	native in Caucasus and most of Europe, introduced in some areas	forest, wood, ornamental
Fragaria[1]	native, cultivated	fruit
Juglans nigra	introduced, naturalized, cultivated	wood, ornamental
Larix[1]	native in some areas, introduced and naturalized in some areas, cultivated	forest, wood, ornamental
Larix laricina	introduced	ornamental
Malus[1]	native, cultivated	fruit, ornamental
Malus domestica	introduced, cultivated	fruit, ornamental
Myrica pensylvanica	introduced	ornamental
Picea[1]	native in most of the PRA area, introduced and naturalized in some areas, cultivated	forest, wood, ornamental
Picea glauca	introduced, naturalized, cultivated	forest, wood, ornamental
Picea mariana	introduced, cultivated	ornamental
Pinus strobus	introduced, naturalized, cultivated	forest, ornamental
Platanus[1]	native in Southern Europe and Middle East, introduced and cultivated in some areas	forest, wood, ornamental
Platanus occidentalis	introduced, cultivated	ornamental
Populus[1]	native in most of the PRA area, introduced and naturalized in some areas	forest, wood, ornamental
Populus deltoides	introduced, cultivated	ornamental
Prunus[2]	native in most of the PRA area, introduced in some areas	fruit
Prunus cerasus	introduced, cultivated	fruit
Prunus domestica	introduced, cultivated	fruit
Pyracantha coccinea	native in Southern Europe, Caucasus and Middle East, introduced and cultivated in some areas	ornamental
Pyrus communis	native in most of Europe and Caucasus, introduced in other areas, cultivated	fruit
Quercus[1]	native	forest, wood, ornamental
Quercus alba	introduced	ornamental
Quercus laurifolia	introduced	ornamental
Quercus nigra	introduced	ornamental
Quercus rubra	introduced	wood, ornamental
Quercus virginiana	introduced	ornamental
Rubus[1]	native	fruit
Salix[1]	native in most of the PRA area, introduced, and naturalized in some areas	forest, ornamental
Tamarix gallica	native in Mediterranean basin, introduced and cultivated in some areas	ornamental
Tilia americana	introduced, cultivated	ornamental
Tsuga[1]	introduced, cultivated	ornamental
Tsuga canadensis	introduced, cultivated	ornamental
Triticum [1]	native in Eastern Europe and Asia, introduced in other areas, cultivated	field crop
Ulmus[1]	native in most of the PRA area, introduced and naturalized in some areas, cultivated	forest, ornamental, bonsai
Ulmus americana	introduced	ornamental
Ulmus rubra	introduced	ornamental
Vaccinium[1]	native	fruit
Vaccinium corymbosum	introduced, cultivated	fruit
Zea mays	introduced, cultivated	field crop

[1] There is no information on which species the pest was recorded.
[2] Refers to 'cherry', listed as host plant in Dedes (2014).

9.3 Biological considerations

Female adults of *O. leucostigma* lay 150–500 eggs in a single froth-covered mass (Belton, 1988; Wilson, 1991; Hall & Buss, 2014 and references therein). Arrival of a single egg mass or a fertile female in the PRA area may be sufficient for the pest to establish if it ends up in a site with high density of suitable host plants. High density of host plants is a prerequisite for a small population to establish, because young larvae often die due to failure to find a suitable host during ballooning dispersal (Medina & Barbosa, 2002; Schowalter 2018, and references therein). Further, not all eggs will hatch, as eggs may contain a dry larva or be unfertilized or parasitized (Ezzine *et al.* 2015). In fact, a study on egg mortality conducted on the species *O. trigotephras* (from 2005 to 2017) showed that up to 40 % of eggs were dead (Ezzine, pers. comm.).

Females of *O. leucostigma* cannot fly. It has been suggested that this trait increases the likelihood that localized populations after an entry manage to establish. Although the ability to fly may assist in finding suitable host plants, flightless individuals may be at an advantage when the initial populations are small because mating success is more likely when offspring stay relatively close to the location of the egg mass from which they originate (Robinet & Liebhold, 2009). This hypothesis is supported by the fact that there are many examples of populations of *Lymantria dispar* with flightless females that have established but there are no examples anywhere in the world of populations with flight-capable females that have managed to establish (Robinet & Liebhold, 2009).

It is not expected that natural enemies could prevent establishment of *O. leucostigma* despite the fact that several natural enemies or related species that have been shown to regulate populations of *O. leucostigma* in North America (see section 2.4) are present in the PRA area, e.g. *Polistes* wasps, the fungus *Entomophaga aulicae* (Boyd, 2020) and nucleopolyhedrosis virus (CABI, 2020d). Of the other natural enemies of *O. leucostigma* listed by CABI (2020a), the following are widespread in the PRA area: *Bacillus thuringiensis* subsp. *kurstaki*, *Cotesia melanoscela*, *Glyptapanteles porthetriae*, *Haematonectria haematococca*, *Hyposoter fugitivus* and *Ooencyrtus kuvanae*.

There is no evidence indicating that establishment in the PRA area could be prevented by competition from *Orgyia* species that are present in the EPPO region. Of these, *O. antiqua* is widely distributed in Europe and is present also in Canada and USA, where it is often found in the same areas as *O. leucostigma* (Natural Resources Canada, 2020b). The larvae of both species feed on deciduous and coniferous woody plants and herbs, but *O. leucostigma* is far more polyphagous. Other widely distributed *Orgyia* species in the PRA area are *O. antiquioides* and *O. recens* (de Jong *et al.*, 2014). The other native *Orgyia* species in the PRA area, such as *O. aurolimbata*, *O. corsica*, *O. dubia*, *O. josephina*, *O. rupestris*, *O. splendida* and *O. trigotephras* (de Jong *et al.*, 2014) have a more localized range and are less polyphagous than *O. antiqua*.

9.4 Overall rating of the likelihood of establishment outdoor

Host plant availability and environmental conditions in part of the EPPO region are comparable with the current range, and are therefore considered suitable for the establishment of the pest. No known biological factor would prevent its establishment.

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

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

There was no evidence or records of infestations in protected conditions in the native range.

Orgyia leucostigma is mainly a pest of woody plants, which are normally not grown under protected conditions in the PRA area. However, bonsais, fruit trees or fruit bushes and ornamental plants may be grown in protected conditions. There is also a limited cultivation of trees for forestry and fruit production in protected conditions. Young plants may also be grown in protected conditions. All hosts may also be grown in protected conditions in botanical gardens.

In order to establish under protected conditions, there should be host plants remaining in the facility over years. This may be the case especially for some fruit hosts. *O. leucostigma* has caused outbreaks in *Vaccinium* crops in North America, in situations where larval abundance is high, and *Vaccinium* may be grown under protected conditions in the EPPO region.

Fragaria (main host) are also commonly grown in protected conditions in the EPPO region, and there might be overlapping *Fragaria* crops in facilities, which would ensure that plants are available all year-round in the facilities (e.g. Huelva, Spain). However, O. *leucostigma* is more likely to be associated with woody hosts than herbaceous hosts. It is not clear if such crops could support larval development and pupation, and subsequent generations under protected conditions. *O. leucostigma* may have transient populations in such crops, without establishing.

The abiotic conditions in protected conditions are likely to be suitable for the pest. However, normal general practices under such protected cultivation are expected to prevent establishment of the pest. The larvae feed on the fresh foliage of the host plants. Numerous holes appearing in young leaves are usually the first sign of an infestation, with larvae highly visible on the leaves. Nursery plants are, compared to wild hosts, generally smaller and more frequently inspected, and thus damage is expected to be detected earlier, which increases the likelihood that the pest will be eliminated.

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

11. Spread in the PRA area

11.1 Natural spread

***Orgyia leucostigma* females cannot fly but the first instar larvae can spin a silken thread which can be carried off by air currents (‘ballooning’) and the mature larvae can also crawl (section 2.5).** It is expected that the ballooning distance by *O. leucostigma* might be similar to that of *O. pseudotsugata* (i.e. most larvae would generally not disperse more than 200 m). Natural spread in the PRA area would be favoured by the fact that many host species are widespread in the EPPO region (ANNEX 6), but still relatively limited due to the inherent restrictions of the available modes of dispersal, i.e. ballooning and crawling (section 2.5).

11.2 Human assisted long-distance spread

***Orgyia leucostigma* could spread over long distances as larvae or cocoons with pupae or egg masses via transportation of infested plants for planting, above-ground fresh plant parts (e.g., Christmas trees), wood, bark, and as a contaminant (e.g. on wood packaging material, outdoor furniture, used vehicles - see section 8.1).**

There is a large trade of woody plants for planting within the PRA area. Within the EU, according to EU Regulation 2016/2031, a plant passport is required for all plants for planting (excluding seeds), implying inspection at the place of production. However, infestation may not be detected until significant symptoms appear, and egg masses may be missed if they are covered with leaves. Egg masses glued onto the female pupal cocoon are most visible during the winter on bare twigs, trunks or in bark crevices.

Mature larvae of *O. leucostigma* spin their cocoons and pupate in protected locations, on the underside of twigs and branches or on the stems of host trees, but it can occur (during outbreak) on other objects (Embree *et al.*, 1984; Foltz, 2006; Hall & Buss, 2014 and references therein; see section 2.2). Egg masses of tussock moths (including *Orgyia* species) have been intercepted at the border of New Zealand on imported used vehicles (Armstrong *et al.*, 2003; MAF Biosecurity New Zealand, 2008). Young larvae hatching from egg masses on non-host commodities may reach a suitable host plant by ballooning as host plants are widely present, but inherent restrictions of the dispersal (section 2.5) are assumed to negatively affect the rate of spread.

11.3 Stratified dispersal

The coupling of stochastic long-distance dispersal and continuous short-distance dispersal events leads to "stratified dispersal" where populations ahead of the invading population gradually expand and coalesce with the main population front. Stratified dispersal may include movement of plants, plants parts and other objects that may contain any life stage of a given species, dramatically increasing the radial expansion rate. There is no data regarding stratified dispersal for *O. leucostigma*. Spread due to stratified dispersal has been estimated for *L. dispar* to exceed 20 km per year (Tobin *et al.*, 2007; Sharov & Liebhold, 1998). By natural dispersal, the area behind the population front will be colonized.

11.4 Overall rating of the magnitude of spread in the PRA area

Natural spread was rated as low (i.e. between 10 m and 1 km per year according to the EPPO PRA guidance). Human-assisted spread would be the main mode of long-distance spread. Nevertheless, if new infestations are detected early, measures may be put in place and would limit further spread. The magnitude of spread was therefore rated as moderate.

Uncertainty: role of human-assisted spread, association with various commodities and as a contaminant, whether the pest will be detected before it can spread further, whether phytosanitary measures can be taken before the rate of spread increases.

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

12. Impact in the current area of distribution

***Orgyia leucostigma* has a wide distribution in the eastern parts of USA and Canada. The review of the impact of this pest provided below shows that outbreaks are mainly reported from the north-eastern USA and eastern Canada**, i.e. from Nova Scotia, Newfoundland, Quebec, Ontario, New Brunswick, Prince Edward Island, Newfoundland and Labrador as well as from Michigan. **Further west and further south the impact appears to be less severe, i.e. based on reports of impact from Manitoba, Ohio, Iowa and Florida**. For example, in Ohio, *O. leucostigma* is considered to have the potential to cause widespread outbreaks but high populations are reported to most often be extremely localised and the outbreaks are usually single-season events (Boggs, 2019) and then subside in one or two additional seasons (Wilson, 1991 and references therein).

It is not known if outbreaks of *O. leucostigma* are cyclic or irruptive (Schowalter, 2018), but they are reported to occur periodically, at least in northern USA and in Canada (van Frankenhuyzen *et al.*, 2002; Taylor *et al.*, 2020). Temperature, food availability and natural enemies are suggested as factors acting on population density (Schowalter, 2018). Regions and/or years with higher temperatures are associated with increased growth rates, e.g. the pest is bivoltine rather than univoltine (Section 2.2). Reynolds *et al.* (2007), found that the abundance of Lepidopteran caterpillars in northern hardwood forests in New Hampshire were positively correlated with summer thermal accumulation (and were uncorrelated or negatively correlated with minimum winter temperatures and host tree growth), but the specific mechanisms were not elucidated. Mortality due to disease and predators may be high (Wilson, 1991) and diseases have been associated with the termination of outbreaks (Embree *et al.*, 1984; Thurston, 2002; van Frankenhuyzen *et al.*, 2002). But infection rates may vary depending on time and location (van Frankenhuyzen *et al.*, 2002).

No record of *O. leucostigma* as a pest in Cuba was found (see section 6).

12.1 Economic impact (sensu-stricto)

12.1.1 Forest and shade trees

In forests, when conditions are favourable, *O. leucostigma* outbreaks can develop rapidly (Wilson, 1991). These outbreaks generally last from one to four years and are usually regulated by natural enemies, mainly a virus-induced disease in the larvae (Embree *et al.*, 1984; Thurston, 2002).

***Orgyia leucostigma* is capable of defoliating large areas of hardwood and softwood forests (Embree *et al.*, 1984; Magasi, 1995; Crozier, 1997; Thurston, 2002). Mature larvae can severely damage conifers when other host plants already have been defoliated** (Hudak & Raske, 1995; Magasi, 1995).

The insect can kill coniferous trees after a single year of severe defoliation (Magasi, 1995), whereas Dedes (2014) reports that repeated years of defoliation in excess of 90% results in significant wood loss and ultimately tree mortality. Top-kill may occur on trees that have undergone 75% defoliation for two or more consecutive years (Thurston, 2002; Dedes, 2014).

O. leucostigma also appears to commonly occur as a pest of ornamental plants in gardens and landscapes (e.g. Baker, 2017; Barrett & Kroening, 2003; Foltz, 2006; University of Minnesota Extension, 2020).

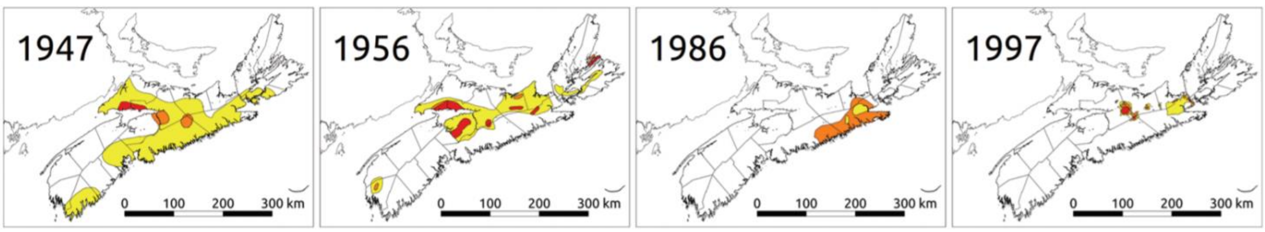
The review of economic impact below shows that a wide range of tree species have been defoliated during *O. leucostigma* outbreaks, i.e. *Abies balsamea*, *Betula papyrifera*, *Alnus incana* subsp. *rugosa*, *Juglans nigra* and, reported at the genus level, *Alnus* sp., *Acer* sp., *Larix* sp. and *Populus* sp. Among the hardwood species, especially *Acer* sp., *Betula* sp., *Platanus* sp. and *Populus* sp. are attacked (Barnd, 2008). **The information about the impact is described separately for Canada and USA since the damage levels reported from USA is so much lower**.

Canada

Outbreaks of *O. leucostigma* are reported to occur in Atlantic Canada (New Brunswick, Nova Scotia, Prince Edward Island, Newfoundland and Labrador) about every 9 years, with major outbreaks occurring every 20 years (Thurston, 2002). The first recorded outbreak in the Maritimes (New Brunswick, Nova Scotia, and Prince Edward Island) was in 1937. Since then, localized outbreaks have been recorded almost every year (Natural Resource Nova Scotia, 1997). In New Brunswick and Nova Scotia, severe outbreaks were observed from 1975 to 1978 (Magasi, 1995). In the Prairie Provinces (i.e. in Alberta, Saskatchewan, and Manitoba), the pest has not been found to cause any discernible damage (Ives & Wong, 1988). Note that *O. leucostigma* is unlikely to be present west of Manitoba.

In Nova Scotia, in 1998 an outbreak caused defoliation over 500 000 ha of forests consisting of balsam fir (*Abies balsamea*) but also *Alnus* sp., *Acer* sp., *Larix* sp. and *Populus* sp. (Thurston, 2002; van Frankenhuyzen *et al.*, 2002). Severe defoliation was first recorded in approximately 250 ha in 1996. The area that was severely defoliated increased rapidly to 19 000 ha in 1997 and to about 230 000 ha in 1998, after which it sharply declined to about 4700 ha in 2000 and to 0 ha in 2001. During this outbreak, about 60 000 ha were treated with aerial application of *Bacillus thuringiensis* subsp. *kurstaki* at a cost of approximately 6 million Canadian dollars making it the largest treatment program against this pest (Nova Scotia Department of Natural Resources, 2015). Since then, two small outbreaks have occurred in Cape Breton in 2005 and Guysborough in 2007 (Nova Scotia Department of Natural Resources, 2015).

Taylor *et al.* (2020) provide a list and maps of some of the significant forest disturbances caused by *O. leucostigma* in Nova Scotia (Figure 3; Table 11).



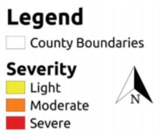


Figure 3. Examples of the extent and severity of damage caused by *Orgyia leucostigma* in Nova Scotia for some selected years (From Taylor *et al*., 2020, CC BY 4.0).

Table 11. Significant forest disturbances caused by *Orgyia leucostigma* in Nova Scotia (Taylor *et al.*, 2020).

Year	Forest disturbance
1948	*O. leucostigma* caused heavy damage to 15 000 ha in Colchester County
1954	*O. leucostigma* attacked hardwood stands in northern Cape Breton
1974	Severe widespread defoliation from *O. leucostigma* in 1974–1977*
1996	*O. leucostigma* defoliation of 590 910 ha of balsam fir forests 1996–2000 in Halifax, Hants, Cumberland, Colchester, Pictou, Antigonish, and Cumberland counties
1997	Increasing populations of *O. leucostigma* were detected in the Cape Breton Highlands
2013	*O. leucostigma* caused pockets of defoliation of in total approximately 100 ha

** According to Magasi (1995) severe defoliation occurred on in total approximately 500 000 ha in Nova Scotia and 250 000 ha in New Brunswick.*

In Newfoundland, *O. leucostigma*, rarely reaches outbreak levels (Magasi, 1995). In 1985–86 in western Newfoundland about 100 ha of white birch (*Betula papyrifera*), speckled alder (*Alnus incana* subsp. *rugosa*), and other hardwoods were severely defoliated (Clarke & Carew, 1986). Further, a small area planted with black spruce (*Picea mariana*) was also severely damaged. Interestingly, from a host preference perspective, only light damage was recorded on balsam fir (*Abies balsamea*) and white spruce (*Picea glauca*).

Orgyia leucostigma has caused occasional but sometimes severe attacks on yellow birch (*Betula alleghaniensis*) in Fundy National Park, New Brunswick, Canada (Titus, 1987). The outbreaks in the park were brought under control by natural factors.

To put the recorded impact of *O. leucostigma* in Canadian forests into perspective, it can be noted that there are at least 15 forest insect pests that cause more damage (based on data from yearly estimates of areas damaged between 1990–2018; Canadian Council of Forest Ministers, 2020).

Belton (1988) reports about an outbreak in shade trees in the early 1900 in Quebec (no details were provided).

USA

For the USA, major outbreaks such as those in Nova Scotia (Canada) have not been documented. According to Drooz (1985) and Furniss & Carolin (2002), *O. leucostigma* only cause minor damages in forested areas. In Michigan, 5% defoliation of individual trees each year were recorded in a four year field study of an *O. leucostigma* population in a black walnut (*Juglans nigra*) plantation (Wilson, 1991). *O. leucostigma* is recorded as a common species of temperate forests in Pennsylvania and throughout the eastern USA, but is not a serious defoliator (Keating *et al*., 2013).

Many US publications refer to *O. leucostigma* as a tree pest, without much detail. In Florida, the larval feeding usually has little impact to large trees, but they may defoliate small trees and shrubs in the vicinity (Foltz, 2006; Hall & Buss, 2014 and references therein). In Iowa, *O. leucostigma* generally does not cause wide-scale defoliation (Iowa tree pests, 2020). In Ohio, *O. leucostigma* outbreaks are most often extremely localized and they are usually single-season events (Boggs, 2019). The same author reports a case where an outbreak of *O. leucostigma* in Ohio caused 100% defoliation in an area with landscape redbud trees (*Cercis canadensis*). Maier *et al*. (2004), dealing with northeastern USA, recorded that during outbreaks, larvae of *O. leucostigma* have damaged balsam fir and other conifer plantations.

An old publication states that *O. leucostigma* is a common pest of amenity trees in the eastern USA, frequently causing much damage in states east of the Mississippi river (Webster, 1916). In Iowa, numerous reports of abundance of *O. leucostigma* were registered in 1916 (Webster, 1916), while the pest seldom caused such notice. Howard (1896) records *O. leucostigma* as a defoliator of urban trees. Howard (1897) note that prior to the 1870s *O. leucostigma* was primarily a pest in orchards, but it later became more prevalent on urban trees.

12.1.2 Christmas tree plantations

In Canada, *Orgyia leucostigma* is particularly devastating to Christmas tree plantations of balsam fir (*Abies balsamea*), where defoliation can lead to a total crop loss in one year, and the presence of egg masses results in unmarketable trees (Embree *et al.*, 1984; Thurston, 2002). The insect may become a major economic factor in Christmas tree areas, even at relatively light infestations, causing degrade of the trees (Magasi, 1995). Outbreaks also occur in plantations of other conifers (Thurston 2002; Maier *et al.*, 2004).

12.1.3 Fruit production

Orgyia leucostigma* outbreaks in blueberry (*Vaccinium* sp.) fields in Nova Scotia (Canada) and Michigan (USA), result in significant crop losses as the larvae can completely defoliate almost all plants in large portions of a field** (Crozier, 1997; CABI, 2020a). In blueberry fields, growers may experience damaging levels of leaf loss on young bushes and in mature fields, the quality of the mechanically harvested crop can suffer from the presence of the pest individuals (Isaacs & van Timmeren, 2008; 2009). The defoliation damage in blueberry fields takes place at a critical time of development in both crop and sprout fields and severe damage in either part of the rotation could affect growth the following year (Crozier, 1997). **According to Crozier (1997), outbreaks of tussock moths in blueberry fields occur very sporadically (about every twenty years in Nova Scotia, Canada) and usually last for two to three years. Accordingly, the blueberry growers in Michigan sporadically experience problems with *O. leucostigma (Szendrei & Isaacs, 2006).

Infestations of blueberry fields in the Great Lakes region (USA) have been found to cause: a) defoliation of the blueberry plants when larvae density is high, even causing young plants to be killed from the loss of leaves; b) significant economic implications for producers due to collection of larvae during harvesting; and c) severe tussockosis (i.e. allergic reaction) in blueberry pickers (Isaacs & Van Timmeren, 2009; Retamales & Hancock, 2012).

In apple orchards in Ontario, *O. leucostigma* is considered a rare pest (Ontario Apple IPM, 2009). One publication (Belton, 1988) reports *O. leucostigma* as a serious defoliator of fruit trees and bushes in the eastern provinces of Canada, e.g., apple (*Malus*), pear (*Pyrus*), plum (*Prunus*), strawberry (*Fragaria*), raspberry (*Rubus*) blueberry and cranberry (*Vaccinium*). Belton (1988) reports several historical outbreaks on crops: a) 1870 – apple (*Malus* sp.) in Ontario; b) 1930 and 1970 – strawberry (*Fragaria* sp.) in Prince Edward Island; c) 1950 – blueberry (*Vaccinium* sp.) in Nova Scotia (in some fields the entire crop was lost); d) in one case complete defoliation in 1.6 ha of two-year old apple stock in Ontario (the year of this outbreak is not mentioned in the text). No further details about this were found.

In the USA, an old publication notes that *O. leucostigma* was prior to the 1870s mostly known as an occasional defoliator in orchards (especially apple; plum, pear and other bushes and trees are mentioned) but its importance in orchards later decreased (Howard, 1897).

12.2 Environmental impact

During severe outbreaks, larvae of *O. leucostigma* cause large-scale severe defoliation as the outbreaks observed in Nova Scotia from 1975 to 1978 up to 345 000 ha (Magasi, 1995) and in 1998 of over 500 000 ha of forests, of which about 230 000 ha were severely defoliated (Thurston, 2002; van Frankenhuyzen *et al.*, 2002). **These severe outbreaks cause considerable changes to forest ecosystems in short time periods** (Taylor *et al.*, 2020).

High levels of tree mortality following outbreaks can result in increased levels of fuel and therefore a high risk of wildfires of greater intensity (as reported for the related species of *O. pseudotsugata* by CABI, 2020b). Defoliation will also result in reduced cone crops which could result in a reduction in the number of wildlife species that depend on conifer seeds as a food source.

12.3 Social impact

In urban and recreation areas the larvae of *O. leucostigma* are a nuisance due to their airborne dispersal 'flights', dropping frass (and themselves) onto people below (CABI, 2020a), and because many larvae spin their difficult-to-remove cocoons on outdoor furniture, stored boats, and the walls and soffits of houses (Foltz, 2006). The hairs of *O. leucostigma* larvae are hollow and contain a toxin that penetrates animal skin (Ontario Apple IPM, 2009). **During the larval feeding, and especially during severe outbreaks, the hairs from their bodies can cause severe allergic reactions, including rashes and anaphylaxis in sensitive people** (Thurston, 2002; Ontario Apple IPM, 2009).

It should be noted that the types of social impact described above are not taken into account in the rating of the impact assessment since only social impact that is a consequence of phytosanitary issues should be considered (FAO, 2019).

12.4 Existing control measures

According to CABI (2020a), control measures in the native range are usually not required since outbreaks are commonly local and brought under control by natural factors, mainly natural microbial enemies (Thurston, 2002). However, extensive spray programs have been used to control outbreaks of *O. leucostigma* in blueberry (*Vaccinium* sp.) plantations (Embree *et al.*, 1984; Isaacs & van Timmeren, 2008) and in forests (Thurston, 2002).

12.4.1 Chemical control

Insecticides for other moth larvae are generally also effective against the young larvae of *O. leucostigma* (Isaacs & van Timmeren, 2008). The following pesticides have been recommended against leaf feeding caterpillars, including *O. leucostigma* larvae: acephate, bifenthrin, carbaryl, chlorpyrifos, cyfluthrin, deltamethrin, esfenvalerate, fluvalinate, insecticidal soap, lambda cyhalothrin, malathion, permethrin, pyrethrins, spinosad, and diflubenzuron (Krischik & Hahn, 2018).

In commercial nurseries of blueberry, preventative chemical management of caterpillar defoliators, including *O. leucostigma*, is seldom required, because the feeding is generally limited to small portions of the canopy on individual plants (Fulcher *et al.*, 2015). Instead, regular scouting is sufficient to enable early detection of caterpillar feeding damage which can be spot-sprayed with insecticides (Fulcher *et al.*, 2015). Insecticides used in blueberry plantations for other pests, such as ‘fruit worms’, blueberry maggot [*Rhagoletis mendax*], and Japanese beetle [*Popillia japonica*], are often able to control *O. leucostigma* (Isaacs & van Timmeren, 2008).

According to CABI (2020a), the best control is obtained when larvae are approximately 12 mm long. Earlier treatments may prove ineffective due to reinvasion by wind-blown smaller larvae. A second spray may be required 7–10 days after the first because of larval drift (ballooning). Small infestations can be treated using portable mist blowers whereas larger infestations may require truck-mounted sprayers or even aerial applications.

12.4.2 Biopesticides

When foliage protection against large scale outbreaks is needed, aerial application of *Bacillus thuringiensis* subsp. *kurstaki* is the most commonly used treatment (Thurston, 2002; Ontario Apple IPM, 2009; Hall & Buss, 2014 and references therein). Products based on *B. thuringiensis* are found to provide good protection when applied against early larval instars at the recommended rate of two applications on 30×10^9 IU ha^{-1} separated by 5 days. Such aerial sprays were used in an attempt to suppress *O. leucostigma* populations during the outbreak in 1998 in Nova Scotia. Thurston (2002) states that the larval mortality was found to be as high as 82% and after-spray defoliation was near zero and suggests that this was because the treatment initiated an epizootic. However, van Frankenhuyzen *et al.* (2002) conclude that the treatment could not account for the collapse since the population collapsed in both sprayed and unsprayed locations. It should also be noted that these types of products do not contribute to long-term population suppression (Thurston, 2002). Nevertheless, aerial and ground application of *Bacillus thuringiensis* subsp. *kurstaki* was used to eradicate *O. thyellina* from 4000 ha after being introduced to Auckland, New Zealand (Hosking et al 2003).

Viral products with the active ingredient *Orgyia pseudotsugata* nucleopolyhedrovirus (OrpsNPV) have been used successfully in both ground and aerial spray trials against *O. leucostigma* (Cunningham & Kaupp, 1995; Thurston, 2002).

12.4.3 Mechanical control

Early control recommendations were to band the trees and to pluck off and burn any twigs with withered leaves, many of which bear egg masses (Webster, 1916; Belton, 1988). The destruction of egg masses was done during the winter as they are conspicuous and may easily be collected by hand (Webster, 1916). However, these methods may not be realistic alternatives for areas of high population densities due to costs associated with labour.

In urban areas, the larvae can be removed from house walls before they have a chance to spin cocoons, or once spun the latter can be removed using rubber gloves (CABI, 2020a). In blueberry plantations, frequent pruning and good weed management reduce the density of *O. leucostigma* (Retamales & Hancock, 2012).

12.4.4 Pheromone disruption

The sex pheromone ((Z)-6-heneicosen-11-one) of *Orgyia pseudotsugata* has been used in pheromone disruption experiments for *O. leucostigma*. For the laboratory-reared adult males, the average disruption was 97.6%, and for the wild populations it was 96-100% (Grant, 1978). However, effects on foliage protection were not quantified. Currently, pheromone disruption is not used for *O. leucostigma* management.

12.5 Overall rating of the magnitude of impact and uncertainty

The EWG decided to rate the magnitude of impact for the current area of distribution as a whole. It is however recognized that (1) There are differences between the data available from Canada and the USA; (2) The magnitude of impact is related to the density of *O. leucostigma* and the availability of host species, and impact is higher in periods when there are outbreaks; (3) Different impact has been reported in different types of environment (e.g. forests, Christmas trees, amenity trees, fruit crops).

There were two main factors for the rating. Outbreaks of economic significance are periodical and there can be many years between severe impact during outbreaks. In addition, populations causing economically-significant damage have not been documented throughout the current range (i.e. not much in the USA), but *O. leucostigma* is still considered a pest throughout its range. If considering only Canada and only outbreak years, impact is higher.

Uncertainty. Situation and impact in the USA, outbreaks are variable based on many biotic and abiotic factors, why impact on fruit trees was reported in the past and not currently.

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

13. Potential impact in the PRA area

There are at least three general factors that would favour a high potential impact in the PRA area, i.e. (1) the climatic conditions appear suitable for the establishment of *O. leucostigma* in a large part of the PRA area (section 9; ANNEX 8) and (2) *O. leucostigma* is a pest of many important host plants that are widely distributed in the PRA area (section 9.2; 12). In addition, *O. leucostigma* is polyphagous and may find new suitable hosts in the PRA area. (3) There may be limited treatment options for parks and recreation areas, and authorization for aerial treatments in forest areas may be difficult to obtain or be subject to derogations.

The potential impact is however also expected to be reduced by two general factors, i.e. (1) some of the natural enemies are widely distributed in the PRA area (section 2.4; 9.3). However, it is not known whether they would regulate populations of *O. leucostigma*, and the same natural enemy complex that exists in North America and regulates populations does not occur in the EPPO region, and (2) some biopesticides are approved for outdoor use at least in parts of the PRA area. For example, *Bacillus thuringiensis* subsp. *kurstaki*, the most commonly used agent for control of *O. leucostigma* populations in its native range, is approved for outdoor use in many countries in the European Union (EU Pesticides database, 2020). Several other insecticidal plant protection products that are recommended against *O. leucostigma* larvae are also approved for outdoor or field use in the European Union (EU Pesticides database, 2020). These are deltamethrin, esfenvalerate, fluvalinate, lambda-cyhalothrin, pyrethrins, spinosad and insecticidal soap (fatty acids C7 to C20 (pelargonic acid (CAS 112-05-0)).

13.1 Economic impact (sensu-stricto)

Orgyia leucostigma is a polyphagous species that has proven to be able to cause damage to several economically important plant species. The main economic impact in the PRA area is expected to be within the following host communities/production sectors.

13.1.1 Forest trees

Orgyia leucostigma can cause severe defoliation in monoculture hardwood and softwood forests, as well as in mixed forests. If severe defoliation during population outbreaks of *O. leucostigma* would occur in parts of the PRA area, aerial spraying with *B. thuringiensis* subsp. *kurstaki*, that was used to control the outbreak in 1998 in Nova Scotia, may be needed. In the European Union aerial spraying with pesticides is prohibited but may be allowed in special cases (Directive 2009/128/EC (EU, 2009)), and for every singular air treatment, permission from the relevant governmental authority is required (Matyjaszczyk *et al.*, 2019).

13.1.2 Christmas tree plantations

The cultivation area for Christmas trees in Europe is 120 000 ha (SDW, 2020). Germany has the largest acreage constituting 25%, of the total area, followed by Denmark with 20%, Poland with 11%, Great Britain with 10% and France with 8% (SDW, 2020). The species cultivated in the PRA area include *Abies nordmanniana*, *Abies procera*, *Abies alba*, *Abies nobilis*, *Abies concolor*, *Abies koreana*, *Picea abies*, *Picea pungens glauca*, *Pseudotsuga menziesii*, and *Pinus sylvestris* (SDW, 2020). Of these *Abies balsamea*, *Picea glauca* and *P. mariana* and *Pinus strobus* are main host plants. *Abies concolor* is listed as a host by Robinson *et al.* (2010), but no reference is given. In addition, it is not excluded that the pest might cause damage on suitable hosts in the genera *Abies*, *Picea* and *Pinus* (in the list of host plants) planted under growing conditions similar to Christmas tree plantations in North America. The market for Christmas trees in Europe is approximately 60 million trees a year (Teagasc, 2006) and, for example, the Christmas tree plantations in Germany generate sales of 700 million Euros per year (SDW, 2020).

If *O. leucostigma* could establish in Christmas tree plantations in the PRA area, its impact may be due to that (1) the pest is able to cause defoliation that can lead to a total crop loss in one year, (2) the presence of egg masses results in unmarketable trees, (3) additional control measures may have to be taken which will increase the production costs (Campbell and Youngs, 1978), and (4) international trade may be influenced because of quarantine pest requirements of importing countries.

13.1.3 Fruit orchards

Several plant species used for fruit production within the PRA area are listed as hosts (ANNEX 6). Impact may occur on *Vaccinium*, as in the USA. There are reports of outbreaks on other fruit crops in the current area of distribution (such as strawberry (*Fragaria*), raspberry (*Rubus*), *Malus domestica* (apple), *Pyrus communis* (pear) and different *Prunus* species). These fruit species are grown throughout the PRA area both commercially and in gardens (ANNEX 6). However, no specific information is available and no data on the potential magnitude of impact. Insecticide treatments applied to control other insect pests could have an effect against *O. leucostigma*.

If *O. leucostigma* is introduced in the fruit production sector, specific control measures may be needed which will increase the production costs. Several of the plant protection products recommended for use against *O. leucostigma* larvae are used in some of the countries in the PRA area, but they would need to be authorized for the control of *O. leucostigma*.

13.1.4 Amenity plantings, private gardens

In its native range of distribution, *O. leucostigma* is often a serious pest of shade and ornamental trees. Larvae can occur at sufficient densities to cause severe defoliation of the trees. Host plants of *O. leucostigma* are widely used as ornamentals in the PRA area (section 9.2). In the PRA area amenity trees or fruit trees in gardens are mostly not treated with pesticides and would therefore be more susceptible to damage.

13.2 Environmental impact

As in North America, outbreaks of *O. leucostigma* may cause large-scale disturbances, especially in ecosystems that are comprised largely of their preferred food source. Some host species, and plants from the same genera as host species, are widespread in the PRA area and attacks on them may have a significant environmental impact.

Two of the host plant species of *O. leucostigma* that are present in the PRA area are in the IUCN Red list (https://www.iucnredlist.org/) as threatened, i.e. *Aesculus hippocastanum* (vulnerable) and *Fraxinus excelsior* (near threatened). In addition, more than 50 'endangered' or 'critically endangered' plant species belong to genera that are in the host range of *O. leucostigma*.

The environmental impact of the similar species with a similar host range and ecology, *L. dispar*, in its introduced range in North America appears to exceed that in its native range in Eurasia (CABI, 2020c). Oaks and other main host trees in North America appear to be more susceptible to defoliation than its native host plant complex, and thus repeated outbreaks have contributed to a regional decline in oaks in eastern North American forests. It is not known if *O. leucostigma* would have similar effects as it has not been introduced outside of its native range.

13.3 Social impact

Many hosts of *O. leucostigma* are used as ornamentals in the PRA area. Their aesthetic value as street trees, in parks, public and private gardens would be impacted.

13.4 Overall rating of the magnitude of impact and uncertainty

The EWG rated the magnitude of potential impact as moderate. Many potentially suitable hosts and a suitable climate are present in the EPPO region. *O. leucostigma* will cause defoliation on suitable hosts in various habitats (such as forests, Christmas trees plantations, amenity trees, private gardens, fruit orchards). In forests, both economic and environmental impacts would be expected. As in North America, there may be fluctuation in impact depending on locations and years. Although, natural enemies are present in the EPPO region, it is not known whether they would regulate populations of *O. leucostigma*. The same natural enemy complex that exists in North America and regulates populations does not occur in the EPPO region.

Uncertainty: whether natural enemies in the EPPO region would regulate populations, whether the same types of large-scale outbreaks as observed in Canada would occur on other hosts.

Rating of the magnitude of impact in the area of potential establishment	Very low ☐	Low ☐	Moderate X	High ☐	Very high ☐
Rating of uncertainty			Low ☐	Moderate ☐	High X

14. Identification of the endangered area

Potential area of establishment. The climatic conditions appear suitable for *O. leucostigma* establishment in a large part of the PRA area, at least from temperate oceanic Europe to Russia (section 9 and fig 3 in ANNEX 8). However, due to lack of data on cold tolerance, there is some uncertainty regarding the northern limit of potential establishment of the pest in Scandinavia and northern Russia. There is also an uncertainty regarding the effect of humidity on the development of the pest, and whether dry areas of the EPPO region would be suitable (Mediterranean area and southern part of the region). The number of generations the pest could have in different parts of the PRA area is unknown.

Endangered area. Eastern and Northern parts of the PRA area. The endangered area is assessed to include areas where the climate is similar to where the pest is known to have caused economic damage in its current area of distribution and suitable hosts are present. *Orgyia leucostigma* is widely distributed throughout the eastern areas of USA and Canada, but outbreaks are mainly reported from the northern USA and Canada, where the climatic conditions are similar to those in Eastern and Northern parts of the PRA area.

15. Overall assessment of risk

Summary of ratings**:**

	likelihood	**uncertainty**
Entry (overall)	**High**	**Moderate**
Plants for planting (except seeds, bulbs, corms, tubers, rhizomes, tissue cultures, pollen) of main hosts (except *Fragaria*, *Zea mays*, *Triticum*)	High	Moderate
Plants for planting (except seeds, bulbs, corms, tubers, rhizomes, tissue cultures, pollen) of other hosts	Moderate	Moderate
Round wood with bark of main hosts	Moderate	Moderate
Round wood with bark of other hosts	Low	Moderate
Sawn wood with bark of main hosts	Low	Moderate
Cut branches (incl. Christmas trees) of main hosts	Low	Moderate
Wood chips, hogwood, processing wood residues (except sawdust and shavings) of hosts	Low	Low
Bark of main hosts	Low	High
Establishment outdoors	High	Low
Establishment in protected conditions	Low	Low
Spread	Moderate	Moderate
Magnitude of impact in the current area of distribution	Moderate	Moderate
Magnitude of potential impact in the PRA area	Moderate	High

The likelihood of entry was rated as high for plants for planting (except seeds, bulbs, corms, tubers, rhizomes, tissue cultures, pollen) of main hosts (except *Fragaria*, *Zea mays*, *Triticum*). It was rated as moderate for plants for planting of other hosts and round wood with bark of main hosts. Other pathways presented a lower likelihood rating (see table above). A moderate uncertainty was associated with most ratings of likelihood. For most pathways, tranfer to a suitable host was the main constraint for entry. Finally, the likelihood of entry as a contaminant on commodities could not be rated.

Hosts are widespread in the EPPO region, and *O. leucostigma* may be able to find other suitable hosts. Suitable climatic conditions exist in a large part of the EPPO region. The likelihood of establishment outdoors was rated as high, and under protected conditions as low, with a low and moderate uncertainty, respectively.

The magnitude of spread was rated as moderate with a moderate uncertainty. Females are flightless, and dispersal occurs primarily by ballooning of young larvae. Human-assisted spread would be the main mode of long-distance spread. Nevertheless, if new infestations are detected early, measures may be put in place and would limit further spread.

Impact in North America was assessed as moderate with a moderate uncertainty. Outbreaks of economic significance are periodical and there can be many years between severe impact during outbreaks. In addition, populations causing economically-significant damage have not been documented throughout the current range, although *O. leucostigma* is still considered a pest throughout North America. If considering only Canada and only outbreak years, impact is higher.

The potential impact (for the endangered area) in the EPPO region was assessed to be moderate with a high uncertainty. Many potentially suitable hosts and climates are present in the EPPO region. *O. leucostigma* could cause defoliation in various habitats (such as forests, Christmas trees plantations, amenity trees, private gardens, fruit orchards). In forests, both economic and environmental impacts would be expected. As in North America, there may be fluctuation in impact depending on locations and years. Although, natural enemies are present in the EPPO region, it is not known whether they would regulate populations of *O. leucostigma*. The same natural enemy complex that exists in North America and regulates populations does not occur in the EPPO region.

Stage 3. Pest risk management

16. Phytosanitary measures

16.1 Measures on individual pathways to prevent entry

The EWG concluded that phytosanitary measures should be recommended for several pathways. Measures were studied for the pathways plants for planting, cut branches (incl. Christmas trees), round wood and sawn wood with bark, and isolated bark (ANNEX 1).

Considering the likelihoods of entry and uncertainties, the EWG recommended that measures should target all woody host species of plants for planting, and main hosts for cut branches (incl. Christmas trees), round wood with bark, sawn wood with bark, and isolated bark. The Working Party recommended to also make a distinction between main hosts and other hosts for plants for planting.

The likelihood of entry on main herbaceous hosts (*Fragaria*, *Zea mays* and *Triticum*) was rated as very low, and is also very low for other herbaceous host species. Measures are therefore recommended only for woody host species.

Possible pathway	Measures identified
Plants for planting (except seeds, bulbs, corms, tubers, rhizomes, tissue cultures, pollen) of main woody hosts. *Note 1*	PFA + when moved outside of the PFA, packing to prevent infestation during storage and transport and keeping packaging free from the pest. Or Pest free production site according to EPPO standard PM 5/8 (complete physical isolation) + packing to prevent infestation during storage and transport and keeping packaging free from the pest. Or Pest free place of production/pest-free production site (visual inspection of the plants throughout the growing period at suitable intervals to detect all life stages and found free from the pest + pheromone trapping and found free from the pest + buffer zone of 1 km around the place of production/production site free from the pest) + visual inspection of the consignment + packing to prevent infestation during storage and transport and keeping packaging free from the pest. *Note 2 & 3.*

Possible pathway	Measures identified
Cut branches (incl. Christmas trees) of main hosts	PFA + when moved outside of the PFA, packing to prevent infestation during storage and transport and keeping packaging free from the pest. Or Pest free production site according to EPPO standard PM 5/8 (complete physical isolation) + packing to prevent infestation during storage and transport and keeping packaging free from the pest. *Note 4* Or Pest free place of production/pest-free production site (visual inspection of the plants throughout the growing period at suitable intervals to detect all life stages and found free from the pest + pheromone trapping and found free from the pest + buffer zone of 1 km around the place of production/production site free from the pest) + visual inspection of the consignment + packing to prevent infestation during transport and storage and keeping packaging free from the pest. *Note 2 & 5*.
Round wood and sawn wood with bark of main hosts	PFA Or Heat treatment according to EPPO Standard PM 10/6(1) *Heat treatment of wood to control insects and wood-borne nematodes* Or Irradiation treatment according to EPPO Standard PM 10/8(1) *Disinfestation of wood with ionizing radiation* Or Bark freedom. *Note 6* Or Debarking + ISPM 28 PT 22 *Sulfuryl fluoride fumigation treatment for insects in debarked wood* or PT 23 *Sulfuryl fluoride fumigation treatment for nematodes and insects in debarked wood*. *Note 6*
Isolated bark of main hosts	PFA Or Chipping to pieces of less than 2.5 cm in any dimension. *Note 7.*

Note 1. NPPOs may decide to implement measures on plants other than main hosts (see Annex 5). These may be either hosts on which the pest can complete its life cycle or plants infested because of dispersing by ballooning events.
Note 2. The choice between pest free place of production and pest free production site is a decision to be taken by the NPPO based on the operational capacities of the producers and biological elements.
Note 3. The feasibility and reliability of visual inspection would depend on the size of plants and on the type of plants. It may be difficult on large plants (e.g. tall nursery plants) and on conifers (dense branches).
Note 4. Not feasible for Christmas trees.
Note 5. The feasibility and reliability of visual inspection would depend on the size of the plants and on the type of plants. It may be difficult on large/tall plants from which cut branches are taken, especially for conifers (for example Christmas tree plantations, or coniferous plantations for the production of cut branches, due to the presence of dense branches). Consequently, this combination may not be relevant for most Christmas trees and cut branches.
Note 6. Definitions in ISPM 5: *Bark-free wood*: Wood from which all bark, except ingrown bark around knots and bark pockets between rings of annual growth, has been removed; *Debarked wood.* Wood that has been subjected to any process that results in the removal of bark. (Debarked wood is not necessarily bark-free wood.).
Note 7. Based on the recommendation of the Panel on Quarantine Pests for Forestry, the chipping size should apply to the three dimensions.

Measures considered by the EWG but not retained at later stages of the PRA development:
<u>Plants for planting</u>
<u>Cut branches (incl. Christmas trees)</u>

- Dormant + visual inspection of all plants for planting/cut branches in the consignment to detect cocoons and egg masses.

The EWG proposed this combination. For cut branches, the EWG did not know if cut branches of some hosts are traded dormant, without foliage. The PPM decided to not retain the combination, because visual inspection of all plants/cut branches in the consignment may not be feasible and reliable for all host species and all plant sizes. It was noted that visual inspection of the consignment is used in another combination of measures, but is combined with other measures that offer additional protection.

- Crop freedom (visual inspection at the place/site of production throughout the growing period at suitable intervals to detect all life stages + pheromone trapping. If the pest is found at visual inspection or trapping: treatment of the crop at the appropriate time) + visual inspection of the consignment + packing to prevent infestation during storage and transport and keeping packaging free from the pest.

The EWG proposed this combination, noting that its applicability would depend on how effective treatments can be at controlling the life stages that may be present. In addition, the EWG expressed the same limitations of visual inspection at the place/site of production as expressed for pest free place of production/pest free production sire (see above, Note 1 for plants for planting, Note 3 for cut branches (incl. Christmas trees)). However, the PPM decided to not retain this combination, because treatment of the crop may not be effective in eliminating all life stages that may be present, nor in all host species, and it does not take into account the risk of reinfestation.

Requirements for establishing a PFA:
PFAs could be established. The EWG noted that the data available are not sufficient to specify the distance between a PFA and the closest area where the pest is known to be present. However, this distance might be rather short, as natural spread is expected to be less than 1 km per year. Based on the elements provided in the PRA, the PPM considered that 1 km was an appropriate distance. No reports were found indicating that the pest would have expanded its range in North America.
To establish and maintain a PFA, detailed surveys (using visual inspection and pheromone traps) should be conducted in the area during a period corresponding to 2-3 generations (based on data from an area with similar climatic conditions where the pest is present) prior to establishment of the PFA and continued every year. Similar surveys should also be carried out in the zone between the PFA and known infestation to demonstrate pest freedom.
There should be restrictions on the movement of plant material from areas where the pest is known to be present into the PFA, and into the area surrounding the PFA. In case of high densities (i.e. outbreaks) in other places in the country, movement of material potentially contaminated should also be regulated.

Note on contaminated commodities: not all commodities included in pathway 5 - Contaminated commodities, may normally be covered by phytosanitary measures in the EPPO region and may not fall under the responsibility of the NPPOs. Such commodities may be made of any material likely to be stored outside prior to export, e.g. furniture not made of wood, containers and vehicles not covered by ISPM 41 (FAO, 2017c).

16.2 Eradication and containment
The EWG outlined the main components of an eradication or containment programme. There is some experience with the eradication of related species in other regions (see further down).

Early detection and proper identification of the pest are necessary:
- The presence of other *Orgyia* species in the PRA area would complicate early detection of *O. leucostigma*. According to Wilstermann & Schrader (2018), *O. leucostigma* can be mistaken for *Orgyia* species that are endemic in the PRA area.
- *O. leucostigma* can be distinguished from most *Orgyia* species that are present in the PRA area by external morphological characters but, due to colour polymorphism and if trapped specimens are damaged, inspection of the male genitalia is sometimes needed (see *Identification*, section 2.7). Further, egg masses are characterized by a froth protective covering (Wilson, 1991). Identification may require DNA-based diagnostic methods (Armstrong *et al*., 2003).

If the pest is detected, thorough visual inspection and intensive trapping should be performed to delimitate infested areas:

- *O. leucostigma* and its symptoms can be detected by inspecting plants visually. The larvae with their bright colourful pattern are generally highly visible on the leaves. However, small larvae may be difficult to see, and similar symptoms can be caused by other defoliators, including *Orgyia* species
- Pheromone trapping should be used (adult males – see section 2.7). Pheromone trapping is used in North America to detect low levels of populations.
- The EWG assessed that natural spread would be slow (see sections 2.5 and 11). Insufficient data were available to specify the size of a buffer zone (see 2.5, Annex 1).

Measures should be applied:
- Treatment: *Orgyia leucostigma* larvae are sensitive to a broad range of plant protection products and some of them are approved for outdoor use at least in parts of the PRA area, e.g. *Bacillus thuringiensis* subsp. *kurstaki*, deltamethrin, pyrethrins and spinosad.
- Removal of host plants: An eradication programme may need removal of all host plants in an area. *O. leucostigma* is highly polyphagous and its host plants occur throughout the PRA area as native or introduced species, in different environments including orchards, gardens, urban areas, forests and plantations, in the wild and as weeds.
- There should be restrictions on the movement of host material.

Pupal cocoons and egg masses can be present on non-host plants and other objects, e.g. logs, fences or houses, which would complicate prevention of human assisted spread.

Finally, information campaigns should be conducted.

Experience with eradication of related species
Orgyia thyellina was successfully eradicated from New Zealand in a campaign carried out in the eastern suburbs of Auckland in 1996–1998 (Hosking *et al.*, 2003; Sinclair *et al.*, 1997). In the campaign, *Bacillus thuringiensis* subsp. *kurstaki* was applied aerially on over 4000 ha and all known infested sites were sprayed also from the ground. The pest population was monitored using live female moths and a synthetic pheromone, quarantine actions were taken to prevent further spread and a major communications initiative was carried out.

Populations of *Lymantria dispar*, another species of the subfamily Lymantriinae, have been the target of several eradication campaigns in the USA (Hajek & Tobin, 2009). Campaigns have been carried out successfully both to slow down the spread of the already established European subspecies (*L. dispar dispar*) and to prevent the introduction of the Asian subspecies (*L. dispar asiatica*). Many of the campaigns have been based on aerial application of *B. thuringiensis* subsp. *kurstaki* to wide areas (up to tens of thousands of hectares). According to Hajek & Tobin (2009), a critical component of a successful eradication campaign has been the availability of a monitoring tool that can detect very low-density populations.

17. Uncertainty

The main uncertainties in this PRA relate to:
- Association of the pest with the host category ‘other hosts’
- Rate of natural spread
- Northern and southern limits of potential establishment in the PRA area, e.g. in dry areas
- Reasons why not present in western North America
- Factors inducing outbreaks
- Reasons for the difference in impact in Canada and the USA
- Magnitude of impact in the PRA area
- Whether natural enemies present in the EPPO region would regulate populations
- Volume of pathways from areas where the pest occurs

18. Remarks

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

- Natural spread, i.e. distance, as well as transfer of the pest by natural means from commodities other than plants for planting (e.g. round wood).
- List of natural enemies present in the EPPO region that have an impact on *Orgyia* spp. or *O. leucostigma*, and overlap with the natural enemies present in North America
- Test choice of larvae on potential hosts in the EPPO region
- Potential establishment could be further studied with climate suitability modelling
- Clarification of the status of *Fragaria* as a host, and whether it supports larval development.

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ANNEX 1. Evaluation of possible phytosanitary measures for the main identified pathways, using EPPO Standard PM 5/3

The table below summarizes the consideration of possible measures for the pathways 'host plants for planting', 'cut branches (incl. Christmas trees) of host plants', 'round wood and sawn wood of host plants with bark', and 'isolated bark of host plants' (based on EPPO Standard PM 5/3).

When a measure is considered appropriate, it is noted "yes", or "yes, in combination" if it should be combined with other measures in a systems approach. "No" indicate that a measure is not considered appropriate. A short justification is included.

Option	**Host plants for planting and cut branches (incl. Christmas trees) of host plants**	**'Round wood and sawn wood of host plants with bark**	**Isolated bark of host plants'**
Existing measures in the PRA area	Partly, see section 8.1.1 and 8.1.2	Partly, see section 8.1.3	Partly, see section 8.1.5
Visual inspection at place of production	Yes, in combination* *Pheromone trapping* is useful for monitoring populations at low densities, and would allow detecting adult males. It should be done during the flight period of the insect. Yes, in combination* *Visual inspection*. Detection by visual inspection of the plants is not considered completely effective. This is because young larvae are difficult to detect (especially before damages on the leaves are visible). Nevertheless, repeated visual inspection at suitable times over the whole growing period would allow detecting the pest. However, the feasibility and reliability of visual inspection would depend on the size of the plants and on the type of plant. It may be difficult on large/tall plants (e.g. tall nursery plants, or plants from which cut branches are taken) and conifers (for example Christmas tree plantations, or coniferous plantations for the production of cut branches, due to the presence of dense branches). During winter, the efficiency of visual inspection is higher for deciduous plants (as only egg masses would be associated with dormant deciduous plants). Inspections should be done when mature larvae, pupae or adults would be expected to be present since the other life stages cannot be identified to species (of adults, only males can be reliably identified).	Yes, in combination* *Pheromone trapping.* As for plants for planting No. *Visual inspection* would be neither reliable nor feasible due to the large size of the plants.	As for wood

Option	Host plants for planting and cut branches (incl. Christmas trees) of host plants	‘Round wood and sawn wood of host plants with bark	Isolated bark of host plants’
Testing at place of production	No. Not relevant.	No. Not relevant.	No. Not relevant.
Treatment of crop	Yes, in combination* Chemical and biological plant protection products are available. Early larval instars are sensitive to a broad range of insecticides (see section 12.4.1). However, insecticides may not be completely effective, particularly if life stages other than early larvae are present. Treatment of the crop at the appropriate time. Also, reinvasions from the surrounding plants may take place as the pest is common and highly polyphagous.	No. Not feasible. The life stages that are the most likely to be present on wood, i.e. cocoons protecting pupae and egg masses, are less likely to be killed by the treatments, because they do not feed and are often in sheltered places such as bark crevices.	No. Not feasible As for round wood and sawn wood with bark.
Resistant cultivars	No. Resistant cultivars are not available.	No. As for plants for planting.	No. As for plants for planting
Growing under complete physical isolation	Yes. Plants for planting could be grown under protected conditions with sufficient measures to exclude the pest, following EPPO Standard PM5/8(1) *Guidelines on the phytosanitary measure ‘Plants grown under complete physical isolation’* (EPPO, 2016). However, this is not common practice for many of the host plants and would not always be feasible. Suitable measures should be in place to take account of the fact that the dispersing early instar larvae are small, and that pupae with cocoons and egg masses can be transported as attached to various sorts of equipment. This measure would also apply to cut branches if the plants can be grown in such conditions. It is unlikely to be feasible for Christmas tree production.	No. Not possible.	No. Not possible.
Specified age of plant, growth stage or time of year of harvest	Yes, in combination* Some life stages can be present on all sizes of plants and throughout the year. However, there will be fewer larvae in winter and none on dormant deciduous plants. Regarding cut branches, the EWG did not know if some cut branches of hosts would be traded dormant without foliage. If so, similar combinations may be possible.	No. The pest can be present on all sizes of plants and throughout the year, and trees need to be large enough before being cut for wood. In areas where the pest has only one generation per year, the pest is less likely to be present on wood in the summer. This is because, at that time, larvae are the only life stage present and they feed on	No. As for round wood and sawn wood with bark.

Option	Host plants for planting and cut branches (incl. Christmas trees) of host plants	'Round wood and sawn wood of host plants with bark	Isolated bark of host plants'
		leaves or thin bark. However, the timing of this period is not known exactly, and it varies between years and regions.	
Produced in a certification scheme	No. Not relevant.	No. Not relevant.	No. Not relevant.
Pest freedom of the crop	No. The pest has a low natural spread. A combination of measures was identified by the EWG that corresponds to crop freedom, and was further combined with measures applied to the consignment. However the combination was not retained by the PPM (see below the table).	No. Not relevant.	No. Not relevant.
Pest free production site	Yes, growing under complete physical isolation (see above). Yes, in combination*. Outdoors. In outdoor environments, invasions from the surrounding plants may take place as the pest is common and highly polyphagous. A wide enough buffer zone with no host plants would decrease the likelihood of invasion but would not eliminate it. A pest free production site would therefore be difficult to maintain. However, a combination of measures was identified allowing a pest free production site. See below the table. There should also be an appropriate buffer zone. Measures should also be applied to the consignment. Based on the elements provided in the PRA, the PPM considered that 1 km around the production site free from the pest was an appropriate size for the buffer zone (see additional elements under pest free area below and section 2.5.1).	No. Not possible.	No. Not possible.
Pest free place of production	As for pest free production site.	No. Not possible.	No. Not possible.
Pest free area	Yes PFAs could be established. The EWG noted that the data available are not sufficient to specify the distance between a PFA and the closest area where the pest is known to be present. However, this distance might be rather short, as natural spread is expected to be less than 1 km per year. Based on the elements provided in the PRA, the PPM considered that 1 km was an appropriate distance. No reports were found indicating that	As for 'plants for planting'.	As for 'plants for planting'.

Option	Host plants for planting and cut branches (incl. Christmas trees) of host plants	‘Round wood and sawn wood of host plants with bark	Isolated bark of host plants’
	the pest would have expanded its range in North America. To establish and maintain a PFA, detailed surveys (using visual inspection and pheromone traps) should be conducted in the area during a period corresponding to 2-3 generations (based on data from an area with similar climatic conditions where the pest is present) prior to establishment of the PFA and continued every year. Similar surveys should also be carried out in the zone between the PFA and known infestation to demonstrate pest freedom. There should be restrictions on the movement of plant material from areas where the pest is known to be present into the PFA, and into the area surrounding the PFA. In case of high densities (i.e. outbreaks) in other places in the country, movement of material potentially contaminated should also be regulated.		
Visual inspection of consignment	Yes, in combination* Visual inspection is unlikely to be completely effective on its own, especially on large plants with leaves or needles. However, on dormant plants only empty cocoons and egg masses can be present and on dormant deciduous plants they would be conspicuous. Since pupal cocoons or egg masses cannot be identified to species, the plants should be free from all egg masses that could possibly indicate the presence of *O. leucostigma*. Requiring that plants should be free from other signs and symptoms of infestation might be problematic since similar signs and symptoms can be caused by several other defoliators.	Yes, in combination* Visual inspection of wood consignments is difficult and egg-covered cocoons can be present in sheltered places such as bark crevices. However, some cocoons may be detected.	As for wood
Testing of commodity	No. Not relevant.	No. Not relevant.	No. Not relevant.
Treatment of the consignment	Yes, in combination* Chemical and biological plant protection products are available, and especially early larval instars are sensitive to a broad range of insecticides. However, insecticides may not be completely effective, particularly if life stages other than early larvae are present. Plants for planting are mostly traded at the dormant stage when only empty cocoons with egg masses can be present.	Yes. - According to the EPPO Standard PM 10/6(1) *Heat treatment of wood to control insects and wood-borne nematodes* (EPPO, 2009a), wood-related insects can be controlled in round and sawn wood with or without bark by heat-treating until	Yes Chipping down to a certain size (2.5 x 2.5 cm) would kill some pupae and larvae. It is expected that chipping would destroy egg masses. For *Lycorma delicatula*,

Option	Host plants for planting and cut branches (incl. Christmas trees) of host plants	'Round wood and sawn wood of host plants with bark	Isolated bark of host plants'
		the core temperature of wood reaches at least 56 °C for at least 30 min. Since *O. leucostigma* is on the surface of the wood, a shorter time and/or lower temperature may be sufficient. - According to the EPPO Standard PM 10/8(1) *Disinfestation of wood with ionizing radiation* (EPPO, 2009b), wood-related insects can be controlled in round and sawn wood with or without bark by an irradiation of 1 kGy. Such treatments might be applied to quality logs but will be too expensive for low-value products such as firewood. Yes, in combination* ISPM 28 PT 22 *Sulfuryl fluoride fumigation treatment for insects in debarked wood* and PT 23 *Sulfuryl fluoride fumigation treatment for nematodes and insects in debarked wood* (FAO, 2017a, 2017b) only apply to debarked wood not exceeding 20 cm in cross-section at its smallest dimension and 75% moisture content (dry basis). Also, fumigation is generally least effective against inactive life stages, i.e. pupae and eggs, which are the most likely life stages to be present in wood consignments. However, for *O. leucostigma*, the treatment would need to be effective only at the surface of the wood. (Methyl bromide has been phased-out and therefore it is not considered here.)	which also lays eggs on bark and has quite soft and vulnerable egg masses, chipping to this size was shown to prevent any emergence (Cooperband *et al.* 2018). The PPM decided to apply the recommendation by the Panel on Quarantine Pests for Forestry that the chipping size should apply to the three dimensions. The Panel on Phytosanitary Measures has decided that heat treatment, fumigation or irradiation should not be proposed as a measure for bark before analysing if the EPPO standards PM 10/6(1) and PM 10/8(1) as well as in ISPM 28 PT 22 and PT 23 are applicable for bark.

Option	Host plants for planting and cut branches (incl. Christmas trees) of host plants	'Round wood and sawn wood of host plants with bark	Isolated bark of host plants'
Pest only on certain parts of plant/plant product, which can be removed	No. Larvae can be present on the foliage, branches and stem. Cocoons with/without pupae, adults, egg masses can be present on branches and stems on exposed bark and in bark crevices, in branch crotches etc.	Yes. Bark freedom would ensure that the pest is removed. Yes, in combination*. Debarking would remove (at least most of) the cocoons with pupae, adults and/or egg masses, but some may remain around branch nodes or similar places where some bark may remain.	No.
Prevention of infestation by packing/handling method	Yes, to be associated with some measures as appropriate Plants can be infested during packing, transportation or storage if those activities take place in an area where the pest is present during the time when young larvae are dispersing, or mature larvae are seeking for pupation sites. Note that also the packages can be suitable sites for pupation. The packaging of the consignments should be kept free from larvae (e.g. stored in conditions preventing access by mature larvae, or cleaning).	No. Not feasible.	No. Not feasible.
Post-entry quarantine	Yes (plants for planting). The pest has 1–3 generations per year. One year of post-entry quarantine would reveal possible infestation of the consignment. Yet, this might not be feasible for all plants. The Panel on Phytosanitary Measures considers that this measure should only be proposed in the framework of a bilateral agreement No (cut branches)	No. Not feasible.	No. Not feasible.
Limited distribution of consignments in time and/or space or limited use	No Limiting the distribution of consignments to areas where the pest is not likely to establish is not possible since these areas cannot be precisely defined. Regarding plant parts, if they are intended for indoor use only and imported only in the winter (Christmas trees), the pest is less likely to be able to disperse to new hosts. However, such plant parts may be discarded outdoors, which would enable the pest to transfer to a suitable host in the following growing season. It would also be difficult to	No If wood was imported only in the winter (when only empty cocoons with egg masses can be present in the consignments) and if it was processed before the eggs would hatch, the pest would not be able to transfer to suitable hosts. The processing would have to be such that	As for 'round wood of host plants with bark'.

Option	Host plants for planting and cut branches (incl. Christmas trees) of host plants	'Round wood and sawn wood of host plants with bark	Isolated bark of host plants'
	control that the plant parts are used indoors.	the pest is destroyed, i.e. especially bark should be processed. Defining the exact dates for import and processing would be difficult and the dates would be different in different parts of the PRA area.	
Surveillance and eradication in the importing country	No Pheromone traps could be used in surveys, natural dispersal of the pest would be rather slow, and plant protection products could be used in eradication campaigns. However, detecting the pest at an early enough stage to enable successful eradication would require intensive surveys and thus a lot of resources. (In case of an outbreak, public awareness campaigns would be needed since the hairs of mature larvae can irritate sensitive skin and can cause severe allergic reactions.)	As for 'plants for planting'.	As for 'plants for planting'.

*The individual measures identified above as 'Yes in combination' were:

Host plants for planting	Round wood and sawn wood	Isolated bark
visual inspection at the place of production	Pheromone trapping	Pheromone trapping
pheromone trapping	Visual inspection of the consignment	Visual inspection of the consignment
treatment of the crop	Debarking	
dormant	Sulfuryl fluoride fumigation	
visual inspection of the consignment		
treatment of the consignment		

The EWG considered whether these measures could be combined to achieve a suitable level of protection.

For host plants for planting & for cut branches (incl. Christmas trees) of host plants, the following combinations were proposed:

- dormant + visual inspection of all plants in the consignment to detect cocoons and egg masses

For deciduous woody hosts. Dormant plants may carry pupal cocoons or egg masses on cocoons, and these are conspicuous on bare twigs and branches. Therefore, requiring that deciduous plants are traded only when dormant might be used in a systems approach coupled with inspection of consignments. This might be feasible since many trees and shrub species are traded mostly as dormant. It requires that all plants are inspected. There is no similar option for conifers because different life stages may be present year-round in the southern part of the range.

For cut branches, The EWG did not know if cut branches of some hosts are traded dormant, without foliage.
The PPM decided to not retain the combination, because visual inspection of all plants/cut branches in the consignment may not be feasible and reliable for all host species and all plant sizes. It was noted that visual inspection of the consignment is used in another combination of measures, but is combined with other measures that offer additional protection.

- pest free place or production/pest free production site (visual inspection of the plants throughout the growing period at suitable intervals to detect all life stages and found free from the pest + pheromone trapping and found free from the pest + buffer zone of 1 km around the place of production/production site) + visual inspection of the consignment + packing to prevent infestation during storage and transport and keeping packaging free from the pest.

This combination of measures may not be possible for all plants for planting and cut branches. The feasibility and reliability of visual inspection would depend on the size of the plants and on the type of plant. It may be difficult on large/tall plants (e.g. tall nursery plants, or plants from which cut branches are taken) and conifers (for example Christmas tree plantations, or coniferous plantations for the production of cut branches, due to the presence of dense branches). Consequently, this combination may not be relevant for most Christmas trees and cut branches.

- crop freedom (visual inspection at the place/site of production throughout the growing period, at suitable intervals to detect all life stages + pheromone trapping. If the pest is found at visual inspection or trapping: treatment of the crop at the appropriate time) + visual inspection of the consignment+ packing to prevent infestation during storage and transport and keeping packaging free from the pest.

The EWG noted that this combination may be an option but it would depend on how effective treatments can be at controlling the life stages that may be present. The same limitations of visual inspection apply as above.
The PPM decided to not retain this combination, because treatment of the crop may not be effective at eliminating all life stages that may be present, nor in all host species, and it does not take into account the risk of reinfestation.

For round wood with bark, the following combination was proposed:
debarking + sulfuryl fluoride fumigation

For isolated bark, no combination is available

ANNEX 2. Life stages of *Orgyia leucostigma*

Adults (left : male ; right : female)
(James Solomon, USDA Forest Service, Bugwood.org)

Adult female with egg mass on cocoon
(John L. Foltz, University of Florida, Bugwood.org)

Egg mass on cocoon
(John L. Foltz, University of Florida, Bugwood.org)

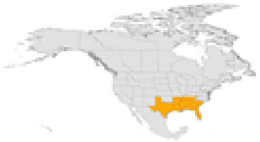
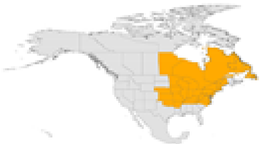
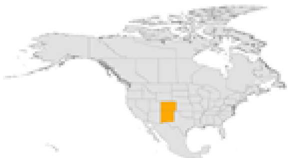
Larva
(John Ghent, John Ghent, Bugwood.org)

Larvae feeding on leaf
(James Solomon, USDA Forest Service, Bugwood.org)

Pupae
(Robert L. Anderson, USDA Forest Service, Bugwood.org)

Multiple life stages
(North Carolina Forest Service , Bugwood.org)

ANNEX 3. Distribution of *Orgyia leucostigma* subspecies

***Orgyia leucostigma* subsp.**	**Distribution**	**Comments**	**References**
leucostigma	 **USA** (Alabama, Arkansas[1], Florida, Georgia, Louisiana, Mississippi, South Carolina, Tennessee[1], Texas)	Nominate *leucostigma* is the subspecies of the Deep South (Alabama, Georgia, Louisiana, Mississippi, South Carolina), from South Carolina, Georgia and Florida through the Gulf States to eastern and southern Texas. [1]Possibly present together with subsp. *intermedia.*	Ferguson, 1978; Hall & Buss, 2014 and references therein
intermedia	 **Canada** (Manitoba, Newfoundland[1], Ontario, Quebec) **USA** (Arkansas[2], Connecticut, Delaware, Illinois, Indiana, Iowa, Kansas, Kentucky, Maine, Maryland, Massachusetts, Michigan, Minnesota, Missouri, Nebraska[3], New Hampshire, New Jersey, New York, North Carolina, Ohio, Oklahoma, Pennsylvania, Rhode Island, Tennessee[2], Vermont, West Virginia, Virginia, Wisconsin)	This subspecies is the dominant subspecies in the eastern and central USA and southern Canada, occurring in the East and Midwest except for the Deep South of USA and the Atlantic Provinces of Canada. [1]Unconfirmed for Newfoundland [2] Possibly present together with subsp. *leucostigma*	Ferguson,1978; Pohl *et al.*, 2018 [3]The information for the presence in Nebraska comes from two webpages that collect reports: 1) picture in BugGuide.Net (2020a); 2) North American Moth Photographers Group (2020)
plagiata	 **Canada** (New Brunswick, Newfoundland, Nova Scotia, Prince Edward Island, Quebec[1])	[1]Unconfirmed for Quebec	Ferguson, 1978; Pohl *et al.*, 2018
oslari	 **USA** (Colorado, New Mexico)	High elevation (2000–3000 m) subspecies, known from the Rocky Mountains. Rare subspecies currently known only from Colorado.	Ferguson, 1978; Pohl *et al.*, 2010; Wallner & McManus, 1989
sablensis	 **Canada** (Nova Scotia)	Sable Island in Nova Scotia constitue the entire known distribution of *sablensis* (Neil, 1979).	Neil, 1979; Pohl *et al.*, 2018

ANNEX 4. Natural enemies of *Orgyia leucostigma*

In addition to the species listed below, Frank & Foltz (1997) provides a long list of natural enemies belonging to Diptera and Hymenoptera orders within Tachinidae, Braconidae, Ichneumonidae, Torymidae, Pteromalidae, Eulophidae and Scelionidae families.

Species	**Comments and reference**
Cotesia delicata (Hymenoptera: Braconidae)	Parasitizing *O. leucostigma* larvae on willow (*Salix nigra*) and box elder (*Acer negundo*). Generalists are indicated with* Medina *et al.* (2005).
Cotesia melanoscela (Hymenoptera: Braconidae)*	
Cotesia sp. (Hymenoptera: Braconidae)*	
Meteorus hyphantriae (Hymenoptera: Braconidae)*	
Meteorus sp. (Hymenoptera: Braconidae)*	
Casinaria limenitidis (Hymenoptera: Ichneumonidae)*	
Casinaria sp. (Hymenoptera: Ichneumonidae)*	
Hyposoter fugitivus (Hymenoptera: Ichneumonidae)*	
Elachertus sp. (Hymenoptera: Eulophidae)	
Carcelia amplexa (Diptera: Tachinidae)	
Polistes paper wasps and other invertebrate predators	Larvae predators. Castellanos *et al.* (2011).
cytoplasmic polyhedrosis viruses (Cypovirus)	Infecting larvae. Hayashi & Bird (1968), Cunningham (1972).
nuclear polyhedrosis viruses (Baculovirus)	
Entomophaga aulicae (fungus)	Entomopathogenic fungus. Thurston (2002).
Birds	Major predator of large larvae. Most mortality of smaller larvae was suggested to be due to failure to find a suitable host during ballooning dispersal and to invertebrate predators in the leaf litter. Medina and Barbosa (2002)

ANNEX 5. Host plants of *Orgyia leucostigma*

Table 1. Host plants of *Orgyia leucostigma* in its native range. Plants indicated with green background are considered as main hosts[2] based on information in Table 2. Information on the presence and status of the plants in the PRA area was obtained from the Euro+Med plantbase database (http://ww2.bgbm.org/EuroPlusMed/query.asp), Royal Horticultural Society database (https://www.rhs.org.uk/Plants), EPPO Global Database (EPPO, 2020), CABI Invasive Species Compendium (CABI, 2020a) and Euforgen platform (Euforgen, 2020).

Host plant	Family	Presence and status in the PRA area		References for host status
*Abies**	Pinaceae	Yes	native in some areas, introduced and cultivated in some areas	Heppner *et al.*, 2003; Robinson *et al.*, 2010; Dedes, 2014
Abies balsamea	Pinaceae	Yes	introduced, cultivated	Ferguson, 1978; Morris, 1980; Drooz, 1985; Wallner & McManus, 1988; van Frankenhuyzen *et al.*, 2002; Maier *et al.*, 2004; Robinson *et al.*, 2010; Van Driesche *et al.*, 2013; Schowalter, 2018;
Abies concolor	Pinaceae	Yes	introduced, cultivated	Robinson *et al.*, 2010
*Acer**	Aceraceae	Yes	native in some areas, introduced and cultivated in some areas	Morris, 1980; Ontario Ministry of Natural Resources, 1991; van Frankenhuyzen *et al.*, 2002; Heppner *et al.*, 2003; Robinson *et al.*, 2010
Acer negundo	Aceraceae	Yes	introduced, cultivated	Webster, 1916; Heppner *et al.*, 2003; Medina *et al.*, 2005; Robinson *et al.*, 2010; Dedes, 2014;
Acer platanoides	Aceraceae	Yes	native in most of Europe, introduced and naturalized in some areas	Drooz, 1985; Heppner *et al.*, 2003; Robinson *et al.*, 2010; Van Driesche *et al.*, 2013
Acer rubrum	Aceraceae	Yes	introduced, cultivated	Heppner *et al.*, 2003; Robinson *et al.*, 2010
Acer saccharinum	Aceraceae	Yes	introduced, naturalized, cultivated	Webster, 1916; Drooz, 1985; Burns & Honkala, 1990; Heppner *et al.*, 2003; Robinson *et al.*, 2010; Van Driesche *et al.*, 2013
Acer saccharum	Aceraceae	Yes	introduced, cultivated	Heppner *et al.*, 2003; Barbehenn *et al.*, 2005; Robinson *et al.*, 2010
Acer spicatum	Aceraceae		introduced, cultivated	Robinson *et al.*, 2010
Aesculus flava	Hippocastanaceae	Yes	introduced, naturalized, cultivated	Heppner *et al.*, 2003
Aesculus glabra	Hippocastanaceae	Yes	introduced, cultivated	Heppner *et al.*, 2003; Robinson *et al.*, 2010
Aesculus hippocastanum	Hippocastanaceae	Yes	native in Balkan peninsula, introduced in other areas, naturalized in Central Europe, cultivated in Eastern Europe	Webster, 1916; Ontario Ministry of Natural Resources, 1991; Heppner *et al.*, 2003; Robinson *et al.*, 2010
Ailanthus altissima	Simaroubaceae	Yes	introduced, naturalized	Heppner *et al.*, 2003; Robinson *et al.*, 2010
Albizia julibrissin	Fabaceae	Yes	native in Azerbaijan, introduced in other areas	Barnard & Dixon, 1983; Wallner & McManus, 1988 (as 'mimosa')
*Alnus**	Betulaceae	Yes	native	Ferguson, 1978; Wallner & McManus, 1988; van Frankenhuyzen *et al.*, 2002; Heppner *et al.*, 2003; Robinson *et al.*, 2010

[2] In the literature, these host plants are mentioned as common or preferred hosts or hosts for which impacts have been recorded. Other plants mentioned are either other hosts on which the pest can complete its life cycle or plants infested because of dispersing by ballooning events.

Host plant	Family	Presence and status in the PRA area		References for host status
Alnus incana	Betulaceae	Yes	native	Robinson *et al.*, 2010
Alnus incana subsp. *rugosa*	Betulaceae	Yes	introduced	Wallner & McManus, 1988
Alnus viridis	Betulaceae	Yes	native	Robinson *et al.*, 2010
Amelanchier canadensis	Rosaceae	Yes	introduced	Heppner *et al.*, 2003; Robinson *et al.*, 2010
Asimina triloba	Annonaceae	Yes	introduced	Heppner *et al.*, 2003
Berberis canadensis	Berberidaceae	No		Heppner *et al.*, 2003; Robinson *et al.*, 2010
Berberis vulgaris	Berberidaceae	Yes	native	Heppner *et al.*, 2003; Robinson *et al.*, 2010
*Betula**	Betulaceae	Yes	native	Webster, 1916; Ferguson, 1978; Wallner & McManus, 1988; Ontario Ministry of Natural Resources, 1991; Robinson *et al.*, 2010; Dedes, 2014
Betula alleghaniensis	Betulaceae	Yes	introduced	Drooz, 1985; Robinson *et al.*, 2010; Van Driesche *et al.*, 2013
Betula lenta	Betulaceae	Yes	introduced	Heppner *et al.*, 2003; Robinson *et al.*, 2010
Betula nigra	Betulaceae	Yes	introduced	Heppner *et al.*, 2003; Robinson *et al.*, 2010
Betula papyrifera	Betulaceae	Yes	introduced	Morris, 1980; Drooz, 1985; Wallner & McManus, 1988; Robinson *et al.*, 2010; Van Driesche *et al.*, 2013
Betula pubescens	Betulaceae	Yes	native	Heppner *et al.*, 2003; Robinson *et al.*, 2010
Buxus sempervirens	Buxaceae	Yes	native in Mediterranean basin, Central Europe and Caucasus, introduced and cultivated in some other areas	Heppner *et al.*, 2003
*Callistemon**	Myrtaceae	Yes	introduced	Heppner *et al.*, 2003
*Camellia**	Theaceae	Yes	introduced	Heppner *et al.*, 2003
Camellia japonica	Theaceae	Yes	introduced	Heppner *et al.*, 2003
Camellia sasanqua	Theaceae	Yes	introduced	Heppner *et al.*, 2003
Campsis radicans	Bignoniaceae	Yes	introduced, naturalized, cultivated	Heppner *et al.*, 2003; Robinson *et al.*, 2010
Carpinus caroliniana	Betulaceae	Yes	introduced	Heppner *et al.*, 2003; Robinson *et al.*, 2010
*Carya**	Juglandaceae	Yes	introduced, naturalized, cultivated	Heppner *et al.*, 2003; Robinson *et al.*, 2010
Castanea dentata	Fagaceae	No		Heppner *et al.*, 2003; Robinson *et al.*, 2010
Castanea pumila	Fagaceae	No		Heppner *et al.*, 2003; Robinson *et al.*, 2010
*Catalpa**	Bignoniaceae	Yes	introduced, naturalized	Webster, 1916; Heppner *et al.*, 2003; Robinson *et al.*, 2010
Catalpa bignonioides	Bignoniaceae	Yes	introduced, naturalized	Heppner *et al.*, 2003; Robinson *et al.*, 2010
Catalpa speciosa	Bignoniaceae	Yes	introduced, cultivated	Heppner *et al.*, 2003; Robinson *et al.*, 2010
Celtis laevigata	Ulmaceae	No		Heppner *et al.*, 2003
Celtis occidentalis	Ulmaceae	Yes	introduced, naturalized, cultivated	Heppner *et al.*, 2003; Robinson *et al.*, 2010
Cephalanthus occidentalis	Rubiaceae	Yes	introduced	Heppner *et al.*, 2003; Robinson *et al.*, 2010
Cercis canadensis	Fabaceae	Yes	introduced	Kimball, 1965; Barnard & Dixon, 1983; Wallner & McManus, 1988; Heppner *et al.*, 2003; Robinson *et al.*, 2010
Chaenactis stevioides	Compositae	No		Robinson *et al.*, 2010
Chamaecyparis thyoides	Cupressaceae	Yes	introduced	Heppner *et al.*, 2003
Chenopodium album	Chenopodiaceae	Yes	native	Heppner *et al.*, 2003; Robinson *et al.*, 2010

Host plant	Family	Presence and status in the PRA area		References for host status
Chionanthus virginicus	Oleaceae	Yes	introduced	Heppner *et al*., 2003; Robinson *et al*., 2010
*Clematis**	Ranuncleaceae	Yes	native in some areas, introduced and naturalized in some areas	Heppner *et al*., 2003; Robinson *et al*., 2010
Convallaria majalis	Liliaceae	Yes	native	Heppner *et al*., 2003; Robinson *et al*., 2010
Cornus alternifolia	Cornaceae	Yes	introduced	Heppner *et al*., 2003; Robinson *et al*., 2010
Cornus canadensis	Cornaceae	Yes	Introduced, cultivated	Robinson *et al*., 2010
Cornus florida	Cornaceae	Yes	introduced	Heppner *et al*., 2003; Robinson *et al*., 2010
*Corylus**	Betulaceae	Yes	native	Heppner *et al*., 2003; Robinson *et al*., 2010
Corylus americana	Betulaceae	No		Heppner *et al*., 2003; Robinson *et al*., 2010
Cotinus coggygria	Anacardiaceae	Yes	native in East and Central Europe and Caucasus, introduced, naturalized and cultivated in some areas	Heppner *et al*., 2003; Robinson *et al*., 2010
*Crataegus**	Rosaceae	Yes	native in some areas, introduced in some areas	Heppner *et al*., 2003; Robinson *et al*., 2010
*Cupressus**	Cupressaceae	Yes	native in some areas, introduced, naturalized and cultivated in some areas	Heppner *et al*., 2003; Robinson *et al*., 2010; BugGuide.Net, 2020b
Cydonia oblonga	Rosaceae	Yes	native in Caucasus, introduced and cultivated in Central Europe and Mediterranean basin	Heppner *et al*., 2003; Robinson *et al*., 2010
Diospyros kaki	Ebenaceae	Yes	introduced, cultivated	Heppner *et al*., 2003; Robinson *et al*., 2010
Diospyros virginiana	Ebenaceae	Yes	introduced	Heppner *et al*., 2003; Robinson *et al*., 2010
Dypsis lutescens	Areaceae	Yes	introduced	Heppner *et al*., 2003
Eriobotrya japonica	Rosaceae	Yes	introduced, cultivated	Heppner *et al*., 2003
Euonymus atropurpureus	Celastraceae	Yes	introduced	Heppner *et al*., 2003 ; Robinson *et al*., 2010
*Fagus**	Fagaceae	Yes	native in Caucasus and most of Europe, introduced in some areas	Heppner *et al*., 2003; Robinson *et al*., 2010; Dedes, 2014
Fagus grandifolia	Fagaceae	Yes	introduced	Heppner *et al*., 2003; Robinson *et al*., 2010
Ficus carica	Moraceae	Yes	native in Central Europe, Mediterranean basin and Caucasus, introduced, naturalized and cultivated in some areas	Heppner *et al*., 2003; Robinson *et al*., 2010
*Fragaria**	Rosaceae	Yes	native, cultivated	Belton, 1988
*Fraxinus**	Oleaceae	Yes	native	Webster, 1916; Heppner *et al*., 2003; Robinson *et al*., 2010
Fraxinus americana	Oleaceae	No		Heppner *et al*., 2003; Robinson *et al*., 2010
Fraxinus excelsior	Oleaceae	Yes	native	Heppner *et al*., 2003; Robinson *et al*., 2010
Geranium maculatum	Geraniaceae	Yes	introduced	Heppner *et al*., 2003; Robinson *et al*., 2010
Gleditsia triacanthos	Fabaceae	Yes	introduced	Burns & Honkala, 1990; Heppner *et al*., 2003; Robinson *et al*., 2010
Gordonia lasianthus	Theaceae	No		Kimball, 1965; Heppner *et al*., 2003; Robinson *et al*., 2010
Gossypium herbaceum	Malvaceae	Yes	introduced, naturalized, cultivated	Heppner *et al*., 2003; Robinson *et al*., 2010
Gymnocladus dioica	Fabaceae	Yes	introduced	Heppner *et al*., 2003 ; Robinson *et al*., 2010
Hamamelis virginiana	Hamamelidaceae	Yes	introduced	Heppner *et al*., 2003; Robinson *et al*., 2010
Hedera helix	Araliaceae	Yes	native	Heppner *et al*., 2003
*Helianthus**	Compositae	Yes	introduced, naturalized, cultivated	Heppner *et al*., 2003; Robinson *et al*., 2010

Host plant	Family	Presence and status in the PRA area		References for host status
Hibiscus syriacus	Malvaceae	Yes	introduced, naturalized, cultivated	Heppner *et al.*, 2003; Robinson *et al.*, 2010
Hibiscus trionum	Malvaceae	Yes	native in Mediterranean basin, Caucasus and East Europe, introduced and naturalized in some areas	Heppner *et al.*, 2003; Robinson *et al.*, 2010
Humulus lupulus	Cannabaceae	Yes	native in most of the PRA area, introduced and naturalized in some areas, cultivated	Heppner *et al.*, 2003; Robinson *et al.*, 2010
Ilex opaca	Aquifoliaceae	No		Heppner *et al.*, 2003; Robinson *et al.*, 2010
Illicium parviflorum	Illiciaceae	No		Heppner *et al.*, 2003
Ipomoea purpurea	Convolvulaceae	Yes	introduced, naturalized, cultivated	Heppner *et al.*, 2003; Robinson *et al.*, 2010
*Iris**	Iridaceae	Yes	native	Ferguson, 1978; Heppner *et al.*, 2003; Robinson *et al.*, 2010
Iris versicolor	Iridaceae	Yes	introduced	Neil, 1979
*Jasminum**	Oleaceae	Yes	native in Mediterranean basin and Caucasus, introduced in some areas	Heppner *et al.*, 2003; Robinson *et al.*, 2010
Juglans cinerea	Juglandaceae	Yes	introduced, cultivated	Heppner *et al.*, 2003; Robinson *et al.*, 2010
Juglans nigra	Juglandaceae	Yes	introduced, naturalized, cultivated	Wilson, 1991; Heppner *et al.*, 2003; Robinson *et al.*, 2010; Schowalter, 2018
Juglans regia	Juglandaceae	Yes	native in Southeast Europe and Caucasus, introduced, naturalized and cultivated in some areas	Heppner *et al.*, 2003; Robinson *et al.*, 2010
Juniperus virginiana	Cupressaceae	Yes	introduced, naturalized, cultivated	Heppner *et al.*, 2003; Robinson *et al.*, 2010
*Kalmia**	Ericaceae	Yes	introduced	Heppner *et al.*, 2003; Robinson *et al.*, 2010
*Larix**	Pinaceae	Yes	native in some areas, introduced and naturalized in some areas, cultivated	Morris, 1980; Drooz, 1985; Wallner & McManus, 1988; van Frankenhuyzen *et al.*, 2002; Robinson *et al.*, 2010; Van Driesche *et al.*, 2013
Larix decidua	Pinaceae	Yes	native in Central Europe, introduced and naturalized in some areas, cultivated	Heppner *et al.*, 2003; Robinson *et al.*, 2010
Larix laricina	Pinaceae	Yes	introduced	Ferguson, 1978; Heppner *et al.*, 2003; Maier *et al.*, 2004; Robinson *et al.*, 2010; Dedes, 2014
Leptochloa nealleyi	Poaceae	No		Heppner *et al.*, 2003; Robinson *et al.*, 2010
Ligustrum vulgare	Oleaceae	Yes	native in most of Europe and Caucasus, introduced in Azores	Heppner *et al.*, 2003; Robinson *et al.*, 2010
Liquidambar styraciflua	Hamamelidaceae	Yes	introduced	Heppner *et al.*, 2003; Robinson *et al.*, 2010
Liriodendron tulipifera	Magnoliaceae	Yes	introduced, cultivated	Heppner *et al.*, 2003; Robinson *et al.*, 2010
Litchi chinensis	Sapindaceae	No		Heppner *et al.*, 2003
*Lonicera**	Caprifoliaceae	Yes	native in most of the PRA area, introduced in some areas	Heppner *et al.*, 2003; Robinson *et al.*, 2010
Maclura pomifera	Moraceae	Yes	introduced, cultivated	Heppner *et al.*, 2003; Robinson *et al.*, 2010
*Magnolia**	Magnoliaceae	Yes	introduced, cultivated	Heppner *et al.*, 2003; Robinson *et al.*, 2010
*Malus**	Rosaceae	Yes	native, cultivated	Robinson *et al.*, 2010; Van Driesche *et al.*, 2013 ; Robinson *et al.*, 2010

Host plant	Family	Presence and status in the PRA area		References for host status
Malus domestica	Rosaceae	Yes	introduced, cultivated	Webster, 1916; Kimball, 1965; Barnard & Dixon, 1983; Drooz, 1985; Belton, 1988; Wallner & McManus, 1988; Heppner *et al.*, 2003; Ontario Apple IPM, 2009; Robinson *et al.*, 2010; Dedes, 2014; Schowalter, 2018
Malus sylvestris	Rosaceae	Yes	native	Heppner *et al.*, 2003
*Malva**	Malvaceae	Yes	native in most of the PRA area, introduced in some areas	Heppner *et al.*, 2003; Robinson *et al.*, 2010
*Mimosa**	Fabaceae	Yes	native in some areas, introduced in some areas	Kimball, 1965; Robinson *et al.*, 2010
Morella cerifera	Myricaceae	No		Heppner *et al.*, 2003
*Morus**	Moraceae	Yes	introduced, naturalized, cultivated	Heppner *et al.*, 2003; Robinson *et al.*, 2010
Morus rubra	Moraceae	Yes	introduced, cultivated	Heppner *et al.*, 2003
Myrica gale	Myricaceae	Yes	native	Robinson *et al.*, 2010
Myrica pensylvanica	Myricaceae	Yes	introduced	Ferguson, 1978; Neil, 1979; Robinson *et al.*, 2010
Nyssa sylvatica	Cornaceae	Yes	introduced	Heppner *et al.*, 2003; Robinson *et al.*, 2010
Ostrya virginiana	Betulaceae	Yes	introduced	Heppner *et al.*, 2003; Robinson *et al.*, 2010
Oxydendrum arboreum	Ericaceae	Yes	introduced	Heppner *et al.*, 2003; Robinson *et al.*, 2010
Parthenocissus quinquefolia	Vitaceae	Yes	introduced, naturalized, cultivated	Heppner *et al.*, 2003; Robinson *et al.*, 2010
Paulownia tomentosa	Scrophulariaceae	Yes	introduced, cultivated	Heppner *et al.*, 2003; Robinson *et al.*, 2010
Pelargonium × hortorum	Geraniaceae	Yes	introduced, cultivated	Heppner *et al.*, 2003
Persea borbonia	Lauraceae	No		Heppner *et al.*, 2003
*Photinia**	Rosaceae	Yes	introduced	Heppner *et al.*, 2003
*Picea**	Pinaceae	Yes	native in most of the PRA area, introduced and naturalized in some areas, cultivated	Maier *et al.*, 2004; Heppner *et al.*, 2003; Robinson *et al.*, 2010; Dedes, 2014
Picea glauca	Pinaceae	Yes	introduced, naturalized, cultivated	Morris, 1980
Picea mariana	Pinaceae	Yes	introduced, cultivated	Clarke & Carew, 1986
Picea rubens	Pinaceae	Yes	Introduced, cultivated	Robinson *et al.*, 2010
*Pinus**	Pinaceae	Yes	native in most of the PRA area, introduced and naturalized in some areas, cultivated	Heppner *et al.*, 2003; Robinson *et al.*, 2010
Pinus strobus	Pinaceae	Yes	introduced, naturalized, cultivated	Ferguson, 1978; Wallner & McManus, 1988; Robinson *et al.*, 2010
*Plantago**	Plantaginaceae	Yes	native	Heppner *et al.*, 2003; Robinson *et al.*, 2010
*Platanus**	Platanaceae	Yes	native in Southern Europe and Middle East, introduced and cultivated in some areas	Drooz, 1985; Van Driesche *et al.*, 2013
Platanus occidentalis	Platanaceae	Yes	introduced, cultivated	Heppner *et al.*, 2003; Robinson *et al.*, 2010
Poa pratensis	Poaceae	Yes	native in most of the PRA area, introduced in some areas	Heppner *et al.*, 2003; Robinson *et al.*, 2010
*Populus**	Salicaceae	Yes	native in most of the PRA area, introduced and naturalized in some areas	Webster, 1916; Drooz, 1985; van Frankenhuyzen *et al.*, 2002; Heppner *et al.*, 2003; Robinson *et al.*, 2010; Van Driesche *et al.*, 2013

Host plant	Family	Presence and status in the PRA area		References for host status
Populus alba	Salicaceae	Yes	native in most of Europe, North Africa and Caucasus, introduced, naturalized and cultivated in some areas	Heppner *et al.*, 2003; Robinson *et al.*, 2010
Populus balsamifera	Salicaceae	Yes	introduced, naturalized, cultivated	Heppner *et al.*, 2003; Robinson *et al.*, 2010
Populus deltoides	Salicaceae	Yes	introduced, cultivated	Heppner *et al.*, 2003; Robinson *et al.*, 2010
Populus fremontii	Salicaceae	Yes	introduced	Heppner *et al.*, 2003; Robinson *et al.*, 2010
Populus nigra	Salicaceae	Yes	native in most of the PRA area, introduced, naturalized and cultivated in some areas	Schowalter, 2018; Robinson *et al.*, 2010
Populus nigra var. *italica*	Salicaceae	Yes	native in Mediterranean basin, introduced, naturalized and cultivated in some areas	Heppner *et al.*, 2003
Populus tremuloides	Salicaceae	Yes	introduced	Lindroth *et al.*, 2002; Heppner *et al.*, 2003; Robinson *et al.*, 2010
Prunus#	Rosaceae	Yes	native in most of the PRA area, introduced in some areas	Dedes, 2014
Prunus americana	Rosaceae	No		Heppner *et al.*, 2003; Robinson *et al.*, 2010
Prunus armeniaca	Rosaceae	Yes	introduced, cultivated	Heppner *et al.*, 2003
Prunus cerasus	Rosaceae	Yes	introduced, cultivated	Heppner *et al.*, 2003; Robinson *et al.*, 2010
Prunus domestica	Rosaceae	Yes	introduced, cultivated	Belton, 1988; Heppner *et al.*, 2003; Robinson *et al.*, 2010
Prunus ilicifolia	Rosaceae	Yes	introduced	Heppner *et al.*, 2003; Robinson *et al.*, 2010
Prunus pensylvanica	Rosaceae	No		Robinson *et al.*, 2010
Prunus persica	Rosaceae	Yes	introduced, cultivated	Heppner *et al.*, 2003; Robinson *et al.*, 2010
Prunus virginiana	Rosaceae	Yes	introduced	Heppner *et al.*, 2003; Robinson *et al.*, 2010
Punica granatum	Punicaceae	Yes	native in Caucasus, introduced, naturalized and cultivated in some areas	Heppner *et al.*, 2003
*Pyracantha**	Rosaceae	Yes	native in Southern Europe, Caucasus and Middle East, introduced and cultivated in some areas	Wallner & McManus, 1988; Heppner *et al.*, 2003
Pyracantha coccinea	Rosaceae	Yes	native in Southern Europe, Caucasus and Middle East, introduced and cultivated in some areas	Kimball, 1965; Barnard & Dixon, 1983; Robinson *et al.*, 2010
Pyrus communis	Rosaceae	Yes	native in most of Europe and Caucasus, introduced in other areas, cultivated	Belton, 1988; Heppner *et al.*, 2003; Robinson *et al.*, 2010
*Quercus**	Fagaceae	Yes	native	Webster, 1916; Heppner *et al.*, 2003; Robinson *et al.*, 2010; Dedes, 2014
Quercus alba	Fagaceae	Yes	introduced	USDA Forest Service, 1989; Heppner *et al.*, 2003; Robinson *et al.*, 2010
Quercus coccinea	Fagaceae	Yes	introduced	Heppner *et al.*, 2003; Robinson *et al.*, 2010
Quercus laurifolia	Fagaceae	Yes	introduced	Barnard & Dixon, 1983
Quercus michauxii	Fagaceae	Yes	introduced	Heppner *et al.*, 2003
Quercus nigra	Fagaceae	Yes	introduced	Barnard & Dixon, 1983; USDA Forest Service, 1989
Quercus phellos	Fagaceae	Yes	introduced	Heppner *et al.*, 2003; Robinson *et al.*, 2010
Quercus rubra	Fagaceae	Yes	introduced	USDA Forest Service, 1989; Heppner *et al.*, 2003; Barbehenn *et al.*, 2005; Robinson *et al.*, 2010

Host plant	Family	Presence and status in the PRA area		References for host status
Quercus virginiana	Fagaceae	Yes	introduced	Kimball, 1965; Barnard & Dixon, 1983; Wallner & McManus, 1988; USDA Forest Service, 1989; Heppner *et al.*, 2003; Robinson *et al.*, 2010; Schowalter, 2018
Rhamnus alnifolia	Rhamnaceae	No		Heppner *et al.*, 2003; Robinson *et al.*, 2010
Rhaphiolepis indica	Rosaceae	Yes	introduced	Heppner *et al.*, 2003
*Rhododendron**	Ericaceae	Yes	native in most of the PRA area, introduced, naturalized and cultivated in some areas	Heppner *et al.*, 2003; Robinson *et al.*, 2010
*Ribes**	Grossulariaceae	Yes	native in most of the PRA area, introduced and cultivated in some areas	Heppner *et al.*, 2003; Robinson *et al.*, 2010
Ricinus communis	Euphorbiaceae	Yes	introduced	Heppner *et al.*, 2003; Robinson *et al.*, 2010
Rhizophora mangle		No		Barro & Núñez, 2011
Robinia pseudoacacia	Fabaceae	Yes	native in Sicily, introduced in some areas	Heppner *et al.*, 2003; Robinson *et al.*, 2010
*Rosa**	Rosaceae	Yes	native	Neil, 1979; Heppner *et al.*, 2003; Robinson *et al.*, 2010
*Rubus**	Rosaceae	Yes	native	U.S. Department of Agriculture, 1976; Belton, 1988; Heppner *et al.*, 2003; Robinson *et al.*, 2010
*Salix**	Salicaceae	Yes	native in most of the PRA area, introduced, and naturalized in some areas	Webster, 1916; Ferguson, 1978; Wallner & McManus, 1988; Heppner *et al.*, 2003; Robinson *et al.*, 2010
Salix babylonica	Salicaceae	Yes	introduced, naturalized, cultivated	Heppner *et al.*, 2003
Salix caroliniana	Salicaceae	No		Heppner *et al.*, 2003
Salix longipes	Salicaceae	No		Heppner *et al.*, 2003
Salix nigra	Salicaceae	No		Heppner *et al.*, 2003; Medina *et al.*, 2005
Sambucus canadensis	Caprifoliaceae	Yes	introduced, naturalized	Heppner *et al.*, 2003; Robinson *et al.*, 2010 (listed as *S. nigra* subsp. *canadensis*.
Sassafras albidum	Lauraceae	Yes	introduced	Heppner *et al.*, 2003; Robinson *et al.*, 2010
Simmondsia chinensis	Buxaceae	Yes	introduced, cultivated	Heppner *et al.*, 2003
Sorbus	Rosaceae	Yes	native	Robinson *et al.*, 2010
*Spiraea**	Rosaceae	Yes	native in most of the PRA area, introduced in other areas	Heppner *et al.*, 2003; Robinson *et al.*, 2010
Staphylea trifolia	Staphyleaceae	Yes	introduced, cultivated	Heppner *et al.*, 2003; Robinson *et al.*, 2010
Symphoricarpos albus	Caprifoliaceae	Yes	introduced, naturalized, cultivated	Heppner *et al.*, 2003; Robinson *et al.*, 2010
Syringa vulgaris	Oleaceae	Yes	native in Balkan Peninsula, introduced in some areas	Heppner *et al.*, 2003; Robinson *et al.*, 2010
Tamarix chinensis	Tamaricaceae	Yes	Introduced, cultivated	Robinson *et al.*, 2010
Tamarix gallica	Tamaricaceae	Yes	native in Mediterranean basin, introduced and cultivated in some areas	Ferguson, 1978; Wallner & McManus, 1988
Taraxacum officinale complex	Asteraceae	Yes	native	Heppner *et al.*, 2003; Robinson *et al.*, 2010
*Taxus**	Taxaceae	Yes	native	Heppner *et al.*, 2003; Robinson *et al.*, 2010
*Tilia**	Tiliaceae	Yes	native in most of the PRA area, introduced in some areas, cultivated	Webster, 1916; Heppner *et al.*, 2003; Robinson *et al.*, 2010; Van Driesche *et al.*, 2013

Host plant	Family	Presence and status in the PRA area		References for host status
Tilia americana	Tiliaceae	Yes	introduced, cultivated	Webster, 1916; Drooz, 1985; Burns & Honkala, 1990; Ontario Ministry of Natural Resources, 1991; Heppner *et al.*, 2003; Robinson *et al.*, 2010
Tilia × europaea	Tiliaceae	Yes	native	Heppner *et al.*, 2003
Trema micrantha	Ulmaceae	No		Heppner *et al.*, 2003
*Trifolium**	Fabaceae	Yes	native	Heppner *et al.*, 2003; Robinson *et al.*, 2010
*Triticum**	Poaceae	Yes	native in Eastern Europe and Asia, introduced in other areas, cultivated	Belton, 1988
*Tsuga**	Pinaceae	Yes	introduced, cultivated	Dedes, 2014
Tsuga canadensis	Pinaceae	Yes	introduced, cultivated	Maier *et al.*, 2004; Robinson *et al.*, 2010
*Ulmus**	Ulmaceae	Yes	native in most of the PRA area, introduced and naturalized in some areas, cultivated	Lintner, 1896; Webster, 1916; Drooz, 1985; Barnard & Dixon, 1983; Burns & Honkala, 1990; Ontario Ministry of Natural Resources, 1991; Heppner *et al.*, 2003; Robinson *et al.*, 2010; Van Driesche *et al.*, 2013; Dedes, 2014
Ulmus americana	Ulmaceae	Yes	introduced	Lintner, 1896; Burns & Honkala, 1990; Heppner *et al.*, 2003; Robinson *et al.*, 2010
Ulmus parvifolia	Ulmaceae	Yes	introduced	Heppner *et al.*, 2003
Ulmus rubra	Ulmaceae	Yes	introduced	Burns & Honkala, 1990; Heppner *et al.*, 2003; Robinson *et al.*, 2010
Urena lobata	Malvaceae	Yes	introduced	Heppner *et al.*, 2003
*Vaccinium**	Ericaceae	Yes	native	Neil, 1979; Belton, 1988; Heppner *et al.*, 2003
Vaccinium angustifolium	Ericaceae	No		Crozier, 1997
Vaccinium corymbosum	Ericaceae	Yes	introduced, cultivated	Isaacs & van Timmeren, 2009; Schowalter, 2018
*Viburnum**	Caprifoliaceae	Yes	native	Heppner *et al.*, 2003; Robinson *et al.*, 2010
Wisteria frutescens	Fabaceae	Yes	introduced	Heppner *et al.*, 2003; Robinson *et al.*, 2010
Wisteria sinensis	Fabaceae	Yes	introduced	Heppner *et al.*, 2003; Robinson *et al.*, 2010
Zanthoxylum clava-herculis	Rutaceae	No		Heppner *et al.*, 2003; Robinson *et al.*, 2010
Zea mays	Poaceae	Yes	introducedi, cultivated	Webster, 1916; Belton, 1988; Heppner *et al.*, 2003; Robinson *et al.*, 2010

* There is no information on which species the pest was recorded.

Refers to 'cherry', listed as host plant in Dedes (2014).

Table 2. Details on association of plants on which *O. leucostigma* and its subspecies are commonly found or for which damages have been recorded. (All plants listed in this table are also indicated with green background in Table 1.)

O. leucostigma - **subspecies**	**Host plants**	**References**
O. leucostigma	**Most destructive on:** *Acer saccharinum, Tilia americana, Ulmus* sp. **Frequently found on:** *Malus domestica* **Larvae found on:** *Acer negundo, Aesculus hippocastanum, Betula* sp., *Catalpa* sp., *Fraxinus* sp., *Populus deltoides, Quercus* sp., *Salix* sp.	Webster, 1916
	Preferred species/reported to cause significant damage: *Abies balsamea, Acer platanoides, Acer saccharinum, Betula alleghaniensis, Betula papyrifera, Larix* sp., *Malus domestica*, *Platanus* sp., *Populus* sp., *Tilia americana, Ulmus* sp.	Drooz, 1985; Van Driesche *et al.*, 2013
	More often a serious pest on: *Juglans nigra, Vaccinium corymbosum*	Schowalter, 2018 and references therein
	Epidemics have occurred: *Abies balsamea, Betula* sp., *Fagus* sp., *Larix laricina, Malus domestica*, *Picea* sp., *Prunus* sp. (referring to "cherry"), *Quercus* sp., *Tsuga* sp. **Infestations in urban areas:** *Acer negundo, Ulmus* sp.	Dedes, 2014
	Preferred: *Quercus* sp.	Foltz, 2006
	Occasionally occurs in epidemic numbers and heavily defoliates: *Quercus alba, Quercus nigra, Quercus rubra, Quercus virginiana*	USDA Forest Service, 1989
	Serious pest of fruit: *Malus domestica*, *Prunus domestica, Pyrus communis* **Damage and/or outbreaks recorded on:** *Fragaria* sp., *Rubus* sp., *Vaccinium* sp., *Triticum sp., Zea mays,* vegetables	Belton, 1988
	Common Hosts: *Malus domestica, Ulmus* spp., *Quercus laurifolia, Quercus virginiana, Albizia julibrissin, Pyracantha cocinnea, Cercis canadensis, Quercus nigra*	Barnard & Dixon, 1983
	Most common on: *Abies balsamea, Betula papyrifera, Picea glauca, Larix* spp., *Acer* spp.	Morris, 1980
	Exceedingly destructive on: elms, horse-chestnut and fruit trees. Girdling of shoots of *Ulmus americana* along streets and in public parks**.**	Lintner 1896
	Preferred hosts: *Ulmus* spp., but stated in chapter on *U. rubra*) **Common defoliator:** *Tilia heterophylla* (syn. *T. americana*)	Burns & Honkala, 1990
- *leucostigma*	**Most commonly recorded from:** *Cercis canadensis, Malus domestica*, mimosa (understood to be *Albizzia julibrissin*), *Pyracantha* sp., *Quercus virginiana, Salix* sp., *Tamarix gallica*	Wallner & McManus, 1988
	Preferred hosts: *Quercus* spp.	CABI, 2020a
- *intermedia*	**Preferred hosts:** *Quercus* spp.	CABI, 2020a
- *plagiata*	**Larvae most abundant on:** *Alnus* sp., *Betula* sp., *Myrica pensylvanica, Pinus strobus, Salix* sp. **Severe damage reported on:** *Larix laricina*, *Abies balsamea*	Ferguson, 1978
	Especially damaging on: *Abies balsamea* Christmas tree plantings **Larvae found on:** *Alnus* sp., *Betula* sp., *Larix* sp., *Pinus strobus, Salix* sp.	Wallner & McManus, 1988

Table 3. Uncertain hosts

The species below are listed as host only in CABI (2020a) where no references are provided, and additional references to support the host status were not found.

Host plant	Family	Presence and status in the PRA area	
Alnus serrulata	Betulaceae	Yes	introduced
Carya illinoinensis	Juglandaceae	Yes	introduced, cultivated
Crataegus crus-galli	Rosaceae	Yes	introduced, cultivated
Lonicera japonica	Caprifoliaceae	Yes	introduced, naturalized, cultivated
Magnolia virginiana	Magnoliaceae	Yes	introduced
Prunus avium	Rosaceae	Yes	native in most of the PRA area, introduced and cultivated in some areas
Prunus salicina	Rosaceae	Yes	native in Russian Far East, introduced in some areas
Quercus montana	Fagaceae	No	
Salix fragilis	Salicaceae	Yes	native in Europe and Western Asia, introduced in other areas
Salix lutea	Salicaceae	No	
Spiraea virginiana	Rosaceae	No	
Taxus canadensis	Taxaceae	No	
Tilia cordata	Tiliaceae	Yes	native
Tilia platyphyllos	Tiliaceae	Yes	native in most of Europe, introduced and cultivated in some areas

ANNEX 6. Presence of *Orgyia leucostigma* host plants in the PRA area

Host plants of *O. leucostigma* occur throughout the PRA area as native or introduced species, in different environments including orchards and gardens (fruit trees and ornamentals), urban areas (ornamentals), forests and plantations, in the wild and as weeds. This annex presents information on twelve host plants on which *O. leucostigma* is commonly found in its native range and which are widespread in the PRA area.

Acer (A. platanoides, A. negundo, A. saccharum)

Acer platanoides (Norway maple) is widespread in the PRA area with a natural distribution range from Greece to the Ural Mountains and from Mediterranean to Scandinavian countries (Figure 1). It has also been planted extensively as a shade tree and for ornamental purposes. The introduced species *A. negundo* and *A. saccharum* are commonly used for ornamental purposes in the PRA area. *Acer negundo* is also considered an invasive alien plant in many countries in the PRA area (EPPO, 2020; Euforgen, 2020).

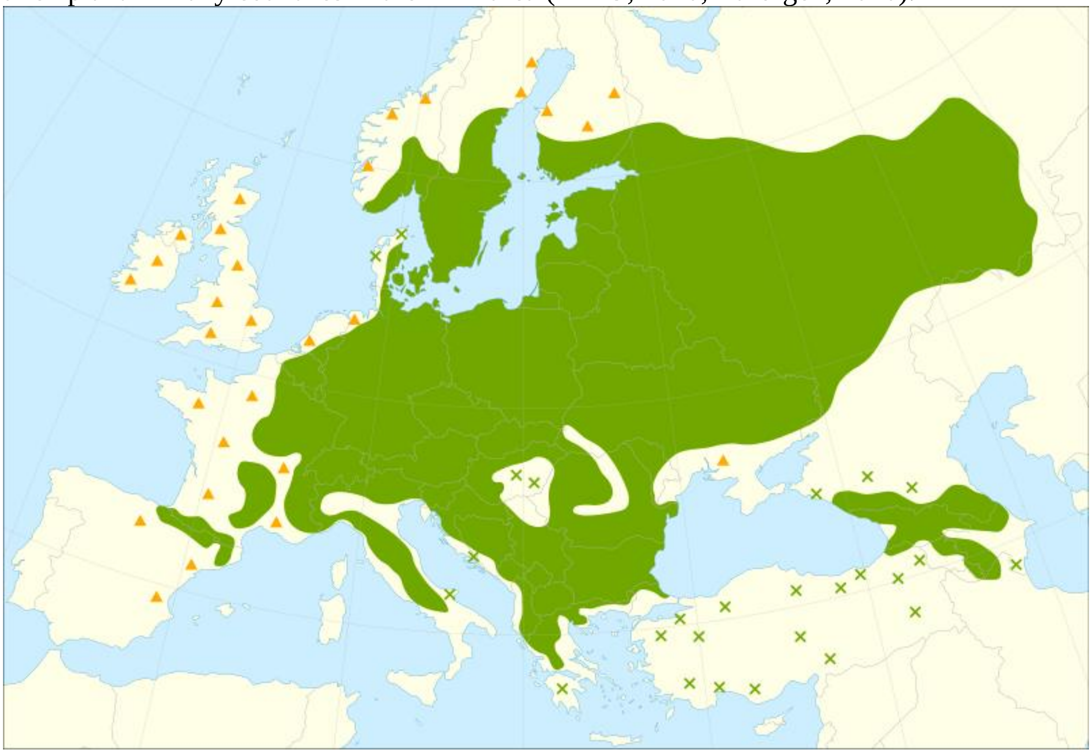


Figure 1. Distribution of *Acer platanoides* (Euforgen, 2020: http://www.EUFORGEN.org). Green area indicates the native range of the species, green crosses isolated populations and orange triangles introduced and naturalized populations.

Aesculus hippocastanum

Aesculus hippocastanum (horse-chestnut) is native in the Balkan Peninsula and widely used as an ornamental tree, particularly as a street tree, in the PRA area (CABI, 2020a; EPPO, 2020).

Fragaria

Fragaria (strawberries) species are widely cultivated in the PRA area commercially (Figure 2) and also widely present in the wild.

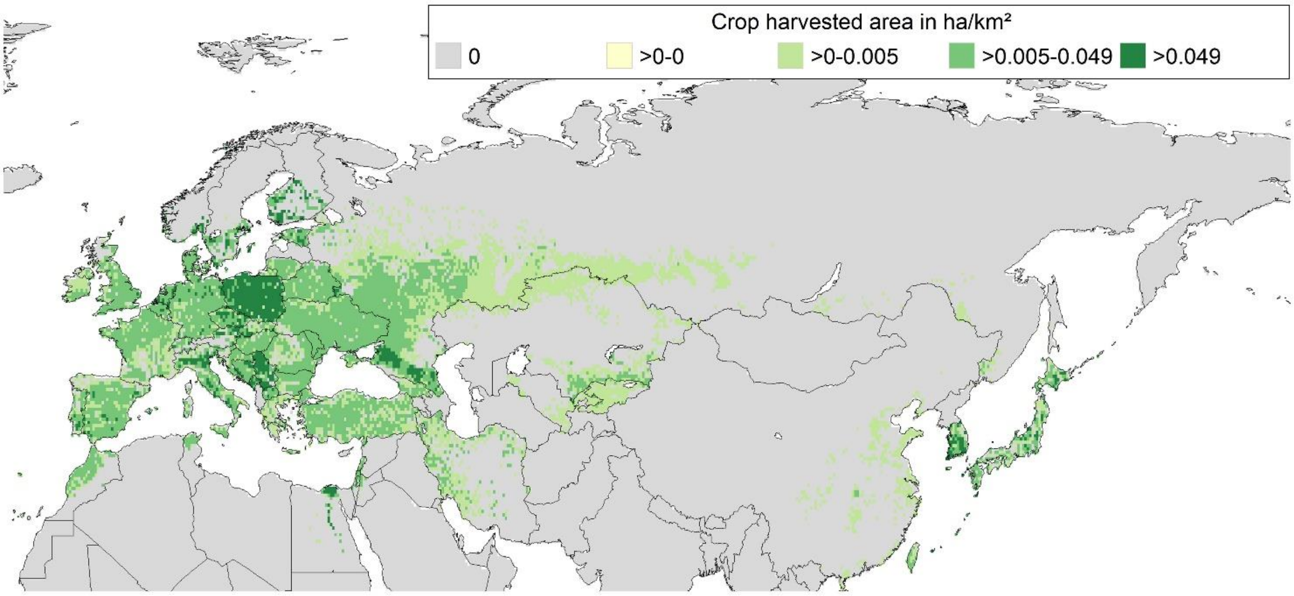


Figure 2. Commercial cultivation area of strawberry (Monfreda *et al.*, 2008).

Juglans nigra
Juglans nigra (black walnut) has been introduced into Europe from North America as a timber tree. It has acclimatized from Western Europe to Ukraine and Russia, through Central Europe. It has been planted for wood production in parts of Central and Eastern Europe, in pure and mixed stands. It is also used for ornamental purposes (EPPO, 2015b).

Malus domestica* and *Pyrus communis
Malus domestica (apple) is grown throughout the PRA area, commercially and in gardens (Figure 3). *Pyrus communis* (pear) is grown commercially in similar areas as *M. domestica* (Figure 4). It is also grown in gardens.

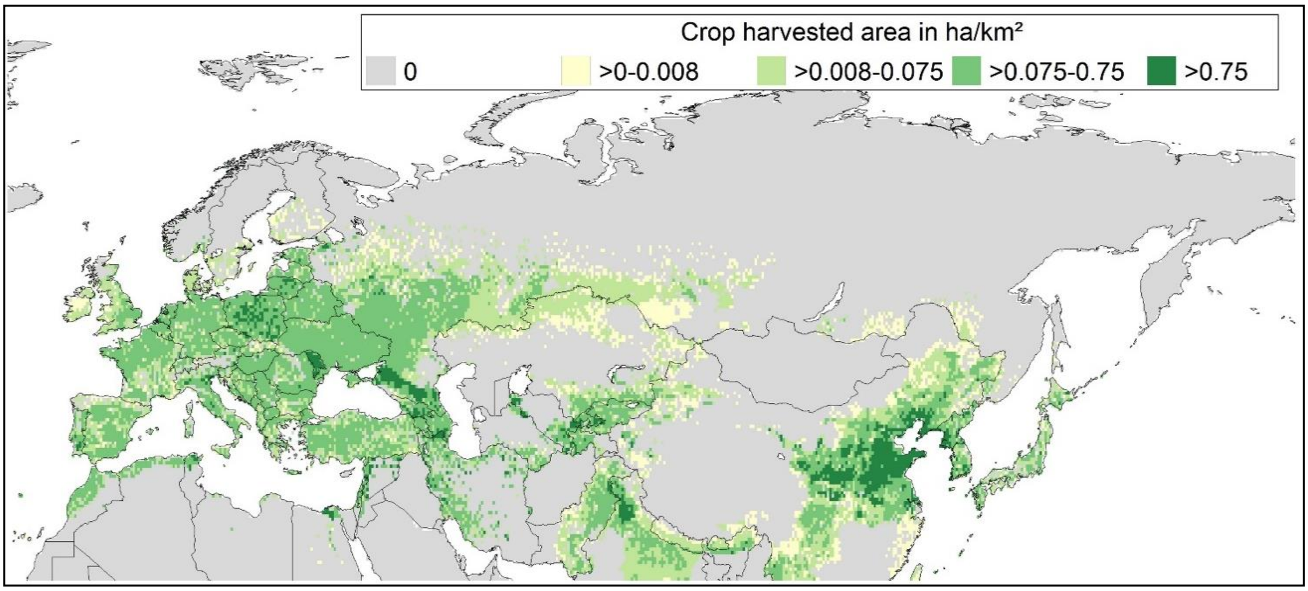


Figure 3. Commercial cultivation area of *Malus domestica* (Monfreda *et al.*, 2008).

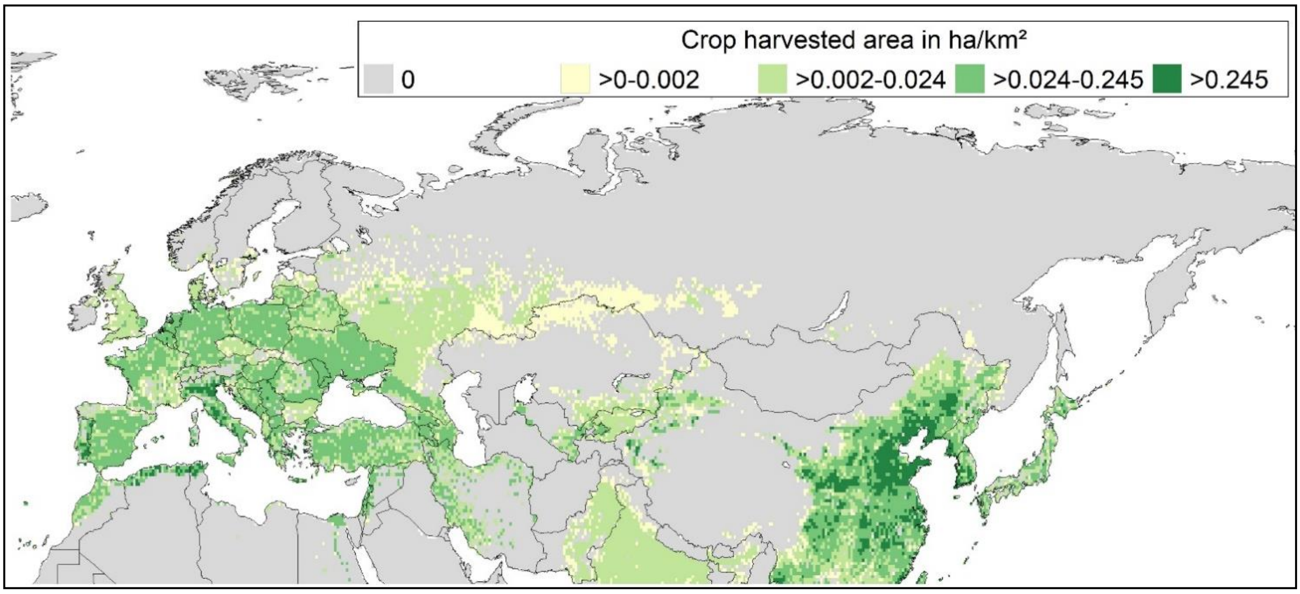


Figure 4. Commercial cultivation area of *Pyrus communis* (Monfreda *et al.*, 2008).

Prunus (P. cerasus, P. domestica)

Prunus species are present throughout the PRA area in a wide variety of habitats, including in the wild, planted as forest trees and orchards, and ornamental trees. *Prunus domestica* (plum) and *P. cerasus* (dwarf cherry) are widely cultivated commercially for fruit production and in gardens. *Prunus domestica* is cultivated throughout the PRA area (Figure 5) and *P. cerasus* throughout most of Europe and the Mediterranean. In parts of the PRA area, *P. domestica* and *P. cerasus* have been naturalized (EPPO, 2020; Euforgen, 2020).

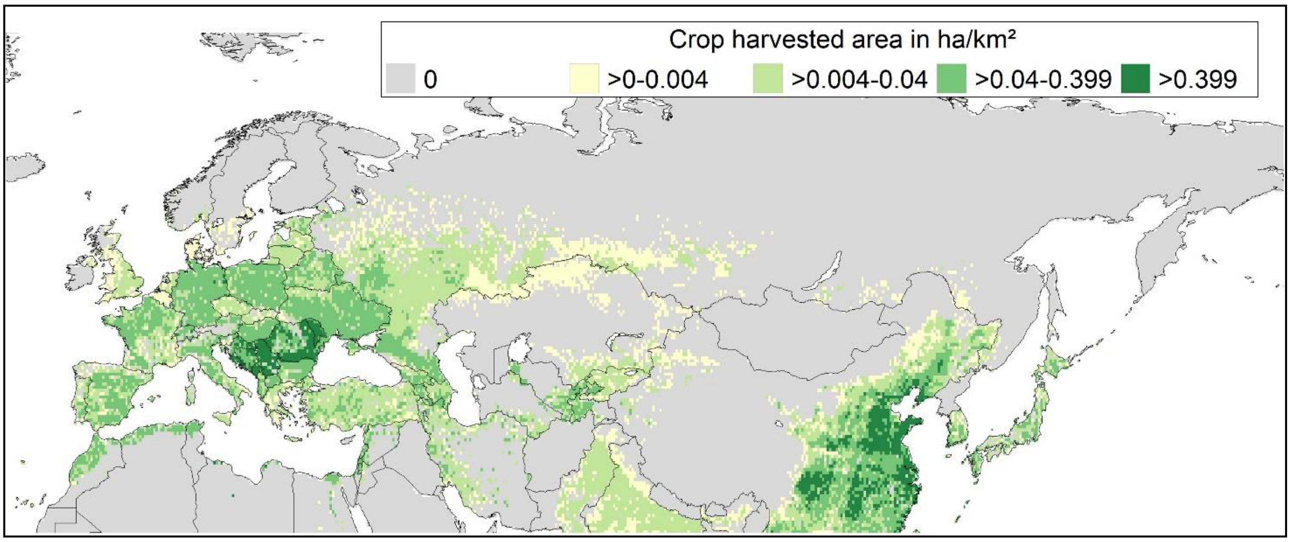


Figure 5. Commercial cultivation area of *Prunus domestica* (Monfreda *et al.*, 2008).

Quercus rubra

Quercus rubra (Northern red oak) has been introduced into Europe from North America as a timber tree. It is now naturalized throughout Europe, except in the coldest part of Scandinavia. It is an important timber species in many countries. *Quercus rubra* is also valued as an ornamental tree (EPPO, 2019; Euforgen, 2020).

Vaccinium corymbosum

Vaccinium corymbosum (the northern highbush blueberry) is cultivated commercially for fruit production in the PRA area (Figure 6). It is a common garden plant and is widely available in garden centres (EPPO, 2020).

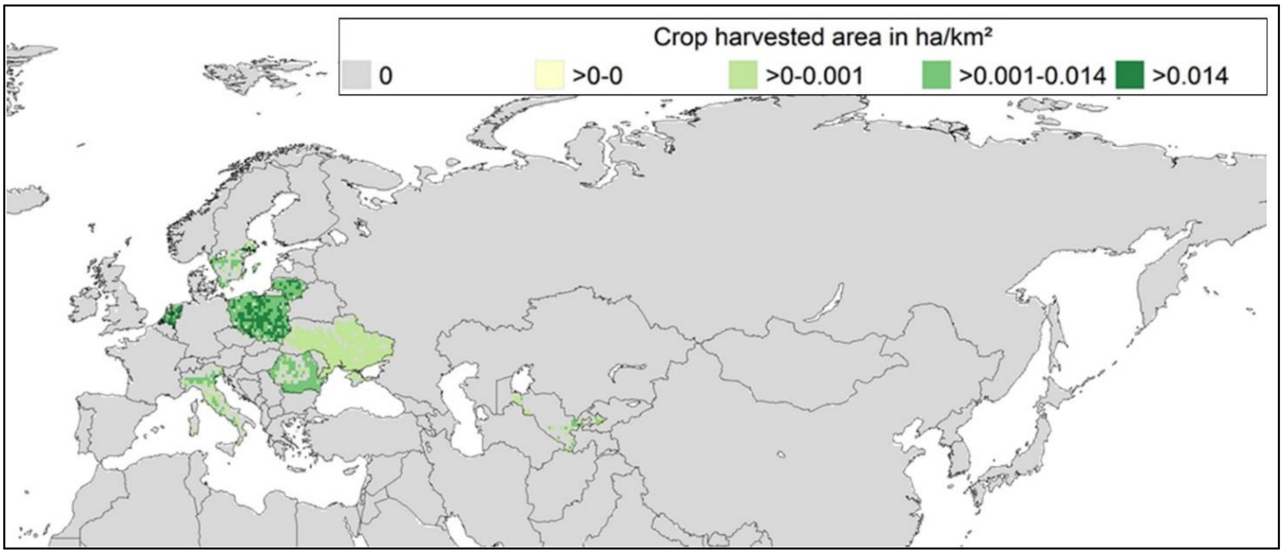


Figure 6. Commercial cultivation area of *Vaccinium corymbosum* (Monfreda *et al.*, 2008).

ANNEX 7 A. Trade in the pathway 'host plants for planting'

Table 1. Trade of *O. leucostigma* host plants for planting from Canada and USA to 14 EPPO countries in 2000–2012 according to the database used for Eschen *et al.* (2017). * indicates that *O. leucostigma* has host species in the genus but the trade data in Eschen *et al.* (2017) is not reported at species level.

	Quantity, pc.	
Host plant	**Canada**	**USA**
*Aesculus**		450
*Amelanchier**	5400	14650
*Asimina**		76000
*Buxus**		164
Callistemon sp.		45
Camellia sp.		600
*Campsis**		1210
Carpinus sp.	200	2750
Carya sp.	48	8
Catalpa sp.	2155	
Celtis occidentalis		150
*Celtis**		6
Cercis canadensis		444
*Cercis**		9071
Chionanthus virginicus		40
*Chionanthus**		6
Clematis sp.		2622
*Convallaria**		2501
*Cotinus**		10201
*Euonymus**	100	145
*Geranium**		20144
Gleditsia triacanthos		100
*Gleditsia**	570	26
*Gymnocladus**		3175
Helianthus sp.		1034
*Hibiscus**		45451
*Ipomoea**		7295
Iris sp.	60000	188292
Kalmia sp.		153

	Quantity, pc.	
Host plant	**Canada**	**USA**
Liquidambar styraciflua		1135
*Liquidambar**	2	1405
*Liriodendron**		19
*Litchi**		4
Malus	1331	22231
Magnolia sp.		12848
Mimosa sp.		2
Morus sp.		2
Nyssa sylvatica		297
*Nyssa**		117
*Ostrya**		11
*Oxydendrum**		6417
*Paulownia**		216
Prunus	0	6
Pyrus	17	7
Rhododendron sp.		542
Ribes sp.	20	10001
Rubus sp.		377615
*Sassafras**		7
Spiraea sp.	3060	182
Syringa vulgaris		625
*Syringa**	3463	1833
*Tamarix**		250
Trifolium sp.		216
Vaccinium corymbosum		36773
Vaccinium sp.		266568
Viburnum sp.		13302
*Wisteria**	50	8601
Total	**76416**	**1147965**

Table 2. Unrooted cuttings and slips (excl. vines) (CN 06021090). Imports by EU countries. EUROSTAT. Quantities in 100 kg (0 means below 100 kg).

	Canada					**USA**				
	2015	**2016**	**2017**	**2018**	**2019**	**2015**	**2016**	**2017**	**2018**	**2019**
Belgium						1	1	0	0	0
Czechia								0		
Denmark				1	2	0	0	7	0	0
Germany						2	2	2	1	2
Ireland										0
Spain						0	0	0	0	2
France					0	0			3	0
Italy						0	0	0	0	0
Hungary							0			
Netherlands	1		5	2	0	49	37	26	9	7
Austria									5	

	Canada					USA				
	2015	**2016**	**2017**	**2018**	**2019**	**2015**	**2016**	**2017**	**2018**	**2019**
Poland		0				0	0	373	0	420
Portugal						1	1	2	1	1
Slovenia							0	0		
Finland								0		
Sweden				0		0				
United Kingdom						4	4			
Total	**1**	**0**	**5**	**3**	**2**	**57**	**45**	**410**	**19**	**432**

Table 3. Outdoor rooted cuttings and young plants of trees, shrubs and bushes (excl. fruit, nut and forest trees) (CN 06029045). Imports by EU countries. EUROSTAT. Quantities in 100 kg (0 means below 100 kg).

	Canada					USA				
	2015	**2016**	**2017**	**2018**	**2019**	**2015**	**2016**	**2017**	**2018**	**2019**
Belgium							3	0		
Germany		3			0	125	1	2	5	9
Ireland								1		
Spain						2			10	51
France						7	42	18	12	17
Italy							1			
Latvia						1				
Hungary									3	
Netherlands		0				17	14	20	19	82
Poland							1			
Portugal							0		0	0
Finland	0	0	0	0		1		0	1	1
Sweden			1			0	0		0	
United Kingdom	4					88	2	1	9	12
Total	**4**	**3**	**1**	**0**	**0**	**241**	**64**	**42**	**59**	**172**

Table 4. Trees, shrubs and bushes of kinds which bear edible fruit or nuts (CN 06022090, 06022020 and 06022080). Imports by EU countries. EUROSTAT. Quantities in 100 kg (0 means below 100 kg).

	Canada					USA				
	2015	**2016**	**2017**	**2018**	**2019**	**2015**	**2016**	**2017**	**2018**	**2019**
Belgium						1		0		
Germany				8		70	18	57	165	8
Spain						123	413	573	1240	438
France						1		0	0	
Croatia								0		
Italy						123	1		1	0
Cyprus						76	145	110	64	
Netherlands			470	0		0	20167	17759	6027	6459
Austria										0
Poland						0	0	115	0	
Portugal						115	213		0	0
Romania						3				
Slovakia						0				
Finland			0	0	0					
Sweden				0						0
United Kingdom	1	0								
Total	**1**	**0**	**470**	**8**	**0**	**512**	**20957**	**18614**	**7497**	**6905**

Table 5 Outdoor trees, shrubs and bushes (excl. cuttings, slips and young plants, and fruit, nut and forest trees) (CN 06029046, 06029048 and 06029047). Imports by EU countries. EUROSTAT. Quantities in 100 kg (0 means below 100 kg).

	Canada					**USA**				
	2015	**2016**	**2017**	**2018**	**2019**	**2015**	**2016**	**2017**	**2018**	**2019**
Belgium	0						2		0	0
Germany	0	0				89	14	14	1611	
Ireland						0	0			
Spain						1				0
France						49	21	17	1	12
Latvia						6				
Hungary										0
Netherlands						2	3094	687	316	
Poland							0	0	0	0
Portugal						2	2		0	15
Sweden						47				
United Kingdom		2	2							
Total	**0**	**2**	**2**			**196**	**3133**	**718**	**1928**	**27**

Table 6 Live forest trees (CN 06029041). Imports by EU countries. EUROSTAT. Quantities in 100 kg (0 means below 100 kg).

	Canada					**USA**				
	2015	**2016**	**2017**	**2018**	**2019**	**2015**	**2016**	**2017**	**2018**	**2019**
France						0		0		0
Netherlands						2	51	67	0	
Finland								0	0	
United Kingdom							1			
Total						**2**	**52**	**67**	**0**	**0**

Table 7. Rhododendrons and azaleas (CN 06023000). Imports by EU countries. EUROSTAT. Quantities in 100 kg (0 means below 100 kg).

	Canada					**USA**				
	2015	**2016**	**2017**	**2018**	**2019**	**2015**	**2016**	**2017**	**2018**	**2019**
Belgium						0				
France							0			
Netherlands							2			
Finland						3	4	5	3	3
Sweden							2		1	
Total						**3**	**8**	**5**	**4**	**3**

Table 8. Roses (CN 06024000). Imports by EU countries. EUROSTAT. Quantities in 100 kg (0 means below 100 kg).

	Canada					**USA**				
	2015	**2016**	**2017**	**2018**	**2019**	**2015**	**2016**	**2017**	**2018**	**2019**
Belgium						0				
France							0			
Netherlands							2			
Finland						3	4	5	3	3
Sweden							2		1	
Total						**3**	**8**	**5**	**4**	**3**

ANNEX 7 B. Trade in the pathway 'above-ground fresh plant parts of host plants'

Table 1. Fresh Christmas trees (CN 06042020). Imports by EU countries. EUROSTAT. Quantities in 100 kg (0 means below 100 kg).

	Canada					**USA**				
	2015	**2016**	**2017**	**2018**	**2019**	**2015**	**2016**	**2017**	**2018**	**2019**
France										0
Total										**0**

Table 2. Fresh conifer branches, suitable for bouquets or ornamental purposes (CN 06042040). Imports by EU countries. EUROSTAT. Quantities in 100 kg (0 means below 100 kg).

	Canada					**USA**				
	2015	**2016**	**2017**	**2018**	**2019**	**2015**	**2016**	**2017**	**2018**	**2019**
Luxembourg										87
Total										**87**

Table 5. Foliage, branches and other parts of plants, without flowers or flower buds, and grasses, fresh, suitable for bouquets or ornamental purposes (excl. Christmas trees and conifer branches) (CN 06042090). Imports by EU countries. EUROSTAT. Quantities in 100 kg (0 means below 100 kg).

	Canada					**USA**				
	2015	**2016**	**2017**	**2018**	**2019**	**2015**	**2016**	**2017**	**2018**	**2019**
Belgium						14 829		530	85	
Czechia						0				
Denmark							0			
Germany	244	207	358	130	296	3 994	1 644	1 140	1 169	1 145
Estonia										0
Spain						4	3	3	2	1
France						10	32	25	162	6
Italy								1	6	
Netherlands	22 220	3 251	6 467	3 289	915	166 857	193 073	167 741	161 279	156 499
Austria						0			0	
Finland								0		
Sweden						107	74	2	0	0
Total	**22 464**	**3 458**	**6 825**	**3 419**	**1 211**	**185 801**	**194 827**	**169 442**	**162 704**	**157 651**

ANNEX 7 C. Trade in the pathway 'wood (round wood and sawn wood) of hosts with or without bark'

Roundwood – conifers & non-conifers - FAOSTAT

Table 1. 'Industrial roundwood, coniferous'. FAOSTAT. Exports quantities from Canada and the USA, in m^3.

	Canada				**USA**			
	2014	**2015**	**2016**	**2017**	**2014**	**2015**	**2016**	**2017**
Algeria					9198	2052	5391	
Austria		80			1000	1	46	
Belgium					9000	7000	3000	
Cyprus					4295	2399	564	
Czechia	1000			1000	173	268	269	
Denmark	318				671	2056		49
Estonia						566	843	
Finland					184	2000	453	
France	410			10	38000	25000	7000	3
Georgia				356				
Germany	459			267	16000	8000	5000	
Greece					2648	1981	1295	382
Ireland	90000	96000	63000	128000	7000	7000	7000	267
Israel	57				951	1623	2939	
Italy	1				434000	431000	241000	
Lithuania						723	1000	
Malta						581		
Morocco			502		1658	4609	5443	
Netherlands					19789	10563	458	1
Norway					448	1000	13000	1000
Poland						1000		394
Portugal					7000	8000	5000	
Romania					1000	1000		
Russia			583					
Slovakia						67	10	
Slovenia					910	7210	2956	
Spain					27000	26000	24000	1000
Sweden					76		1000	2
Switzerland				137	4	22	1	
Turkey					24000	25000	2000	1053
Ukraine		252			1226			
United Kingdom	5000	1000			91000	86000	35000	141
Uzbekistan							8000	
Total	**97245**	**97332**	**64085**	**129770**	**697231**	**662721**	**372668**	**4292**

Table 2. 'Industrial roundwood, non-coniferous non-tropical'. FAOSTAT. Exports quantities from Canada and the USA, in m^3.

	Canada				**USA**			
	2014	**2015**	**2016**	**2017**	**2014**	**2015**	**2016**	**2017**
Albania							241	
Algeria					2687	2085	1271	1373
Austria		1000	2000	399	4000	8000	2000	10000
Belarus								1272
Belgium	208	1000		41	127000	37000	29000	12000
Bosnia and Herzegovina							352	799
Bulgaria					302			

	Canada				USA			
	2014	**2015**	**2016**	**2017**	**2014**	**2015**	**2016**	**2017**
Croatia						447	420	
Cyprus					864		855	714
Czechia	351	4000	1697		6875	15000	1000	5000
Denmark			42		57000	23000	19000	8000
Estonia					15081	25477	19226	20027
Finland					28000	6000	6000	7000
France	29	158	90	385	31000	17000	22000	3593
Germany	3954	7000	10000	2000	143000	128000	119000	154000
Greece					5682	3405	419	
Hungary					1			
Ireland	674	853			31504	16419	10447	11845
Israel					20006	15069	12977	11747
Italy			494		231000	189000	175000	297000
Latvia								101
Lithuania					7818	7000	2000	521
Luxembourg				5	29			7
Malta					3433	4986	2426	929
Morocco					7103	6994	5188	3709
Netherlands		221	3		3616	17922	12470	7686
Norway		1230		363	35031	15659	30245	36202
Poland					2000	9000	3000	1000
Portugal					189000	143000	112000	139000
Romania						1000	2000	2000
Russia					2519	659		
Slovenia	171	375	2	293	1000	8696	2551	2686
Spain	15	8			145000	95000	121000	62000
Sweden	156	4000	305		51000	30000	24000	26000
Switzerland	196	608			11	1910	695	60
Turkey					204508	167051	129065	99909
Ukraine	133				220		1248	2216
United Kingdom	22991	27155	1554	101	328167	280925	232048	22000
Total	**28878**	**47608**	**16187**	**3587**	**1684457**	**1275704**	**1099144**	**950396**

Sawnwood – conifers & non-conifers - FAOSTAT

Table 3. 'Sawnwood, coniferous'. FAOSTAT. Exports quantities from Canada and the USA, in m^3.

	Canada				USA			
	2014	**2015**	**2016**	**2017**	**2014**	**2015**	**2016**	**2017**
Albania		11						
Algeria		191	449		7000	6000	3000	2000
Austria	38000	31000	35000	34000	178	212		
Belgium	217000	223000	163000	185000	3000	4000	6000	7000
Bosnia and Herzegovina							12	
Bulgaria	73	178	225		51	12	96	48
Croatia	2		21		27			
Cyprus	89	267	167	63	13	7	188	14
Czechia	1891	884	3000	750	352	62		28
Denmark	7000	4000	8000	5000	1000	2000	1000	423
Estonia	115	418	108	152	525	340	1000	1000
Finland	1893	456	422	57		60	40	21
France	209000	254000	257000	214000	8000	7000	9000	7000
Georgia						71	5	

	Canada				USA			
	2014	**2015**	**2016**	**2017**	**2014**	**2015**	**2016**	**2017**
Germany	415000	486000	552000	543000	15000	7000	8000	9000
Greece	2	64	110		193	97	248	242
Hungary			3	348	2		1	
Ireland	3779	1511	1364	587	2389	586	345	112
Israel	2185	1149	1034	620	6077	4392	5651	5037
Italy	12000	11000	18000	15000	22000	21000	16000	14000
Kazakhstan	91							
Kyrgyzstan						354		
Latvia	270	239	126					
Lithuania	951	480	58		174	398	23	
Luxembourg	5				21	31	9	24
Malta					134	414	33	
Morocco	801	314	1030	124	1000	1000	1000	1000
Netherlands	152000	176000	168000	179000	5000	5000	5000	3000
Norway	1527	1435	2391	1000	4000	3000	4000	2000
Poland	390	298	600	22	7	53	274	
Portugal			128	14	2566	1561	1153	779
Republic of Moldova			148	176			14	
Romania			597			67		
Russia	701		2	4	544	238	1059	110
Slovakia			159	33	423	148		
Slovenia	22	119	10			2000	3000	10
Spain	11000	8000	10000	9000	18000	20000	25000	32000
Sweden	2416	1971	5894	741	2137	1693	171	
Switzerland	1356	1664	1965	839	547	80	195	87
Tunisia		56		41	89	149	178	41
Turkey	264	337	86	36	3000	1000	1000	1000
Ukraine	3	31						
United Kingdom	815000	847000	904000	998000	16000	15000	15000	6000
Total	**1894826**	**2052073**	**2135097**	**2187607**	**119449**	**105025**	**107695**	**91976**

Table 4. 'Sawnwood, non-coniferous all'. FAOSTAT. Exports quantities from Canada and the USA, in m^3.

	Canada				USA			
	2014	**2015**	**2016**	**2017**	**2014**	**2015**	**2016**	**2017**
Albania					131	159	508	270
Algeria	95	26	427		255	293	286	85
Austria	31	316	267	81	1000	1000	1000	433
Azerbaijan								6
Belarus					464	347	436	236
Belgium	1000	1000	1000	2000	10000	11000	12000	12000
Bosnia and Herzegovina		9	2		3	25	56	69
Bulgaria	187		141	366	193	309	316	57
Croatia	72	52	104	139	40	28	149	142
Cyprus	38	76	148	316	428	635	794	1122
Czechia	31		5	16	1305	301	636	158
Denmark	1274	1737	2023	1000	6658	4286	7468	5000
Estonia	2870	761	1080	1057	16065	7626	7517	9696
Finland	318	335	192	225	2496	2538	3099	2930
France	1000	1000	1000	1000	4000	5000	7000	5000
Georgia				511	113	266	152	107
Germany	11000	10000	10000	9000	50000	45000	53000	57000

	Canada				USA			
	2014	**2015**	**2016**	**2017**	**2014**	**2015**	**2016**	**2017**
Greece	180	160	345	145	4946	3485	4693	3489
Hungary				95		79	17	
Ireland	1995	2433	2559	1997	11798	13196	15136	11699
Israel	2000	1271	822	592	11000	8922	7997	9300
Italy	2000	2000	2000	1000	73000	59000	57000	55000
Kazakhstan					29		17	
Kyrgyzstan						378		
Latvia			9	23	863	607	265	21
Lithuania	1154	416	1000	1000	3675	3000	3000	3000
Malta		291			2725	2605	3411	2838
Morocco	3555	2505	1920	799	2188	3067	3246	2539
Netherlands	1000	1000	2000	2000	7000	7000	6000	6000
Norway	177	259	233	570	4624	6659	6456	6964
Poland	1000	498	394	138	3000	3000	4000	3000
Portugal	1703	1278	1441	2669	18708	15690	17076	14852
Republic of Moldova				37			11	4
Romania					1523	887	758	1142
Russian Federation	180	14	6	110	2289	636	1072	589
Slovakia	11	23	26	2	108	6	23	25
Slovenia	55	42			91	70	93	3495
Spain	2000	1000	1000	2000	36000	45000	47000	48000
Sweden	676	433	1796	2091	15854	15401	15565	11394
Switzerland	84	178	67	89	376	107	213	256
Tunisia	65	3		14	28			9
Turkey	2657	4746	2699	2304	13204	17140	11907	11398
Ukraine	6			6	26	4		14
United Kingdom	16000	15000	13000	10000	106000	95000	113000	145000
Total	**54414**	**48862**	**47706**	**43392**	**412206**	**379752**	**412373**	**434339**

Wood in the rough – conifers - EUROSTAT

Table 5. Fir (*Abies* spp.) and spruce (*Picea* spp.) in the rough, whether or not stripped of bark or sapwood, or roughly squared, excl. sawlogs (CN 44032019, 44032400 and 44032390). Imports by EU countries. EUROSTAT. Quantities in 100 kg (0 means below 100 kg).

	Canada					USA				
	2015	**2016**	**2017**	**2018**	**2019**	**2015**	**2016**	**2017**	**2018**	**2019**
Germany			57							
Ireland								0		
Spain										265
Austria	4							3		
Total	**4**		**57**					**3**		**265**

Table 6. Pine (*Pinus* spp.) in the rough, whether or not stripped of bark or sapwood, or roughly squared, excl. sawlogs (CN 44032039, 44032200 and 44032190). Imports by EU countries. EUROSTAT. Quantities in 100 kg (0 means below 100 kg).

	Canada					USA				
	2015	**2016**	**2017**	**2018**	**2019**	**2015**	**2016**	**2017**	**2018**	**2019**
Belgium				181						
Ireland				219						
Spain				125			176	476	527	769
France					52			0		
Italy										18

	Canada					USA				
	2015	**2016**	**2017**	**2018**	**2019**	**2015**	**2016**	**2017**	**2018**	**2019**
Netherlands								18	9	9
Austria			1				7	10		
Poland									0	
Sweden							2			
Greece								258	242	
Total			**1**	**525**	**52**		**185**	**762**	**778**	**796**

Table 7. Coniferous wood (excl. pine, fir and spruce) in the rough, whether or not stripped of bark or sapwood, or roughly squared excl. sawlogs (CN 44032099, 44032600 and 44032590). Imports by EU countries. EUROSTAT. Quantities in 100 kg (0 means below 100 kg).

	Canada					USA				
	2015	**2016**	**2017**	**2018**	**2019**	**2015**	**2016**	**2017**	**2018**	**2019**
Belgium					319	0	0			5
Czechia									0	47
Denmark								102	59	
Ireland	115	307				1439	588			
Spain						241	246			
France							0	0		0
Netherlands						164	39		0	
Austria	6									
Poland								22		
Slovenia							86		55	
Sweden							242			2
Greece						484	1			
United Kingdom	1626					20				
Total	**1747**	**307**			**319**	**2348**	**1202**	**124**	**114**	**54**

Wood in the rough – non-conifers - EUROSTAT

Table 8. Birch (*Betula* spp.) in the rough, whether or not stripped of bark or sapwood, or roughly squared (CN 44039959, 44039600 and 44039590). Imports by EU countries. EUROSTAT. Quantities in 100 kg (0 means below 100 kg).

	Canada					USA				
	2015	**2016**	**2017**	**2018**	**2019**	**2015**	**2016**	**2017**	**2018**	**2019**
Czechia									0	
Denmark		5				946	358			
Ireland				56						
France	0									
Italy						390				
Finland							0			
Total	**0**	**5**		**56**		**1336**	**358**		**0**	

Table 9. Beech (*Fagus* spp.) in the rough, whether or not stripped of bark or sapwood, or roughly squared (CN 44039290, 44039300 and 44039400). Imports by EU countries. EUROSTAT. Quantities in 100 kg (0 means below 100 kg).

	Canada					USA				
	2015	**2016**	**2017**	**2018**	**2019**	**2015**	**2016**	**2017**	**2018**	**2019**
Portugal								217		
Total								**217**		

Table 10. Poplar and aspen (*Populus* spp.) in the rough, whether or not stripped of bark or sapwood, or roughly squared (CN 44039910 and 44039700). Imports by EU countries. EUROSTAT. Quantities in 100 kg (0 means below 100 kg).

	Canada					**USA**				
	2015	**2016**	**2017**	**2018**	**2019**	**2015**	**2016**	**2017**	**2018**	**2019**
Germany										462
Spain						7610	11167			
France										
Italy						1916	3743	466	73	
Finland				0						
Sweden						440		182	193	220
Greece										200
United Kingdom						404				
Total				**0**		**10370**	**14910**	**648**	**266**	**882**

Table 11. Oak (*Quercus* spp.) in the rough, whether or not stripped of bark or sapwood, or roughly squared (CN 44039190). Imports by EU countries. EUROSTAT. Quantities in 100 kg (0 means below 100 kg).

	Canada		**USA**	
	2015	**2016**	**2015**	**2016**
Belgium				12
Czechia			1920	739
Denmark			229	0
Germany			15291	16910
Ireland	263		1284	
Spain			143249	104348
France			2213	2508
Netherlands			298	
Austria			3	
Portugal			36150	26985
Slovenia		1		
Finland				0
Sweden			168	
United Kingdom	1072		203	1559
Total	**1335**	**1**	**201008**	**153061**

Table 12. Non-coniferous wood in the rough, whether or not stripped of bark or sapwood, or roughly squared (excl. tropical wood, oak, beech, birch, poplar, aspen and eucalyptus) (CN 44039995 and 44039900). Imports by EU countries. EUROSTAT. Quantities in 100 kg (0 means below 100 kg).

	Canada					**USA**				
	2015	**2016**	**2017**	**2018**	**2019**	**2015**	**2016**	**2017**	**2018**	**2019**
Belgium			4	103		405	207		12	20
Bulgaria										239
Czechia	2744	1303			0	8828	10550	253	3158	16554
Denmark						7459	5791	4994	317745	10338
Germany	380		767	1001	462	126143	111239	102768	90029	92229
Ireland						195	3	0	0	0
Spain						10444	22182	25828	24636	15843
France		217	208	243	247	817	3663	190	0	0
Croatia										0
Italy		432			956	396591	372526	372593	341250	240960
Luxembourg			2							
Hungary									209	
Malta										

	Canada					USA				
	2015	**2016**	**2017**	**2018**	**2019**	**2015**	**2016**	**2017**	**2018**	**2019**
Netherlands				105	10	15506	4635	3769	8652	7938
Austria		419			240	6528	12127	2570	2146	2229
Poland						203	203	3	442	230
Portugal						44500	37336	44590	49186	42625
Romania								776		
Slovenia						8017	2326	970	859	1371
Finland						0		6	4	0
Sweden						554				
United Kingdom	6194	787	840	425	1	2662	1580	2134	933	913
Total	**9318**	**3158**	**1821**	**1877**	**1916**	**628852**	**584368**	**561444**	**839261**	**431489**

Sawlogs – conifers - EUROSTAT

Table 13. Sawlogs of fir (*Abies* spp.) and spruce (*Picea* spp.), whether or not stripped of bark or sapwood, or roughly squared (CN 44032011 and 44032310). Imports by EU countries. EUROSTAT. Quantities in 100 kg (0 means below 100 kg).

	Canada					USA				
	2015	**2016**	**2017**	**2018**	**2019**	**2015**	**2016**	**2017**	**2018**	**2019**
France							0			
Italy						6801	612			
Netherlands			0					0		
Poland						73				
United Kingdom						5				
Total			**0**			**6879**	**612**	**0**		

Table 14. Sawlogs of pine (*Pinus* spp.), whether or not stripped of bark or sapwood, or roughly squared (CN 44032031, 44032031 and 44032110). Imports by EU countries. EUROSTAT. Quantities in 100 kg (0 means below 100 kg).

	Canada					USA				
	2015	**2016**	**2017**	**2018**	**2019**	**2015**	**2016**	**2017**	**2018**	**2019**
Spain						204			461	
Netherlands								0	9	
Sweden								0		
United Kingdom									196	
Total						**204**		**0**	**666**	

Table 15. Sawlogs, coniferous (excl. pine, fir and spruce), whether or not stripped of bark or sapwood, or roughly squared (CN 44032091 and 44032510). Imports by EU countries. EUROSTAT. Quantities in 100 kg (0 means below 100 kg).

	Canada					USA				
	2015	**2016**	**2017**	**2018**	**2019**	**2015**	**2016**	**2017**	**2018**	**2019**
Germany							162			
Italy							221			
Austria						39				
United Kingdom									8	
Total						**39**	**383**		**8**	

Sawlogs – non-conifers - EUROSTAT

Table 16. Sawlogs of birch (*Betula* spp.), whether or not stripped of bark or sapwood, or roughly squared (CN 44039951 and 44039510). Imports by EU countries. EUROSTAT. Quantities in 100 kg (0 means below 100 kg).

	Canada					**USA**				
	2015	**2016**	**2017**	**2018**	**2019**	**2015**	**2016**	**2017**	**2018**	**2019**
France						204				
Italy						207				
Portugal						445				
Total						**856**				

Table 17. Sawlogs of beech (*Fagus* spp.), whether or not stripped of bark or sapwood, or roughly squared (CN 44039210). Imports by EU countries. EUROSTAT. Quantities in 100 kg (0 means below 100 kg).

	Canada		**USA**	
	2015	**2016**	**2015**	**2016**
France				172
Austria				1077
Total				**1249**

Table 18. Sawlogs of oak (*Quercus* spp.), whether or not stripped of bark or sapwood, or roughly squared (CN 44039110). Imports by EU countries. EUROSTAT. Quantities in 100 kg (0 means below 100 kg).

	Canada		**USA**	
	2015	**2016**	**2015**	**2016**
Germany			597	
Spain			904	718
Austria				615
Portugal			9816	4732
Sweden	865	110	17979	2005
United Kingdom				905
Total	**865**	**110**	**29296**	**8975**

ANNEX 7 D. Trade in the pathway 'wood chips, hogwood, processing wood residues (except sawdust and shavings)'

Table 1. 'Wood chips and particles'. FAOSTAT. Exports quantities from Canada and the USA to the EPPO countries, in m^3.

	Canada				**USA**			
	2014	**2015**	**2016**	**2017**	**2014**	**2015**	**2016**	**2017**
Austria	1				18	85		22
Azerbaijan					3			
Belgium	91	20	10	37	4578	1278		13
Czechia	7		15		5	15	1	
Denmark			18	127	4000	11000		
Finland	27	24		21	13	23	7	11
France				5	37000	38000	28000	85000
Georgia					127	20		
Germany	1000	1000	11	1000	55000	18000	27000	193000
Greece	4		9	106				
Hungary	1		2	244		13		
Ireland					17	16		
Israel	1	2		354	1361	8186	2	466
Italy	27000	11	31	24	95000	15000	37000	76000
Lithuania				228				
Malta			9	18				
Netherlands	337	1000	447	1000	3488	9000	1	236
Norway	21				126	10		
Poland	6	4	2	1	11	1000	1	38
Portugal							11	5
Republic of Moldova							1	3
Russia					8	10	3	2
Slovenia						18		22
Spain		84		75	14000	29080	7	
Sweden	99	39	30	379	187	173		195
Switzerland	2		2		5	27		2
Turkey	528000	460000	352000	236000	1826000	1703000	2246000	2168000
Ukraine	1							
United Kingdom	36	107	70	92	6438	8058	8	203
Total	**556633**	**462292**	**352656**	**239711**	**2047385**	**1842012**	**2338042**	**2523218**

ANNEX 8. Climate in North America and the PRA area

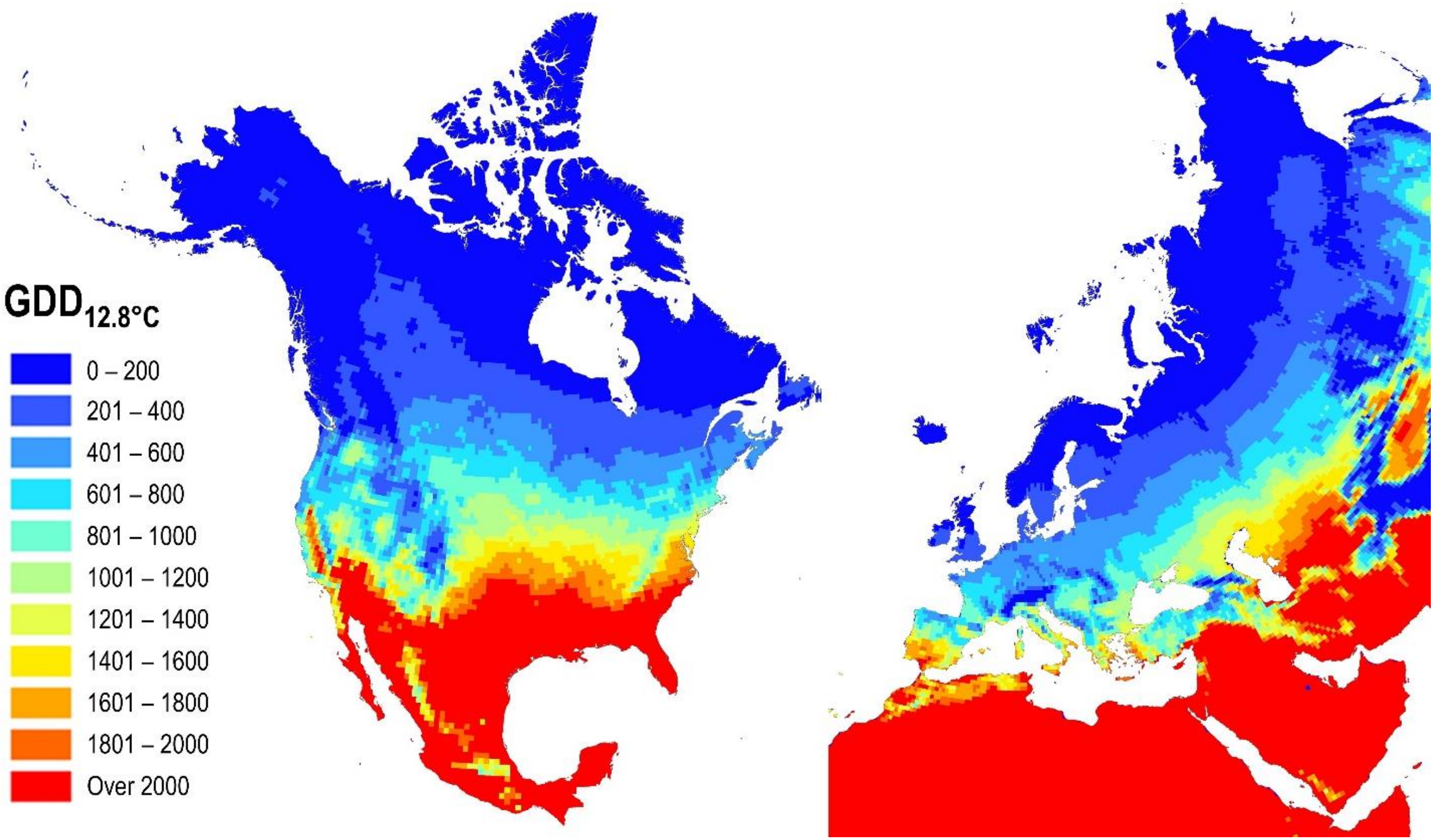


Figure 1. Annual growing degree days ($GDD_{12.8°C}$) calculated using the CLIMEX software (Kriticos *et al.*, 2015) and temperature data for 1960–1990 (Kriticos *et al.*, 2012).

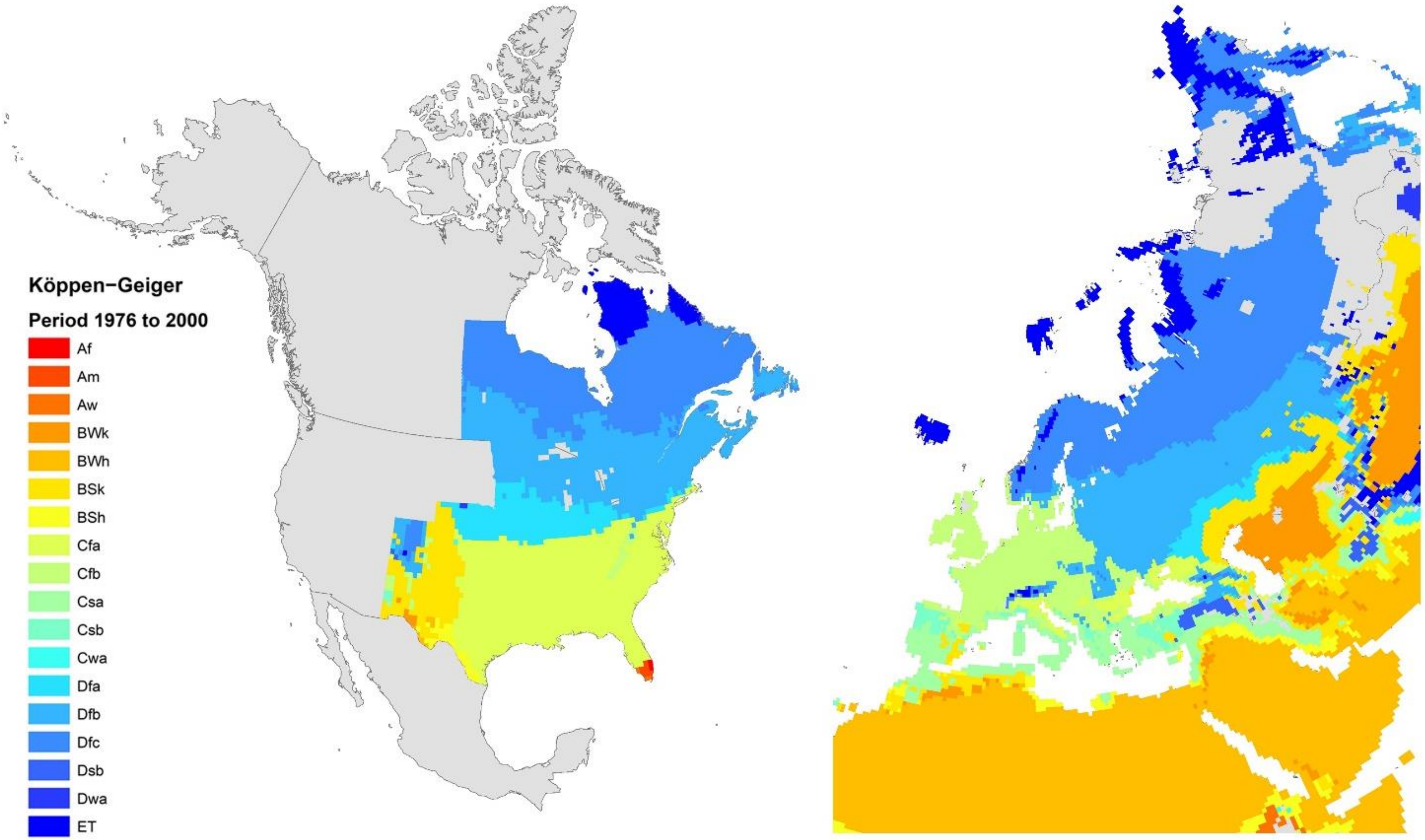


Figure 2. Köppen-Geiger climate classification calculated from observed temperature and precipitation data for 1976–2000 by Rubel & Kottek (2010). For North America the climate types are only shown for the states and provinces where *O. leucostigma* is reported to occur (section 6, Table 3). For the PRA area, only the climate types occurring in the distribution range of the pest in North America are presented.

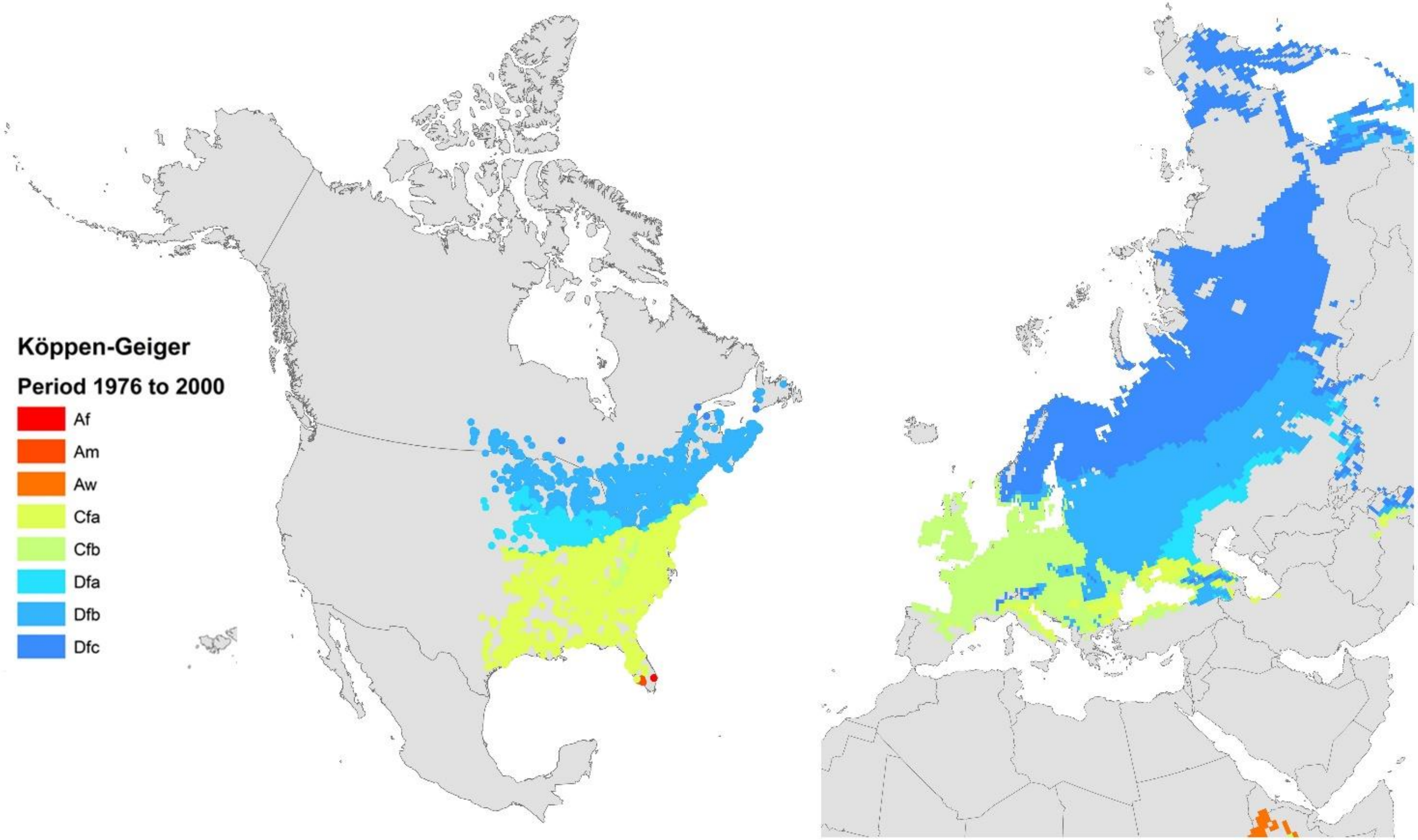


Figure 3. Köppen-Geiger climate classification calculated from observed temperature and precipitation data 1976–2000 by Rubel & Kottek (2010). For North America, the climate types are shown only for the observation points of *O. leucostigma* recorded in the iNaturalist database (iNaturalist 2020). Only the observations that had a community agreement (Research grade status), public coordinates and a geographical location within the administrative regions where *O. leucostigma* is reported to be present (section 6, Table 3) were used. The number of such observations was 8047. For the PRA area, only the climate types occurring in the observation points of *O. leucostigma* in North America are presented.

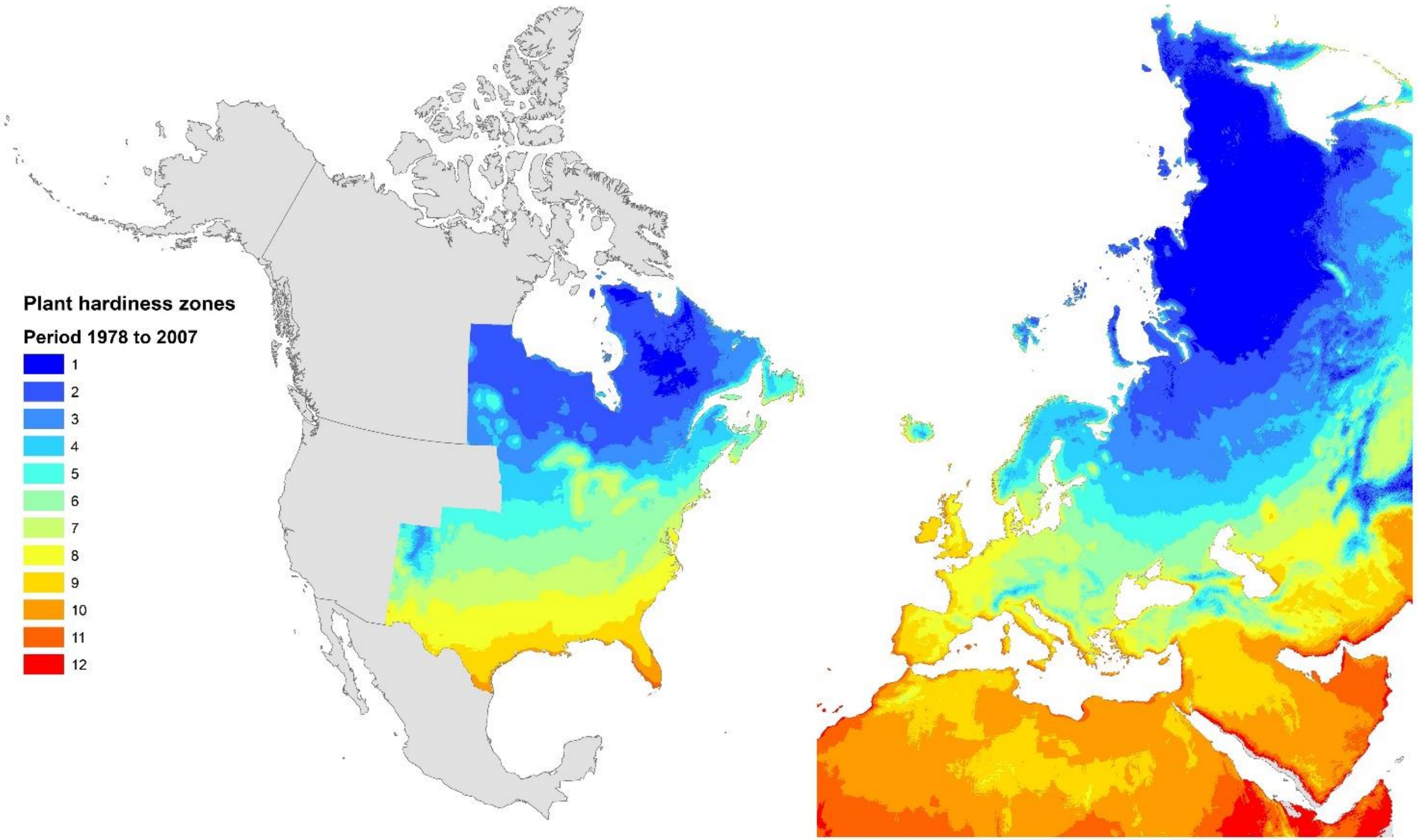


Figure 4. Global plant hardiness zones for 1978–2007 by Magarey *et al.* (2008). For North America plant hardiness zones are only shown for the states and provinces where *O. leucostigma* is reported to occur (section 6, Table 3). For the PRA area, only the plant hardiness zones occurring in the distribution range of the pest in North America are presented.

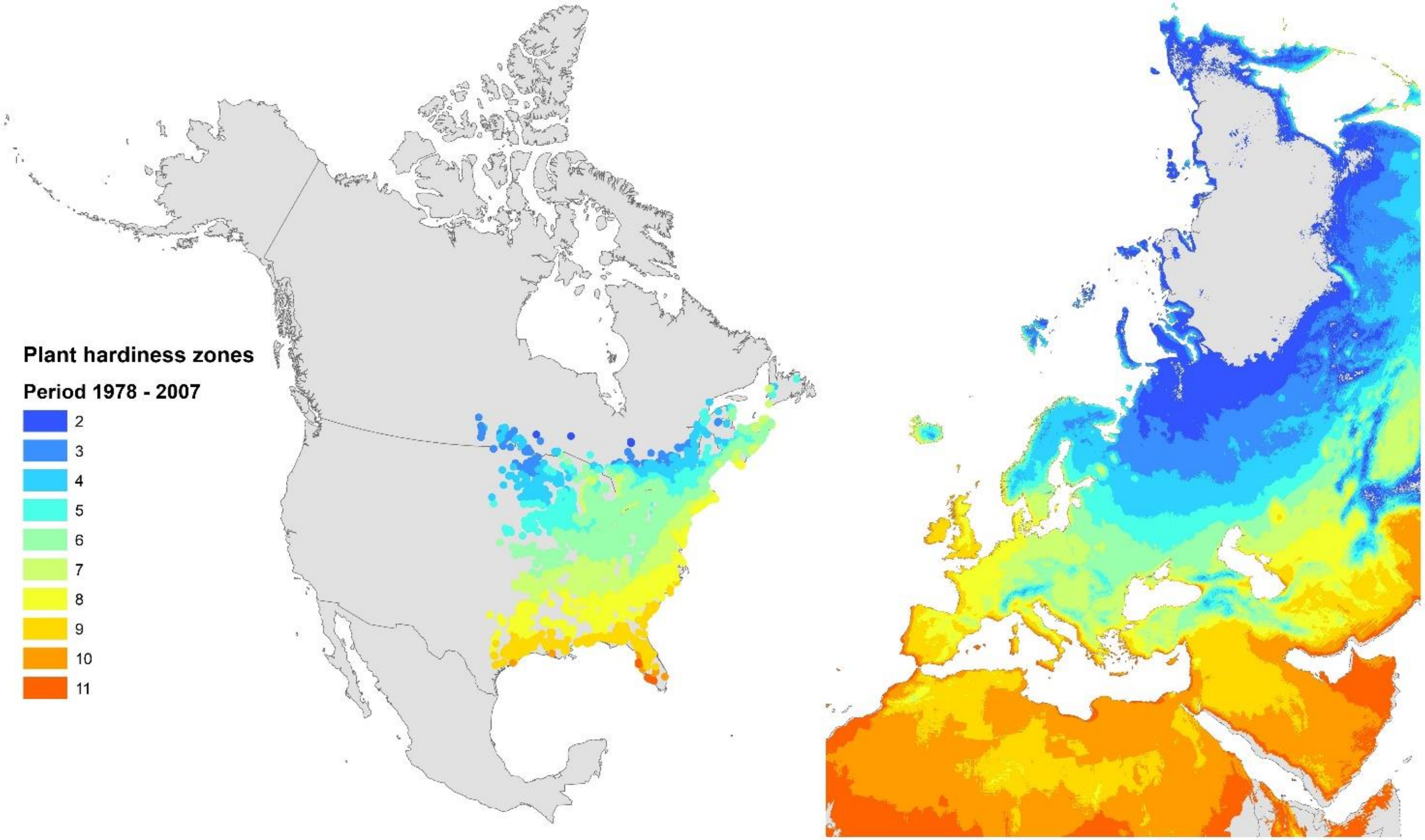


Figure 5. Global plant hardiness zones for 1978–2007 by Magarey *et al.* (2008). For North America, plant hardiness zones are shown for *O. leucostigma* observation points recorded in the iNaturalist database (iNaturalist 2020). Only the observations that had a community agreement (Research grade status), public coordinates and a geographical location within the administrative regions where *O. leucostigma* is reported to be present (section 6, Table 3) were used. The used dataset had 8047 observations of the species. For the PRA area, only the plant hardiness zones occurring in the observation points of *O. leucostigma* in North America are presented.