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SCIENTIFIC OPINION

Commodity risk assessment of debarked conifer wood chips fumigated with sulfuryl fluoride from the US

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Abstract

The European Commission requested the EFSA Panel on Plant Health to deliver a risk assessment on the likelihood of pest freedom from regulated EU quarantine pests, with emphasis on *Bursaphelenchus xylophilus* and its vectors *Monochamus* spp. of debarked conifer wood chips fumigated with sulfuryl fluoride as proposed by the United States (US) and as outlined in ISPM 28 - PT23 of sulfuryl fluoride (SF) fumigation treatment for nematodes and insects in debarked wood. The assessment considered the different phases in the wood chips' production, with special emphasis on the SF treatment. In addition to *B. xylophilus* and its vectors *Monochamus* spp., 22 EU quarantine pests and protected zone quarantine pests, some of which are regulated as groups of pests by the Commission Implementing Regulation (EU) 2019/2072, are present in the US and are potentially associated with the commodity. For these pests an expert judgement is given on the likelihood of pest freedom taking into consideration the available scientific information and technical information provided by the US, including uncertainties associated with the assessment. The likelihood of pest freedom varies among the pests evaluated, with *B. xylophilus* being the pest most frequently expected on the commodity. The Expert Knowledge Elicitation (EKE) indicated with 95% certainty that between 9491 and 10,000 m^3 of debarked conifer wood chips treated with SF per 10,000 m^3 will be free from *B. xylophilus,* and that between 9987 and 10,000 m^3 of wood chips per 10,000 m^3 will be free from *Monochamus* spp. Technical elements which are critical for a successful treatment and for minimising the presence of Union quarantine pests on the commodity are identified and described in the opinion. In particular, it is important to note that SF treatments are generally less effective in eliminating fungi than insects, the required parameters of the fumigation should be met at all points of the pile of wood chips and the time of storage of wood chips before treatment should be kept as short as possible because *B. xylophilus* can easily reproduce and spread throughout the pile under conducive conditions.

KEYWORDS

bark, *Bursaphelenchus xylophilus*, fumigant, *Monochamus*, pines, pinewood nematode, quarantine pests, SF, treatment

CONTENTS

1 | INTRODUCTION

1.1 | Background and Terms of Reference as provided by European Commission

1.1.1 | Background

Special requirements apply to the introduction of wood of conifers in the form of chips, originating from, amongst other countries, the United States (US), in order to assure that the wood is free from the pinewood nematode (PWN) *Bursaphelenchus xylophilus* (Steiner et Bührer) Nickle et al. and its vector *Monochamus*. These special requirements are laid down in points 77 and 81 of Annex VII to Regulation 2019/2072.[1] They include heat treatment with additional measures and a fumigation to a specification approved by the Commission under a regulatory procedure.

In February 2022, the US introduced a request to use sulfuryl fluoride (SF) on debarked conifer chips, for phytosanitary certification. To this end, a specific treatment regime was proposed. It is noted by the Commission, that this regime has similarities with the regime set out in the International Standard for Phytosanitary Measures (ISPM) No 28, Annex 23 'sulfuryl fluoride fumigation treatment for nematodes and insects in debarked wood'.

In support of the request, several background documents, including scientific publications, were submitted.

1.1.2 | Terms of Reference

EFSA is requested, pursuant to Article 29 of Regulation (EC) No 178/2002,[2] to provide a scientific opinion.

In particular, EFSA is requested to assess, based on the information provided by the US, the level of certainty of freedom from regulated EU quarantine pests for debarked conifer chips fumigated with sulfuryl fluoride as proposed by the US. EFSA shall describe the technical elements which are critical for a successful treatment.

The assessment shall put emphasis on the efficacy of the method against *Bursaphelenchus xylophilus* and its vector *Monochamus*.

In this assessment, EFSA shall take into account the available scientific information, and in particular the scientific and technical information provided by the US, as well as existing international and regional phytosanitary standards. If necessary to complete its assessment, EFSA may ask additional technical information or clarifications regarding the US request to use SF on debarked conifer chips shipments for phytosanitary certification. Following the provision of such information, EFSA shall proceed with the assessment.

1.2 | Interpretation of the Terms of Reference

The Panel proceeded with the assessment of the likelihood of pest freedom from Union quarantine pests, with an emphasis on *B. xylophilus* and its vectors belonging to the genus *Monochamus*, of conifer wood chips produced in the US and treated with sulfuryl fluoride, as described by the applicant country. For the assessment, the available scientific information as well as the technical information provided by the applicant country were considered. Technical elements which are critical for a successful treatment and for minimising the presence of Union quarantine pests on the commodity were identified and highlighted.

While the applicant country described the production of wood chips to occur only in some areas of the US by using a limited number of conifer tree species (Dossier Section 2.0), after consulting the European Commission, the Panel proceeded with an assessment encompassing any conifer tree species growing anywhere in the US.

2 | DATA AND METHODOLOGIES

2.1 | Data

2.1.1 | Data provided by the applicant

The Panel considered all the data and information (hereafter called 'the Dossier') provided by the US Department of Agriculture (USDA), Animal and Plant Health Inspection Service (APHIS) in January 2022 and September 2022, following a request for further information by the EU Commission. Additional information was provided by USDA APHIS in January 2024, after EFSA's request. The Dossier is managed by EFSA.

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[1] Commission Implementing Regulation (EU) 2019/2072 of 28 November 2019 establishing uniform conditions for the implementation of Regulation (EU) 2016/2031 of the European Parliament and the Council, as regards protective measures against pests of plants, and repealing Commission Regulation (EC) No 690/2008 and amending Commission Implementing Regulation (EU) 2018/2019. OJ L 319, 10.12.2019, p. 1–279.

[2] Regulation (EC) No 178/2002 of the European Parliament and of the Council of 28 January 2002 laying down the general principles and requirements of food law, establishing the European Food Safety Authority and laying down procedures in matters of food safety. OJ L 31, 1.2.2002, pp. 1–24.

The structure and overview of the Dossier is shown in Table 1. The number of the relevant section is indicated in the Opinion when referring to a specific part of the Dossier.

TABLE 1 Structure and overview of the Dossier.

Dossier section	Overview of contents	Filename
1.0	Technical dossier	OC 20220131 EUU.S. Pine Chips to EU with Sulfuryl Floride (SF) OC 20220923 EUU.S. wood chips_Response to questions fumigation of pine chips with SF Encl-1-Response to question regarding fumigation SF in wood chips Encl-2-Ecolab Standard operating procedure
2.0	Additional information: answers to EFSA queries provided in January 2024	EFSA Wood chip Question Final 1 18 24 NC timber_report

The data and supporting information provided by USDA APHIS formed the basis of the commodity risk assessment.

2.1.2 | Literature search performed by EFSA on the association of EU quarantine pests with conifers

The list of EU quarantine pests was retrieved from Commission Implementing Regulation 2019/2072. For each of those pests the databases listed in Table 2 were checked for the association of the pest with conifer taxa (genus/species) belonging to the following families: Araucariaceae, Cupressaceae, Pinaceae, Podocarpaceae, Sciadopityaceae and Taxaceae. For the pests identified as associated with conifers a literature search on whether they are present in the US was performed. The searches were run between June and September 2023.

Additional searches, limited to retrieve documents, were run when developing the Opinion. The available scientific information, including previous EFSA opinions on the relevant pests and diseases and the relevant literature and legislation, were taken into account.

TABLE 2 Databases used by EFSA for the compilation of the EU quarantine pest list associated with conifer species.

Database	Platform/link
Bark and Ambrosia Beetles of the Americas	https://www.barkbeetles.info/regional_chklist_index.php
CABI Crop Protection Compendium	https://www.cabi.org/cpc/
GBIF	https://www.gbif.org/
Database of the World's Lepidopteran Hostplants	https://www.nhm.ac.uk/our-science/data/hostplants/search/index.dsml
EPPO Global Database	https://gd.eppo.int/
Nemaplex	http://nemaplex.ucdavis.edu/
Scalenet	https://scalenet.info/
USDA ARS Fungal Database	https://fungi.ars.usda.gov/

2.1.3 | Literature search performed by EFSA on the efficacy of sulfuryl fluoride treatment

A systematic literature search was performed by EFSA in order to retrieve information on the efficacy of sulfuryl fluoride treatment against *B. xylophilus* and *Monochamus* spp. as well as against other pests identified for further evaluation. Details on the literature review and the search string are provided in Appendix B. Information on sulfuryl fluoride treatments were already retrieved in EFSA PLH Panel (2020a) and EFSA PLH Panel (2023) and are included in Appendix C. The information retrieved in the new literature review performed in 2024 and from EFSA PLH Panel (2020a) and EFSA PLH Panel (2023) was compared to the information provided by the applicant on the proposed treatment (see Section 6 of the current opinion).

2.1.4 | Further information provided by experts

The working group consulted a specialist on fumigation of wood to provide information on critical elements for successful treatment of wood chips with sulfuryl fluoride.

2.2 | Methodologies

2.2.1 | Identification of pests potentially associated with the commodity

To evaluate the pest risk associated with the importation of the commodity from the US, a pest list was compiled. The pest list is a compilation of all identified EU quarantine pests reported as potentially associated with conifer species based on information provided in the Dossier Sections 1.0 and 2.0 and on searches performed by the Panel as indicated above in Section 2.1.2. The search strategy and search syntax were adapted to each of the databases listed in Table 2, according to the options and functionalities of the different databases and CABI keyword thesaurus.

The scientific names of the EU quarantine pests were used when searching in the databases.

The compiled pest list (see Microsoft Excel® in Appendix D) includes all identified EU quarantine pests that use as host conifer species.

2.2.2 | Listing and evaluation of different phases in the production of the commodity with reference to the reduction of risks associated with plant pests

The production of conifer wood chips includes several steps such as inspection of trees before harvest, removal of branches and roots, debarking, chipping and finally fumigation with sulfuryl fluoride that can mitigate the risk of pests being present in the final product. These steps are described in the Section 3 and assessed with regard to their effectiveness in reducing the risk in the Section 6 and in Appendix F of the current opinion.

2.2.3 | Expert Knowledge Elicitation

To estimate the pest freedom of the commodity, an EKE was performed following EFSA Guidance (Annex B.8 of EFSA Scientific Committee, 2018). The commodity to be exported to the EU is debarked conifer wood chips loaded into shipholds and fumigated with sulfuryl fluoride. The specific question for EKE was: 'Taking into account the available scientific information and the technical information provided by the US, how many m^3 out of 10,000 m^3 of debarked conifer wood chips fumigated with sulfuryl fluoride will be infested with living relevant EU quarantine pests'?

The uncertainties associated with the EKE were considered and quantified in the probability distribution applying the semi-formal method described in section 3.5.2 of the EFSA Guidance on quantitative pest risk assessment (EFSA PLH Panel, 2018a). Finally, the results were reported in terms of the likelihood of pest freedom. The lower 5% percentile of the uncertainty distribution reflects the opinion that pest freedom is with 95% certainty above this limit.

3 | THE COMMODITY

3.1 | Description

The commodity consists of debarked conifer wood chips treated with sulphuryl fluoride (Dossier Section 1.0).

Wood chips used have the size limits: 102 mm in length, width and thickness. They are tested following TAPPI standard T-16 TS-61 sieve analysis procedures. The specifications require that no more than 5% of the chips exceed 45 mm in length, and a maximum of 3% should be under 4.8 mm in length. Ideally, 85% of the chips should measure between 4 and 8 mm in thickness to meet quality standards. The wood chips should contain no more than 2.0% bark and rot. The moisture content of wood chips is 45%–52% based on wet weight.

In Dossier Section 2.0, it was specified that wood chips are produced from *Pinus taeda*, *Pinus echinata*, *Pinus elliottii*, *Pinus palustris*, *Pinus clausa*, *Pinus glabra* and *Pinus serotina*. However, as explained in the interpretation of ToR (see Section 1.2), the current assessment was extended to wood chips produced from any conifer tree species.

3.2 | Production areas

3.2.1 | Origin of wood used for wood chip production

Wood used for production for wood chips comes from trees grown in the US (Dossier Section 2.0). It was specified that wood chips are obtained from trees harvested in US eastern and southern states including Virginia, North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana, Texas and Tennessee. However, as explained in the interpretation of ToR (see Section 1.2), the current assessment was extended to wood chips produced from conifer trees grown anywhere in the US.

Trees used for wood chip production are obtained from standard forest harvest operations. This includes both final harvests (clearcuts), and intermediate harvests (thinning).

3.2.2 | Sources of wood chips

The source of the wood chip material is fresh cut wood and wood in storage in dedicated intermediate staging storage yards.

There are three primary sources of debarked conifer wood chips for export: (a) in-woods log chipping operations, (b) sawmill byproduct or residual wood chips and (c) dedicated wood chip mill.

a. In-woods log chipping operations:

Most wood chips for export are from low value pre-commercial tree thinning and chipping that takes place in the woods. Processing of these logs is at cleared decks created by loggers adjacent to the cut areas but capable of being connected to transportation infrastructure for delivery to the ports. There can be any number of decks throughout a forest cut area to minimise the log haul distance from actual cut locations.

b. Sawmill byproduct or residual wood chips:

Lumber mills receive logs for processing. Logs are debarked then forwarded to saws for optimising the log for lumber output. The outer portion of the tree (sapwood, not bark) or waste portion of the processed log is converted to wood chips as a residual product. These wood chips are loaded either from temporary piles or wood chip storage bins for daily delivery to the port accumulating vessel load quantities.

c. Dedicated wood chip mill:

Wood chip mills dedicated to domestic pulp manufacture typically have 10%–20% available capacity for export markets although these high-quality wood chips are much more costly. Wood chips are loaded from temporary storage piles post-production to both wood chip trailers and open top hopper rail cars.

3.3 | Production and handling processes

3.3.1 | Production systems and preparation of the commodity

The following summarises the information provided by the applicant in the Dossier Sections 1.0 and 2.0.

<u>Trees are inspected before harvest:</u>

Based on Dossier Section 2.0, trees are harvested from healthy stands free of symptoms or signs of rot or insect infestation. Trees are inspected prior to harvest to ensure only trees perceived to be healthy enter the commercial supply chain. Prior to harvest, the forester hired by the landowner marks trees to be either harvested or culled (such as diseased trees to be cut and destroyed). Logs are sorted by grade at the log deck near the harvest site for transport to the buyers. Further details on the selection of trees are provided in Dossier Section 2.0.

<u>Removal of branches, no roots entering the wood chip production:</u>

Wood is sorted, delimbed and graded by the logging company. Tree limbs are left at the forest site and are not used in production of wood chips. Branches and tops of the stem under 50 mm in diameter are excluded from production of wood chips. Likewise, wood portions located below ground (stump and roots) are also excluded from production of wood chips (trees are cut about 15 cm above the ground).

<u>Debarking:</u>

Debarking can occur in the forest or at the sawmill. For forest debarking, portable 6-chain debarkers are most commonly used. For sawmill debarking, fixed 27.4 m (90 feet) by 3.4 m (11 feet) rotary drum are most commonly used type of debarkers. After debarking, a maximum of 2% of the bark may be present on wood prior to chipping.

<u>Chipping:</u>

Chipping occurs in the same locations as debarking or at the port. Chipping logs at the port uses the same process and portable equipment as in-woods chipping. The only difference is the log is brought from the log deck in the woods to the port where it is debarked and chipped to the storage pile.

Chips are accumulated at the port and are stored outdoors on concrete or asphalt pads before loading on to the ships (see Figure 1). Up to 80,000 MT storage piles accumulate prior to loading to vessel. Wood chips are stored for a maximum of 90 days at the port.

FIGURE 1 Wood chip pile stored at the port before loading to the ship (from Dossier Section 2.0).

Quality control after chipping:

Wood chip piles are visually inspected by third party surveyor prior to loading for quality related to blue stain and wood rot. The USDA APHIS inspects export piles for any insect infestation prior to loading the piles on the vessel for shipment. This inspection includes walking around the entire perimeter and on top of the wood chip pile. No information was provided on the measures taken in case the quality standards are not achieved at this stage of production.

3.3.2 | Fumigation with sulfuryl fluoride

After loading into the ships, the wood chips are fumigated with sulfuryl fluoride in the sealed ship holds. A recirculation tubing is used to ensure efficient fumigation. Illustrations of the fumigation process are provided in Figures 2 and 3 below from the Dossier Section 1.0.

FIGURE 2 Shiphold with recirculation tubing (indicated by red arrows).

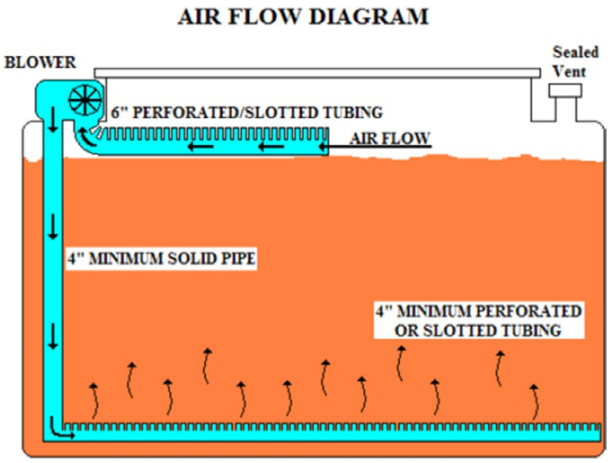


FIGURE 3 Schematic illustration of the recirculation fumigation system in the shiphold.

USDA APHIS suggests treatment of wood chips, following the requirements outlined in ISPM 28 - PT23 for sulfuryl fluoride fumigation treatment for nematodes and insects in debarked wood. The sulfuryl fluoride concentrations and concentration-time s (CT) are listed in Table 3.

It should be noted that the sulfuryl fluoride concentrations listed in ISPM 28 - PT23 are not for fumigation of piles of wood chips. They refer to fumigation of debarked wood not exceeding 20 cm in cross section at its smallest dimension and 75% moisture content (dry basis).

TABLE 3 Suggested sulfuryl fluoride (SF) treatment according to ISPM 28 - PT23. CT is the concentration-time, expressed in g-hour/m^3.

Minimum temperature during treatment	Minimum required CT (g × h/m^3)	SF dose (g/m^3)	Minimum concentration (g/m^3) at hour:						
			0.5	2	4	12	24	36	48
20°C or above	3000	120	124	112	104	82	58	41	29
30°C or above	1400	82	87	78	73	58	41	n/a	n/a

Sulphuryl fluoride concentrations in the shiphold are measured and recorded over the entire fumigation exposure period. The monitoring lines with the sensors are placed into the mass of the wood chips at 3 m height from the bottom of the shiphold and 1.82 m from the side of each ship hold and in addition on top of the wood chip pile.

The temperature of the wood chip pile is measured with data loggers on top of the piles at a depth of 30.5–45.7 cm. The wood chips are not heated. A temperature of more than 37.8°C is expected to be naturally generated from slow decomposition of wood chips.

3.4 | Overview of interceptions

Data on the interception of harmful organisms on conifer wood can provide information on some of the organisms that can be present on wood chips despite the proposed measures taken.

According to EUROPHYT (2024) and TRACES-NT (2024) (Accessed: 13 November 2024), there were six interceptions of wood and bark of conifer species from the US due to the presence of harmful organisms (see Table 4) between the years 1995 and October 2024.

TABLE 4 Overview of harmful organisms intercepted on wood and bark of conifer species from the US (1995 to October 2024), based on notifications of interceptions by EU Member States [based on EUROPHYT (2024) andTRACES- NT (2024)].

N	Name of harmful organism	Group	Plant species	Commodity	Additional information on the commodity in the notes	Country of origin	Country of entry/ destination country	Year of interception	Number of interceptions
1	Nematoda	Nematodes	*Pinus* sp.	Products: wood and bark	–	the US	France	1999	1
2	*Bursaphelenchus xylophilus*	Nematodes	*Pinus* sp.	Products: wood and bark	–	the US	Spain	2001	1
3	*Bursaphelenchus xylophilus*	Nematodes	*Pinus* sp.	Products: wood and bark	Debarked wood chips - *Pinus palustris*	the US	Belgium/Germany	2011	1
4	Aphelenchoididae	Nematodes	Pinales	Products: wood and bark	Wood chips in a personal luggage	the US	Ireland	2014	1
5	Siricidae	Insects	*Pinus* sp.	Products: wood and bark	–	the US	Italy	2015	1
6	*Bursaphelenchus xylophilus*	Nematodes	–	Products: wood	–	the US	Sweden	2021	1

4 | IDENTIFICATION OF PESTS POTENTIALLY ASSOCIATED WITH THE COMMODITY

The search for EU quarantine pests and protected zone quarantine pests associated with conifers rendered 963 pests. Many of these pests are regulated as groups of species (e.g. non-European Scolytinae, *Gymnosporangium* spp.) by the Commission Implementing Regulation (EU) 2019/2072 (see Microsoft Excel® file in Appendix F). Altogether, 65 pests including pests regulated as individual species and pests regulated as groups of species were evaluated.

4.1 | Selection of relevant EU quarantine pests associated with the commodity

The relevance of an EU quarantine pest or a protected zone quarantine pest for this opinion was based on evidence that:

a. the pest is present in the US;
b. at least one conifer species is a host of the pest;
c. one or more life stages of the pest can be associated with the wood used for wood chips production.

Pests that fulfilled all criteria were selected for further evaluation. If one of the three criteria was not fulfilled the other criteria were not assessed.

Table 5 presents an overview of the evaluation of the 65 EU quarantine pests that are reported as associated with conifers.

Of these 65 EU quarantine pests evaluated, the following are present in the US and can be associated with the wood used for wood chips production and hence were selected for further evaluation: *Arceuthobium* spp., *Atropellis* spp., *Bursaphelenchus xylophilus*, *Choristoneura carnana*, *Choristoneura conflictana*, *Choristoneura fumiferana*, *Choristoneura lambertiana*, *Choristoneura occidentalis occidentalis*, *Choristoneura orae*, *Choristoneura pinus*, *Choristoneura retiniana*, *Choristoneura rosaceana*, *Coniferiporia sulphurascens*, *Coniferiporia weirii*, *Cronartium* spp., *Euwallacea fornicatus sensu lato*, *Fusarium circinatum*, *Gremmeniella abietina*, *Gymnosporangium* spp., *Lycorma delicatula*, *Monochamus* spp. (non-European populations), *Phytophthora ramorum* (non-EU isolates), *Pissodes nemorensis*, Scolytinae (non-European).

TABLE 5 Overview of the evaluation of the 65 EU quarantine and protected zone quarantine pests for which information was found in the Dossier, databases and literature searches that use conifer species as a host plant for their relevance for this opinion.

No.	Pest name according to EU legislation[a]	EPPO code	Group	Pest present in the US	Conifer species confirmed as a host	Pest can be associated with the wood used for wood chips production[b]	Pest relevant for the opinion
1	*Acleris gloverana*	ACLRGL	Insects	Yes	Yes	No	No
2	*Acleris variana*	ACLRVA	Insects	Yes	Yes	No	No
3	*Anoplophora chinensis*	ANOLCN	Insects	No	Yes	Not assessed	No
4	*Aphrophora permutata*	APHRPE	Insects	Yes	Yes	No	No
5	*Apriona germari*	APRIGE	Insects	No	Yes	Not assessed	No
6	*Arceuthobium* spp.	1AREG	Plants	Yes	Yes	Yes	Yes
7	*Aschistonyx eppoi*	ASCXEP	Insects	No	Yes	Not assessed	No
8	*Atropellis* spp.	1ATRPG	Fungi	Yes	Yes	Yes	Yes
9	*Bursaphelenchus xylophilus*	BURSXY	Nematodes	Yes	Yes	Yes	Yes
10	*Cephalcia lariciphila*	CEPCAL	Insects	No	Yes	Not assessed	No
11	*Choristoneura carnana*	CHONCA	Insects	Yes	Yes	Yes	Yes
12	*Choristoneura conflictana*	ARCHCO	Insects	Yes	Yes	Yes	Yes
13	*Choristoneura fumiferana*	CHONFU	Insects	Yes	Yes	Yes	Yes
14	*Choristoneura lambertiana*	TORTLA	Insects	Yes	Yes	Yes	Yes
15	*Choristoneura occidentalis biennis*	CHONBI	Insects	No	Yes	Not assessed	No
16	*Choristoneura occidentalis occidentalis*	CHONOC	Insects	Yes	Yes	Yes	Yes
17	*Choristoneura orae*	CHONOR	Insects	Yes	Yes	Yes	Yes
18	*Choristoneura pinus*	CHONPI	Insects	Yes	Yes	Yes	Yes
19	*Choristoneura retiniana*	CHONRE	Insects	Yes	Yes	Yes	Yes
20	*Choristoneura rosaceana*	CHONRO	Insects	Yes	Yes	Yes	Yes
21	*Chrysomyxa arctostaphyli*	CHMYAR	Fungi	Yes	Yes	No	No
22	*Coniferiporia sulphurascens*	PHELSU	Fungi	Yes	Yes	Yes	Yes
23	*Coniferiporia weirii*	INONWE	Fungi	Yes	Yes	Yes	Yes
24	*Cronartium* spp.	1CRONG	Fungi	Yes	Yes	Yes	Yes
25	*Dendroctonus micans*	DENCMI	Insects	No	Yes	Not assessed	No
26	*Dendrolimus sibiricus*	DENDSI	Insects	No	Yes	Not assessed	No
27	*Diabrotica virgifera zeae*	DIABVZ	Insects	Yes	Yes	No	No
28	*Eotetranychus lewisi*	EOTELE	Mites	Yes	Yes	No	No
29	*Euwallacea fornicatus sensu lato*	XYLBFO	Insects	Yes	Yes	Yes	Yes
30	*Fusarium circinatum*	GIBBCI	Fungi	Yes	Yes	Yes	Yes

TABLE 5 (Continued)

No.	Pest name according to EU legislation[a]	EPPO code	Group	Pest present in the US	Conifer species confirmed as a host	Pest can be associated with the wood used for wood chips production[b]	Pest relevant for the opinion
31	*Gilpinia hercyniae*	GILPPO	Insects	Yes	Yes	No	No
32	*Gremmeniella abietina*	GREMAB	Fungi	Yes	Yes	Yes	Yes
33	*Guignardia laricina* (current name according to Index Fungorum: *Neofusicoccum laricinum*)	GUIGLA	Fungi	No	Yes	Not assessed	No
34	*Gymnosporangium* spp.	1GYMNG	Fungi	Yes	Yes	Yes	Yes
35	*Homalodisca vitripennis*	HOMLTR	Insects	Yes	Yes	No	No
36	*Ips amitinus*	IPSXAM	Insects	No	Yes	Not assessed	No
37	*Ips cembrae*	IPSXCE	Insects	No	Yes	Not assessed	No
38	*Ips duplicatus*	IPSXDU	Insects	No	Yes	Not assessed	No
39	*Ips sexdentatus*	IPSXSE	Insects	No	Yes	Not assessed	No
40	*Ips typographus*	IPSXTY	Insects	No	Yes	Not assessed	No
41	*Lycorma delicatula*	LYCMDE	Insects	Yes	Yes	Yes	Yes
42	*Melampsora farlowii*	MELMFA	Fungi	Yes	Yes	No	No
43	*Meloidogyne chitwoodi*	MELGCH	Nematodes	Yes	Yes	No	No
44	*Monochamus* spp. (non-European populations)	1MONCG	Insects	Yes	Yes	Yes	Yes
45	*Mycodiella laricis-leptolepidis*	MYCOLL	Fungi	No	Yes	Not assessed	No
46	*Oemona hirta*	OEMOHI	Insects	No	Yes	Not assessed	No
47	*Oligonychus perditus*	OLIGPD	Mites	Yes	Yes	No	No
48	*Phymatotrichopsis omnivora*	PHMPOM	Fungi	Yes	Yes	No	No
49	*Phytophthora ramorum* (non-EU isolates)	PHYTRA	Oomycetes	Yes	Yes	Yes	Yes
50	*Pissodes cibriani*	PISOCI	Insects	No	Yes	Not assessed	No
51	*Pissodes fasciatus*	PISOFA	Insects	Yes	Yes	No	No
52	*Pissodes nemorensis*	PISONE	Insects	Yes	Yes	Yes	Yes
53	*Pissodes nitidus*	PISONI	Insects	No	Yes	Not assessed	No
54	*Pissodes punctatus*	PISOPU	Insects	No	Yes	Not assessed	No
55	*Pissodes strobi*	PISOST	Insects	Yes	Yes	No	No
56	*Pissodes terminalis*	PISOTE	Insects	Yes	Yes	No	No
57	*Pissodes yunnanensis*	PISOYU	Insects	No	Yes	Not assessed	No
58	*Pissodes zitacuarense*	PISOZI	Insects	No	Yes	Not assessed	No
59	*Polygraphus proximus*	POLGPR	Insects	No	Yes	Not assessed	No

(Continues)

TABLE 5 (Continued)

No.	Pest name according to EU legislation[a]	EPPO code	Group	Pest present in the US	Conifer species confirmed as a host	Pest can be associated with the wood used for wood chips production[b]	Pest relevant for the opinion
60	*Pseudocercospora pini-densiflorae* (current name according to Index Fungorum: *Mycosphaerella gibsonii*)	CERSPD	Fungi	No	Yes	Not assessed	No
61	Scolytinae (non-European)	1SCOLF	Insects	Yes	Yes	Yes	Yes
62	*Spodoptera frugiperda*	LAPHFR	Insects	Yes	Yes	No	No
63	*Thaumetopoea pityocampa*	THAUPI	Insects	No	Yes	Not assessed	No
64	*Thaumetopoea processionea*	THAUPR	Insects	No	Yes	Not assessed	No
65	*Xiphinema americanum sensu stricto*	XIPHAA	Nematodes	Yes	Yes	No	No

[a] Commission Implementing Regulation (EU) 2019/2072.

[b] The association with wood used for wood chip production was not further assessed if the pest is not present in the US.

4.2 | Summary of pests selected for further evaluation

The 24 pests satisfying all the relevant criteria listed above in the Section 4.1 are included in Table 6. The effects on the pests of each of the phases in the production of the commodity, including the treatment with sulphuryl fluoride, were evaluated.

TABLE 6 List of relevant pests selected for further evaluation. All pests are EU quarantine pests according to Commission Implementing Regulation (EU) 2019/2072 except *Gremmeniella abietina* which is a Protected zone quarantine pest according to the same piece of legislation.

Number	Current scientific name	EPPO code	Name used in the EU legislation	Taxonomic information	Group	Name of Pest datasheet
1	*Arceuthobium* spp.	1AREG	*Arceuthobium* spp. [1AREG]	Santalales Santalaceae	Plants	*Arceuthobium* spp.
2	*Atropellis* spp.	1ATRPG	*Atropellis* spp. [1ATRPG]	Helotiales Godroniaceae	Fungi	*Atropellis* spp.
3	*Bursaphelenchus xylophilus*	BURSXY	*Bursaphelenchus xylophilus* (Steiner and Bührer) Nickle et al. [BURSXY]	Rhabditida Parasitaphelenchidae	Nematodes	*Bursaphelenchus xylophilus* (PWN) and *Monochamus*
4	*Choristoneura carnana*	CHONCA	*Choristoneura carnana* Barnes & Busck [CHONCA]	Lepidoptera Tortricidae	Insects	*Choristoneura* species (example of *Choristoneura fumiferana*)
5	*Choristoneura conflictana*	ARCHCO	*Choristoneura conflictana* Walker [ARCHCO]	Lepidoptera Tortricidae	Insects	*Choristoneura* species (example of *Choristoneura fumiferana*)
6	*Choristoneura fumiferana*	CHONFU	*Choristoneura fumiferana* Clemens [CHONFU]	Lepidoptera Tortricidae	Insects	*Choristoneura* species (example of *Choristoneura fumiferana*)
7	*Choristoneura lambertiana*	TORTLA	*Choristoneura lambertiana* Busck [TORTLA]	Lepidoptera Tortricidae	Insects	*Choristoneura* species (example of *Choristoneura fumiferana*)
8	*Choristoneura occidentalis occidentalis*	CHONOC	*Choristoneura occidentalis occidentalis* Freeman [CHONOC]	Lepidoptera Tortricidae	Insects	*Choristoneura* species (example of *Choristoneura fumiferana*)

TABLE 6 (Continued)

Number	Current scientific name	EPPO code	Name used in the EU legislation	Taxonomic information	Group	Name of Pest datasheet
9	*Choristoneura orae*	CHONOR	*Choristoneura orae* Freeman [CHONOR]	Lepidoptera Tortricidae	Insects	*Choristoneura* species (example of *Choristoneura fumiferana*)
10	*Choristoneura pinus*	CHONPI	*Choristoneura pinus* Freeman [CHONPI]	Lepidoptera Tortricidae	Insects	*Choristoneura* species (example of *Choristoneura fumiferana*)
11	*Choristoneura retiniana*	CHONRE	*Choristoneura retiniana* Walsingham [CHONRE]	Lepidoptera Tortricidae	Insects	*Choristoneura* species (example of *Choristoneura fumiferana*)
12	*Choristoneura rosaceana*	CHONRO	*Choristoneura rosaceana* Harris [CHONRO]	Lepidoptera Tortricidae	Insects	*Choristoneura* species (example of *Choristoneura fumiferana*)
13	*Coniferiporia sulphurascens*	PHELSU	*Coniferiporia sulphurascens* (Pilát) L.W. Zhou & Y.C. Dai [PHELSU]	Hymenochaetales Hymenochaetaceae	Fungi	*Coniferiporia* species
14	*Coniferiporia weirii*	INONWE	*Coniferiporia weirii* (Murrill) L.W. Zhou & Y.C. Dai [INONWE]	Hymenochaetales Hymenochaetaceae	Fungi	*Coniferiporia* species
15	*Cronartium* spp.	1CRONG	*Cronartium* spp. [1CRONG]	Pucciniales Cronartiaceae	Fungi	*Cronartium* species
16	*Euwallacea fornicatus sensu lato*	XYLBFO	*Euwallacea fornicatus sensu lato* [XYLBFO]	Coleoptera Curculionidae Scolytinae	Insects	Ambrosia beetles (example of *Gnathotrichus sulcatus*)
17	*Fusarium circinatum*	GIBBCI	*Fusarium circinatum* Nirenberg & O'Donnell [GIBBCI]	Hypocreales Nectriaceae	Fungi	*Fusarium circinatum*
18	*Gremmeniella abietina*	GREMAB	*Gremmeniella abietina* (Lagerberg) Morelet	Helotiales Helotiaceae	Fungi	*Gremmeniella abietina*
19	*Gymnosporangium* spp.	1GYMNG	*Gymnosporangium* spp. [1GYMNG]	Pucciniales Gymnosporangiaceae	Fungi	*Gymnosporangium* species
20	*Lycorma delicatula*	LYCMDE	*Lycorma delicatula* (White) [LYCMDE]	Hemiptera Fulgoridae	Insects	*Lycorma delicatula*
21	*Monochamus* spp. (non-European populations)	1MONCG	*Monochamus* spp. (non-European populations) [1MONCG]	Coleoptera Cerambycidae	Insects	*Bursaphelenchus xylophilus* (PWN) and *Monochamus*
22	*Phytophthora ramorum* (non-EU isolates)	PHYTRA	*Phytophthora ramorum* (non-EU isolates) Werres, De Cock & Man in 't Veld [PHYTRA]	Peronosporales Peronosporaceae	Oomycetes	*Phytophthora ramorum*
23	*Pissodes nemorensis*	PISONE	*Pissodes nemorensis* Germar [PISONE]	Coleoptera Curculionidae Molytinae	Insects	*Pissodes* and bark beetles (example of *Pissodes nemorensis*)
24	Scolytinae (non-European)	1SCOLF	Scolytinae spp. (non-European) [1SCOLF]	Coleoptera Curculionidae Scolytinae	Insects	1. Ambrosia beetles (example of *Gnathotrichus sulcatus*); 2. *Pissodes* and bark beetles (example of *Pissodes nemorensis*)

5 | THE TARGET PESTS

5.1 | Main target pests: *Bursaphelenchus xylophilus* and *Monochamus* species

5.1.1 | Taxonomy

Bursaphelenchus xylophilus (Rabditida, Parasitaphelenchidae) is the Pine Wood Nematode (PWN), the causal agent of the Pine Wilt Disease (PWD). *B. xylophilus* has several hosts among conifers, but the nematode is most frequently associated with *Pinus* spp., in North America (Canada, the US and Mexico), Western Europe (Portugal, Spain) and Asia (China, Taiwan, South Korea and Japan). The nematode is transmitted, via maturation feeding and oviposition, by adults of longhorn beetles in the genus *Monochamus*. This phoresy is a very specialised interaction between the nematode and the beetles, obligatory for the nematode but facultative for the insects and a clear mutualistic relationship (Akbulut & Stamps, 2012; Back et al., 2024; Borges, 2022).

Monochamus is a genus of Coleoptera in the family Cerambycidae (subfamily Lamiinae), commonly called sawyers; they are widely distributed throughout the world and include from 94 to 163 species, depending on the different sources (EFSA PLH Panel, 2018). Fourteen of these species are currently known as vectors of *B. xylophilus* (EFSA PLH Panel, 2018; Akbulut & Stamps, 2012; Atkins et al., 2021), and eight of them are present in the US.

5.1.2 | Distribution and prevalence in the continental US

5.1.2.1 | *Bursaphelenchus xylophilus*

B. xylophilus is widely present in the US, although the impact of the PWD is generally low due to the resistance or tolerance of most native pine hosts and unsuitable climate conditions (Sutherland, 2008). *B. xylophilus* is currently reported in all the US except Alaska, Idaho, Maine, Montana, Nevada, New Mexico, North Dakota, South Dakota, Utah, Washington and Wyoming (EPPO, 2024a). In California and Oregon it is considered of little phytosanitary concern (CDFA, 2021; Dwinell, 1993). In addition, no phoresy of *B. xylophilus* on *Monochamus* spp. has been observed in Arizona nor in California (Pimentel et al., 2014). In Colorado it is present in 6 out of 64 counties and has only been found in urban areas on exotic pine species (Blunt et al., 2014).

Despite its wide presence in the conifer forests of the US, the distribution and abundance of *B. xylophilus* is spatially variable, partly because of differences in climate and ecology of forests, pine hosts and vector insects. According to CABI (2022), *B. xylophilus* is ultimately more abundant in eastern forests, while its occurrence is rarer and fragmented in western US. In eastern forests the nematode could take advantage of both more susceptible hosts and more effective phoresy, also due to the presence of larger and/or multivoltine beetle species (Pimentel et al., 2014; Togashi et al., 2009).

5.1.2.2 | *Monochamus species*

According to TITAN-GBIF (2024) and Back et al. (2024), eight species of *Monochamus* are present in the US: *M. carolinensis, M. clamator, M. maculosus* (=*mutator*), *M. marmorator, M. notatus, M. obtusus, M. scutellatus* and *M. titillator*. All species, in a lesser or greater extent, are vectors of *B. xylophilus*. North America is the native area of the phoretic system *B. xylophilus* /*Monochamus* spp. according to Pimentel et al. (2014). Of the eight species, only *M. scutellatus* has a wide and plain distribution, being present in almost all states. Among the remaining seven species, a clear separation into two groups can be emphasised, with four species mainly spread in the East (*M. carolinensis, M. marmorator, M. notatus* and *M. titillator*) and three species (*M. clamator, M. maculosus* and *M. obtusus*) having a more fragmented distribution in the western US. Co-occurrence of different *Monochamus* species has often been found through pheromone traps in both eastern and western forests (e.g. *M. carolinensis* and *M. titillator* in New Jersey and Louisiana, *M. notatus* and *M. scutellatus* in Vermont, and *M. clamator* and *M. obtusus* in California) (Pimentel et al., 2014).

5.1.2.3 | *Remarks on prevalence*

Current knowledge on the distribution and prevalence of *B. xylophilus* shows that the nematode is absent from a substantial part of the US. In some of the western states the reports of presence of *B. xylophilus* are restricted to urban areas and non-native, susceptible conifers. Although *Monochamus* species are widespread in the US, in several cases the phoretic system *B. xylophilus*/*Monochamus* spp., has not been confirmed (Alya & Hain, 1985; Pimentel et al., 2014). *B. xylophilus* -free and/or low-risk area include all the states west of Minnesota, Nebraska, Kansas, Oklahoma and Texas, as well as Alaska. This different prevalence of *B. xylophilus* in the two parts of the US could eventually play a role in assessing the risk profile of wood products intended for export.

5.1.3 | Biology

5.1.3.1 | *Bursaphelenchus xylophilus*

B. xylophilus was initially described in 1934 in the US as *Aphelenchoides xylophilus*, and only in 1981 the synonymy with *B. xylophilus*, the agent of PWD in Japan, was recognised (Nickle et al., 1981). Although certainly native to North America, *B. xylophilus* is part of a small group of closely related species also including *B. mucronatus* and *B. fraudulentus*, both non-pathogenic and widely distributed in Europe and Siberia up to eastern Asia. The three species are very similar but clearly distinguishable on both morphological and molecular basis (CABI, 2022; Filipiak et al., 2017, 2019). Hybrids *mucronatus/xylophilus* have been recently observed in China, also under natural conditions, showing pathogenicity similar to that of *B. xylophilus* (Li et al., 2021).

The life cycle of *B. xylophilus* is closely related to that of *Monochamus* beetles developing in the wood of dying and dead pines; it includes a saprophytic fungal-feeding phase and a phytophagous pathogenic phase (Back et al., 2024; CABI, 2022; Vicente et al., 2021). The infection by the nematode occurs in summer in two possible ways: (1) primary transmission by maturation feeding of adult sawyers (both sexes) to twigs and shoots of healthy hosts; (2) secondary transmission by oviposition of *Monochamus* females on dying trees (EPPO, 2023a). The first way is typical of the pathogenic phase on susceptible and previously healthy hosts, while the second is more characteristic of the saprophytic phase on hosts dying for other causes; this latter way is prevalent in the native range of *B. xylophilus* in North America (CABI, 2022; Wingfield, 1983).

B. xylophilus has 6 life stages: egg, four juvenile stages and adult. The lower developmental threshold of the nematode has been estimated to 9.5°C (Mamiya, 1975); The completion of a generation takes from 3 to 12 days with temperatures of 30 and 15°C respectively (in laboratory conditions) (CABI, 2022). The life cycle of *B. xylophilus* consists of the propagative phase with the juveniles J1, J2, J3, J4 and adult females and males. The dispersal life cycle consists of the juveniles JIII and JIV. When the propagative part of the life cycle takes place in cut or wind fallen trees, cut tops and other objects, it is known as the saprophytic life cycle. Here juveniles and adults increase rapidly in wood, mostly feeding on parenchyma cells and the hyphae of bluestain ophiostomatoid fungi such as *Ophiostoma*, *Leptographium*, *Graphilbum* and *Sporothrix* (Vicente et al., 2022). Also, for the dispersal life stages (JIII and JIV) fungi seem to play a role also in improving the efficacy of phoresy since only few nematodes are vectored by adult sawyers when fungi are absent (Back et al., 2024).

In spring, when the insects pupate, dispersal juveniles of the third stage (JIII) colonise the wood surrounding the pupal chambers (EFSA, 2019). Here they quickly develop into the fourth dispersal stage (JIV), also called dauer stage, which invade the chambers and enter the tracheal system of the immature adults of *Monochamus*. Dauers can distinguish vectors from non-vector species by testing the beetle cuticle (Gonçalves et al., 2021). After emergence, the vector beetles fly to healthy pines for a maturation feeding on fresh twigs and shoots (CABI, 2022). One adult *Monochamus* beetle can carry thousands of nematodes (1600 on average) in its tracheal system (Futai, 2013). This is the start of the pathogenic life cycle of the nematode. During maturation feeding, the JIV stage nematodes leave the tracheal system of the vector and infect pines through the insect feeding scars. In the wound the JIV moult into the adult stage. Adult nematodes multiply and spread very quickly in the wood of the host (up to 150 cm/day) (EFSA, 2019; EPPO, 2023a), mainly moving through resin ducts and affecting the circulation of water in the tracheids, so leading to rapid death of the host.

Needles of trees infected by *B. xylophilus* gradually change to grey and finally red. Infected pines become suitable for oviposition by *Monochamus* females. The larvae of the beetles develop inside the wood along with the developing nematode population; upon completion of the insect life cycle, the newly emerged immature adults infected by the dauers spread the nematode to other healthy hosts. The natural spread of *B. xylophilus* occurs by its insect vectors, and it has been estimated to be 4.5–6 km/year (EFSA, 2020; EFSA, 2019; Togashi & Shigesada, 2006). However, non-vector spread of *B. xylophilus* on pine saplings via infested wood chips and sawdust was found several times both in laboratory experiments and in field trials (Arbuzova et al., 2023; Halik & Bergdahl, 1992; Hopf & Schroeder, 2013; Hopf-Biziks, 2019; Kiyohara & Tokushige, 1971). Non-vector spread could be a risk if infected wood chips are used as compost or mulching material around susceptible tree species (ANSES, 2018).

As confirmed by its wide distribution range, *B. xylophilus* shows considerable adaptation to different environmental conditions, being able to survive both in subboreal and subtropical forests, also without stages specifically adapted to resist adverse conditions. Only a prolonged longevity of adults, and a greater resistance to freezing conditions by the dispersal third stage juveniles (JIII), have been recognised so far to explain the successful adaption of *B. xylophilus* to low temperatures (Zhao et al., 2007). Abundant populations of the nematode are commonly associated with a temperature range between 25°C and 31°C, and the impact of the PWD was long time considered limited to regions with average summer temperatures above 20°C and annual average temperature over 10°C. However, recent outbreaks in northern China may require re-evaluation, also considering the notable resistance to low temperatures of the nematode (Li et al., 2022).

5.1.3.2 | *Monochamus species*

The North American *Monochamus* are medium sized (13–35 mm) longhorn beetles; the smaller species are *M. carolinensis* and *M. obtusus*; the biggest *M. notatus* and *M. scutellatus*. All the species have a similar life history, which can be exemplified by that of *Monochamus carolinensis* (Akbulut & Stamps, 2012). *Monochamus* spp. have four stages of development: egg, larva (three to eight instars), pupa and adult. The beetles usually complete their life cycle in one or more years; in warmer southern areas they can have two or even three generations per year (EFSA, 2020; Akbulut & Stamps, 2012), whereas in northern colder areas they need 2 years to complete the development. Adult beetles feed on conifer needles and thin bark of healthy tree twigs for 10–14 days; this food source is necessary for sexual maturation after the emergence of new adults. After mating, the females lay one or more eggs in oviposition scars chewed by their robust mandibles in the bark of dying or stressed pines. The mean fecundity of adult females varies depending on species, body size and longevity. For instance, for *M. carolinensis*, the number of eggs has been reported to range from 117 to 451 (Togashi et al., 2009). Both the wounds due to the maturation feeding and the oviposition scars are entry ways to the host for the phoretic nematode. Larvae develop first under the bark, then in the phloem and cambium and finally in the wood of stems or branches of weakened or dying trees after fire, windthrows, defoliation caused by insects and drought. They may also breed on freshly cut trees and logs, both on the ground and in stacks. Larvae initially excavate galleries feeding on the phloem and cambium; later they penetrate the sapwood by boring deep oval shaped tunnels. Mature larvae burrow a pupal chamber in the outer sapwood close to the bark. Either mature larva or pupa is usually the overwintering stage, but *M. carolinensis* eggs may overwinter as well. Pupal stage usually lasts 2–3 weeks, and immature adults emerge through circular exit holes. The development time lasts 38–103 days from oviposition to adult emergence and this may allow more than one generation per year under favourable climatic conditions (Akbulut & Stamps, 2012). Adult beetles live from 1 to 5 months and can fly from a few hundred meters up to 2–3.5 km (EFSA, 2020; Akbulut & Stamps, 2012). However, long flight distances (10 km or more) are also flown by adult beetles searching for suitable hosts when they are scarce or absent (EFSA, 2020). Human-assisted spread of *Monochamus* beetles easily occurs mainly through the transport of infested commodities, particularly round or sawn wood and wood packaging material containing immature stages (larvae, pupae, immature adults) (EFSA, 2019), as confirmed by the frequency of interceptions (EUROPHYT, 2024; TRACES-NT, 2024).

Different species of *Monochamus* present in the US show some preference for host plants (*Abies, Larix, Picea, Pinus, Pseudotsuga*) and parts of the tree (stem or branches) (EFSA, 2020). However, pines are the preferred hosts for all species except for *M. marmorator*, which only feeds and reproduces on *Abies* and *Picea* (Akbulut & Stamps, 2012).

M. carolinensis (Carolina sawyer) is considered one of the main vectors of *B. xylophilus* in the eastern and central US, where it is common in pine forests and urban areas from Vermont to Florida and Minnesota to Texas. Its life cycle is greatly temperature dependent, being semi-voltine in the North of its range and bi-voltine in the southern warmer states. The beetle only develops on *Pinus*, and it is found on both native (*P. banksiana*, *P. echinata, P. resinosa*, *P. strobus*, *P. taeda, P. virginiana*) and exotic pines (*P. densiflora, P. nigra, P. sylvestris, P. thunbergii*). However, native pines are only rarely damaged by *M. carolinensis* as vector of *B. xylophilus*, probably due to the coevolution of the complex beetle/nematode and the tree species (Akbulut & Stamps, 2012).

Monochamus clamator (spotted pine sawyer) has a main western distribution, and it is more common in high altitude ponderosa pine stands from Oregon to California and Arizona, and *Pinus monophylla* forests in Nevada, Arizona and southern California (Gorring & Farrell, 2014; Atkins et al., 2021; Pimentel et al., 2014); however, no other detailed information on the host range of the beetle is available. The role of *M. clamator* as a vector of *B. xylophilus* seems to be limited, as the beetle/nematode association has been reported for the first time in the US only in recent years (Atkins et al., 2021).

Monochamus maculosus (syn. *M. mutator*) (spotted pine sawyer) has a distribution partly similar to that of *M. clamator* in the western states, but apparently with a different host range. Out of *Pseudotsuga menziesii*, it is also found on *Pinus banksiana* and *P. resinosa*. Its importance as a vector of *B. xylophilus* seems to be low (EPPO, 2022a).

Monochamus marmorator (balsam-fir sawyer) is present in the northeastern states of the US where it is found on *Abies balsamea* and *Picea rubens* as sole host plants. The association of *M. marmorator* and *B. xylophilus* has been recognised on *A. balsamea* in Minnesota and in Canada (EPPO, 2022b), but no other data is available about the importance of the beetle as a vector of the nematode.

Monochamus notatus (northeastern sawyer) is a large species mainly distributed in the north-eastern US and Canada. Its host range includes *Abies balsamea*, *Picea glauca*, *P. rubens*, *Pinus monticola*, *P. resinosa*, *P. strobus* and *Pseudotsuga menziesii* (EPPO, 2022c). The beetle is known as much less efficient vector of *B. xylophilus* than the similar species *M. scutellatus* in the same locations (Bergdahl et al., 1991); the two species are often sympatric and show interspecific competition mostly in the oviposition on large diameter logs (Hughes & Hughes, 1987).

Monochamus obtusus (obtuse sawyer) has a restricted western distribution, being present in California, Idaho, Montana, Oregon and Washington where it is found on *Abies concolor*, *A. grandis*, *Pinus contorta*, *P. coulteri*, *P. lambertiana*, *P. ponderosa*, *P. sabiniana* and *Pseudotsuga menziesii* (EPPO, 2022d). There is only little evidence on that *M. obtusus* is vector of *B. xylophilus* (Akbulut & Stamps, 2012), and phoresy has not been observed in California by Pimentel et al. (2014).

Monochamus scutellatus (white-spotted sawyer) has both the widest distribution and the most extensive host range among the sawyer species in the US. It is present almost everywhere in the US with exception of Texas, Oklahoma, Kansas, Missouri and South Dakota, which are all in the area of central plains. The list of host plant species includes: *Abies balsamea*, *Larix laricina*, *Picea glauca*, *P. mariana*, *Pinus nigra*, *P. resinosa*, *P. strobus*, *Pseudotsuga menziesii*, *Tsuga canadensis* and *T. heterophylla* (EPPO, 2022e). The beetle has a 2-years life cycle in the north of its range, while is monovoltine in the most part of the US, usually developing on large conifer logs. *Monochamus carolinensis* is more important as a vector of *B. xylophilus* than *M. scutellatus* according to Akbulut and Stamps (2012).

Monochamus titillator (southern pine sawyer) is often sympatric with *M. carolinensis* in southern pine forests, but also occurs elsewhere in the eastern US, partly because of its host range, which also includes some conifer species other than pines. In the US *M. titillator* is found on *Pinus elliotti, P. glauca, P. rigida* as native species, and *P. sylvestris* and *P. thunbergii* as exotic species; other hosts are *Abies balsamea* and *Picea* sp. (EPPO, 2022f). Like *M. carolinensis*, *Monochamus titillator* is frequently found on dying trees and windthrows, as well as in woody waste left on the ground after logging (Alya &

Hain, 1985). In the southern states the beetle has two or three generation per year (Akbulut & Stamps, 2012). Its importance as a carrier seem to vary greatly depending on locality and state. In Virginia, Florida and Louisiana it is considered a primary vector of *B. xylophilus* (Carling, 1984; Luzzi et al., 1984; Pimentel et al., 2014) while in North Carolina no association with the nematode has been found (Alya & Hain, 1985).

5.1.4 | Symptoms

5.1.4.1 | *Bursaphelenchus xylophilus*

A needle yellowing and redding is the main external symptom usually observed on susceptible pine hosts, which then wilt and die rapidly. Wilting may firstly appear on a single branch and then may be extended to the whole crown (CABI, 2022; Malek & Appleby, 1984). Both needle discoloration and wilting are non-specific symptoms of infection of *B. xylophilus* on pines, not easily distinguishable from symptoms caused by other pests, diseases, root damage or drought stress. A reliable identification of *B. xylophilus* on symptomatic plants or wood material needs to be assessed by laboratory tests (EPPO, 2023a). In warm conditions, infected susceptible hosts may die in a few months (Back et al., 2024; Malek & Appleby, 1984). The course of the infection may be slower, like in northern areas of Japan, where the discoloration on needle often appear gradually and the death of pines may be delayed 1–2 years after infection. This means that pines infected in autumn may not show symptoms until the following year (CABI, 2022; EFSA, 2019; Futai & Takeuchi, 2008). The asymptomatic infections may last for extended time. This was reported in Vermont northern US, where nematode infected *P. sylvestris* remained asymptomatic for up to 14 years (Bergdahl & Halik, 2003; Bergdahl pers. comm. 2009).

5.1.4.2 | *Monochamus species*

Main symptoms of attack by adult beetles on pine shoots and twigs are the feeding scars nibbled by mandibles on thin bark, which may be visible when they are fresh during summer. Wilting of shoots and needle falling is only occasionally observed as consequence of stronger feeding activity. Young larvae (1st and 2nd instar) living in the phloem galleries are easily observed under the bark of dying pines. From the cambium, aged larvae bore oval entry holes to enter the wood. Frass composed by wood shreds and larval excrements is expelled out of the galleries by larvae and are frequently observed in bark crevices along the trunk and under the bark of both standing trees and logs on the ground. Round exit holes have a diameter corresponding to the width of emerging adults (7 mm in *M. carolinensis*) and are easily detectable. However, all the symptoms caused by feeding activity of *Monochamus* species are non-specific, as they are common to other Lamiinae species of similar size living on conifers. *Monochamus* as a genus is easy to identify. The identification at species level is of little importance since all *Monochamus* species can be vectors.

5.1.5 | Host range and host status

According to CABI (2022) and EPPO (2024b), 59 conifer species are currently known as hosts of *B. xylophilus* in North America, Asia and Europe. Of these, 32 are native to the US and nine of them can be considered as main hosts of the nematode. Despite this wide range of hosts, however, only a restricted list of pine species (*Pinus thunbergii*, *P. densiflora*, *P. luchuensis, P. massoniana, P. nigra, P. pinaster* and *P. sylvestris*) have been found as highly susceptible to infection by *B. xylophilus* in the field, and all are species non-native to North America. All the other species are confirmed as hosts mostly after experimental inoculation to assay susceptibility/resistance to the nematode, sometimes showing unclear results. This is the case of *Pinus elliottii* and *P. radiata*, two North American native species, which have been proved susceptible in experimental tests but never found as a host in field in the US (CABI, 2022; Dwinell & Nickle, 1989).

5.1.6 | Impact

Bursaphelenchus xylophilus is a destructive species, able to cause severe economic and environmental impacts to the forests, mostly out of its native range. In Asia, the damage caused by *B. xylophilus* has been estimated in many millions of trees killed per year in Japan, China and South Korea in the first decade of the 2000s (EPPO, 2023a). In China only, the economic losses due to PWD from 1998 to 2017 were over a billion dollars per year (CABI, 2022). In both Japan and China, the spread of PWD has also progressively changed the composition of natural forests over large areas, leading to the local disappearance of native pines which have been replaced by broadleaved species. A decline of natural pine forests after spread of PWD was also registered in Portugal from 1995 to 2010 (Back et al., 2024). *Bursaphelenchus xylophilus* is of a great concern for Europe, mostly the southern EU states, where 25% yield losses in pine plantations have been estimated in case of spread of the pathogen (EFSA, 2019).

In North America, where *B. xylophilus* is native, no environmental impacts are observed in the natural forests, and also direct economic losses are low. The damage is limited to ornamental plantings with exotic pines in urban areas and to Christmas tree plantations. However, an indirect economic impact of *B. xylophilus* is due to the severe import restrictions of wood products from the US (round/sawn wood and wood chips) imposed by the EU since 1993 to protect its forests from PWD. The exports of softwood from the US to Europe declined by 69 million dollars the year after the ban (Hoover et al., 2010).

Excluding nematode phoresy, *Monochamus* species are considered secondary pests only attacking severely weakened trees due to various causes (storms, wildfires, defoliating or scale insects' infestations). However, these beetles frequently also breed on freshly cut trees as well as on post disturbance salvaged timber. The presence of larval tunnels in the conifer logs is often associated with bluestain fungi and leads to considerable loss of value, so that *Monochamus* are among the most destructive pests causing timber degradation in Canada and the US (Allison et al., 2004; Evans et al., 2007; Miller et al., 2023).

5.1.7 | Remarks on survival and development of *Bursaphelenchus xylophilus* and its vectors in wood chips

Phoresy may also potentially occur after adult beetles reach piles of wood chips containing *B. xylophilus* and become infected (Tomminen & Akar, 1990). *B. xylophilus* is well known for its high survival capability in a wide range of adverse conditions of both temperature and humidity, as well as of lack of food (100 days of survival under starvation in JIII juveniles) (Ishibashi & Kondo, 1977).

For the nematode, wood chips are a very suitable substrate for development; however, chips are strongly different from round and sawn wood, mostly due to the temperature and humidity conditions of the piles. In general, *B. xylophilus* can complete the development in 3–12 days at temperatures between 15–20°C and 25–30°C. In the case of wood chips the optimal range is a little higher (35–40°C) due to the greater availability of thermotolerant fungi which are the main source of food for the nematode (Dwinell, 1986). *B. xylophilus* may survive in the wood chips from 14 to 20 months at a temperature of 20–22°C according to Halik and Bergdahl (1992) and Panesar et al. (1994). The survival of *B. xylophilus* in fresh wood chips depends only initially on parenchymal cells, and after 2 weeks saprophytic fungi become the main food source (Kopinga et al., 2010). In a laboratory study conducted at 30°C and 38% relative humidity, the nematode population in wood chips increased by a factor of 140–200 over 12 weeks (Halik & Bergdahl, 1990). Additionally, the ability of the nematode to move 10 cm across pine bark surfaces (Arakawa & Togashi, 2002) demonstrates its potential for spread, including movement between pieces of wood chips. The nematode can also transfer from infested to non-infested trees via temporary stem grafts (Malek & Appleby, 1984), further suggesting its ability to spread between wood chips in close contact. The reports of Halik and Bergdahl (1990) and Tomminen et al. (1991) showed that the nematode also can infect wood chips from water suspensions, so it is likely that the nematode could spread from infested chips through water films to infest new chips stored in a pile. It should also be noticed that *B. xylophilus* is able to reproduce in bark infested by fungi (Forge & Sutherland, 1996). A small amount of bark (up to 2%) is tolerated in wood chip consignments.

Relative humidity (RH) is a key factor for the reproduction of the nematode. A moisture content 22% is the minimum threshold for the colonising fungi, and over 38% the fungal growth progressively decreases, leading to the similar trend for *B. xylophilus* as well. The higher the water content of the chips, the more the oxygen content necessary for the development of the nematode is reduced, but the population decline occurs slowly over several weeks, often remaining at high levels (Halik & Bergdahl, 1990). On the converse, the natural decrease in moisture content in all wood materials also leads to a reduction of the *B. xylophilus* population as consequence of lower capacity of wood to support fungal populations which are source of food for the nematode (Sousa et al., 2011). When the temperature rises to 45°C the nematode population rapidly declines (to zero within 13 h at 50°C and within 1 h at 60°C) (Dwinell, 1986). The interior of a wood chip pile may rapidly rise to 60°C due to spontaneous heating, but the temperature is lower in the outer layers (Kopinga et al., 2010; Tomminen et al., 1991). According to Panesar et al. (1994) a combination of temperature 40°C, 20 days and 52% RH can kill all nematodes in wood chips.

Data on lethal temperature of *B. xylophilus* is basically consistent with that of its vectors *Monochamus*, and it is the basis for the heat treatment of wood to a temperature of 56°C for 30 min which has been accepted as a phytosanitary standard ISPM 15 – 2009 (EPPO, 2018; NAPPO, 2013). Microwave and radio frequency treatments have also been proposed to reduce the exposure time of infested wood to 1 min with 100% mortality of *B. xylophilus*, as alternative to conventional heating (Hoover et al., 2010; Uzunovic et al., 2013). The efficacy of the microwave treatment has been proved by Hoover et al. (2010) also on small wood samples (2.5 × 3.8 × 0.64 cm).

Concerning the survival of *B. xylophilus* at low temperatures, recent studies have shown the considerable cold tolerance of the nematode. Pan et al. (2021) demonstrated that 92% of the third stage dispersal juveniles (JIII) are able to survive at −20°C for 30 days through cryptobiosis. However, Li et al. (2022) found that after exposure to −5 and −10°C for 24 h the survival rates of the nematode were respectively 93.04%–94.85% and 9.93%–10.56%.

In the case of *Monochamus* the lethal temperatures in lumber are 60–71°C (NAPPO, 2013) and −6 to −15°C in summer and in winter, respectively (Ma et al., 2006). Wood chips are not suitable for beetle development. Adults only feed on young shoots and cannot survive more than 12–14 days without feeding. Larvae from 1st to 3rd instar are unable to complete the development on small pieces of wood. Only a relatively large wood chip might eventually host a mature larva or a pupal chamber so that the possibility that the vector can transfer with wood chips is considered negligible (ANSES, 2018; Evans et al., 1996).

5.2 | Other target pests

All the information on the additional EU quarantine pests relevant for this opinion are summarised in the Appendix A.

6 | EVALUATION OF THE DIFFERENT PHASES IN THE PRODUCTION OF THE COMMODITY WITH REFERENCE TO THE REDUCTION OF RISKS ASSOCIATED WITH PESTS

The evaluation of different phases in the production of the commodity with reference to the reduction of risks associated with each of the target pests is summarised in Appendix D.

6.1 | Trees are inspected before harvest

The selection of trees without visible symptoms before harvest will reduce the likelihood that infected/infested trees are entering the wood chips production process. However, low levels of infections may be overlooked and some pests, such as wood decay fungi, may be present asymptomatically. Similarly, low levels of infestations by defoliators, ambrosia and bark beetles, as well as other wood-boring insects may be difficult to detect. Pinewood nematode may not cause any symptoms on some host species. Further details on impact of this measure are provided in Appendix D.

6.2 | Removal of branches, no roots entering the wood chip production

The removal of branches, stumps and roots before wood chip production will reduce the likelihood that infected/infested parts of the trees are entering the wood chips production process. However, most pests like fungi, ambrosia and bark beetles, wood borers and pinewood nematode can also be associated with the main stem and larger branches. Further details on the efficacy of this measure are provided in Appendix D.

6.3 | Debarking

Debarking will be effective against canker-causing fungi as it removes all bark infections. It will only be partially effective against fungi present in the sapwood as only in the best case the outer sapwood is removed by the debarking machinery used. Debarking most likely will remove all larvae and eggs of some pests (e.g. bark beetles, wood-boring insects, *Choristoneura* spp.).

Debarking will not be effective against fungi and insects which are located deeper inside the logs (e.g. wood decay fungi, ambrosia beetles or wood borers like *Monochamus* spp.), neither effective against the pinewood nematode.

However, in the 2% of tolerated bark, there could be remnants of sporulating tissues of different fungi or different stages of insects. In addition, contaminating spores could remain on the wood chips.

Further details on impact of this measure are provided in Appendix D.

6.4 | Chipping

Chipping will not be effective against most fungal pathogens, except for obligate parasites, for which it could be effective as they are not expected to be able to survive on the chips for a long period of time.

Chipping will be partially effective against some insect pests (e.g. bark and ambrosia beetles, and woodborers like *Monochamus* spp.) since the measure will affect most of their galleries by direct killing and because of drying out after chipping. However, considering the dimensions of the chips and the size of the beetles, survival of some specimens within the chips cannot be excluded. This measure will not be effective against defoliators nor against *B. xylophilus*. Further details on impact of this measure are provided in Appendix D.

6.5 | Quality control after chipping

Quality control after chipping consists of visual inspection of the wood chip piles walking around the perimeter and on top of the wood chip piles. In principle, this measure may be partially effective against blue stain and rot fungi, and for insects like ambrosia and wood borer beetles which display clear symptoms or signs of presence. However, the visual inspection is targeted only at surface layers at the top of the wood chip piles and their perimeters. Moreover, up to 2% rot is tolerated in wood chips. The measure will also be partially effective against *B. xylophilus* as this pest could be associated with blue stain and, consequently, could be detected during quality control.

Visual inspection will not be effective against fungi that do not cause visible rot or blue stain.

Further details on impact of this measure are provided in Appendix D.

6.6 | Sulfuryl fluoride fumigation

The applicant proposed a treatment of wood chips in shipholds following the requirements outlined in ISPM 28 - PT23 of sulfuryl fluoride (SF) fumigation treatment for nematodes and insects in debarked wood (see Section 3.3.2). Below information on relevant groups of organisms is summarised and compared with the sulfuryl fluoride treatment suggested by USDA APHIS. Information on the efficacy of SF treatment is available from EFSA PLH Panel (2020a) and EFSA PLH Panel (2023) and an additional literature search conducted by EFSA (see Appendix B and C).

Monochamus and other insects:

Sulfuryl fluoride was tested against a wide range of wood dwelling insects belonging to the families Buprestidae, Cerambycidae, Curculinonidae, Platypodidae, Anobidae, Lyctidae and Bostrychidae.

The studies were done at various concentrations, temperatures and substrates. This made a comparison of relative sensitivity of different groups of insects difficult. Data were available for only one *Monochamus* species (*M. alternatus*), which was not sufficient to draw a conclusion on whether *Monochamus* species are more or less sensitive compared to other tested insect species.

From the available studies it seems that the concentrations, temperature and duration of exposure to SF in ISPM 28 - PT 23 is sufficient to kill adult, pupae and larvae of insects. However, it is less clear for insect eggs. Several studies show that the most susceptible life stages are adults and pupae. Larvae are less susceptible than adults and eggs are less sensitive than other life stages requiring up to 4–54 times more SF than adults in order to kill them (Su & Scheffrahn, 1990; Thoms & Scheffrahn, 1994; Mizobuti et al., 1996; Soma et al., 1996, 1997; Zhang, 2006; Armstrong et al., 2014; Myers et al., 2021).

The results of Soma et al. (1996) show 100% mortality of eggs of *Cryphalus fulvus*, (Curculionidae) when exposed to 130 g/m^3 at 15°C for 48 h (eggs on glass container covered with filter paper) and mortality was 95% at 86.4 g/m^3. However, only 39.3% mortality of eggs of *Xyleborus pfeilii* (Curculionidae) was observed when exposed to 100 g/m^3 for 24 h at 25°C (eggs were exposed in glass container covered with filter paper). Only 19% egg mortality was observed at a concentration of 80 g/m^3, 15°C for 24 h and 23.1% mortality at a concentration of 50 g/m^3 (15°C) for 48 h (Mizobuti et al., 1996). Mortality of *Agrilus planipennis* (Buprestidae) eggs (on filter paper) was 91.7% and 93% at 129.6 g/m^3 and 145.5 g/m^3 at 21.1°C for 24 h (Barak et al., 2010). The duration of exposure was less than 48 h but the concentrations exceeded the requirements of ISPM 28 - PT 23. Therefore, it is unclear whether the requirements of ISPM 28 - PT 23 would be sufficient to kill all eggs of *A. planipennis*.

Bursaphelenchus xylophilus:

In wood chips, no surviving *B. xylophilus* were found at exposure to SF of 70–90 g/m^3 for 48 h (3420–3788 g × h/m^3) at 20°C. However, *B. xylophilus* was not controlled in chips at concentrations of 50–90 g/m^3 for 24 h (1208–2109 g × h/m^3) and at 50–60 g/m^3 for 48 h (2559–2860 g × h/m^3) at 20°C (Seabright et al., 2020). The size of wood chips in the study of Seabright et al. (2020) was 25 × 38 × 6 mm. However, *B. xylophilus* survived the SF treatment in wood blocks with a size of 75 × 75 × 150 mm and exposure up to 180 g/m^3 (8943 g × h/m^3), suggesting that the size of wood chips is an important factor for successful treatment. Reasons for this are larger surface areas of wood chips compared to wood blocks and the smaller distance for the gas to diffuse in wood chips compared to wood blocks. The applicant specified for the wood chips a maximum length of 102 mm with maximum 5% of the chips exceeding 45 mm in length which is larger than the size of wood chips tested in Seabright et al. (2020) where successful SF treatment was observed. The moisture content of wood chips tested was 162% (dry weight basis), which is higher than suggested by the applicant (45%–52% based on wet weight which is approximately 85%–110% moisture content based on dry weight). Given that SF penetrates dry wood quickly but does not penetrate wet wood well (Scheffrahn et al., 1992), the drier wood chips as specified by the applicant should facilitate a more efficient SF treatment.

In the study of Bonifácio et al. (2013), pinewood boards naturally infested with *B. xylophilus* were treated with SF at concentrations ranging from 50 to 170 g/m^3 for 24 h at temperatures of 15, 20 and 30°C and CT of 3169–4407 g × h/m^3, 2145–4051 g × h/m^3 and 1360–2141 g × h/m^3. No *B. xylophilus* survived the treatments at 15 and 30°C. However, *B. xylophilus* could survive the treatment at 20°C. The authors mention higher moisture content of wood and possible survival of nematode eggs as potential reasons for the observed survival of nematodes (adults retrieved after 24 h, 72 h and 21 days) and suggested further investigation. The observed survival of *B. xylophilus* at 20°C raises some doubts on whether the treatment with SF as recommended in ISPM 28 - PT 23 is always sufficient to eliminate all *B. xylophilus*.

Dwinell et al. (2003) observed 10% survival of *B. xylophilus* at 60 g/m^3 after 24 h at 20°C. No survivors were found at ≥ 25°C in naturally infested pine sticks and logs, and 35°C and 997–1751 hg/m^3 in pin slabs, cants and lumber.

Concentrations of 20–80 g/m^3 for 24 and 48 h at 15°C were tested on conifer wooden boards and lumber infested with *B. xylophilus*. Some *B. xylophilus* survived at a concentration of 60 g/m^3 for 48 h (Soma et al., 2001).

Overall, it can be concluded that the requirements of ISPM 28 - PT23 seem to be sufficient to kill *B. xylophilus*. However, in the study of Bonifácio et al. (2013) surviving *B. xylophilus* were observed at 2145–4051 g × h/m^3 which was hypothesised to be related to high moisture content and survival of nematode eggs. This raises some doubts on whether the requirements in ISPM 28 - PT23 are always sufficient. Particular attention must be paid to long enough exposure duration, low enough wood moisture and small enough wood particle size.

Fungi:

Yang et al. (2019) tested SF concentrations of 128–320 g/m^3 for 73 and 96 h on logs naturally infected *by Bretziella fagacearum* at a temperature of 15.6°C. Living fungal isolates were found at 280 and 320 g/m^3 (72 h), at 128 g/m^3 and at 240 g/m^3 (96 h). The results are not directly comparable to ISPM 28 - PT23 since the temperature is lower, but the concentrations tested were higher and the exposure duration was longer with 72–96 h instead of 48 h.

Uzunovic et al. (2017) tested 23 fungal species at SF concentrations of 40–240 g/m^3 at temperatures of 15°C and 20°C for 24, 48 and 72 h on artificial growing media. Most fungi survived an exposure duration of 24 h. Even at the highest concentration of 240 g/m^3 more than half of the fungal species survived the exposure duration of 24 h. Most fungi were killed after 48 h and the highest concentration of 240 g/m^3. However, four species survived 72 h exposure to 240 g/m^3 suggesting that the requirements of ISPM 28 - PT 23 are not sufficient to kill all fungal species.

Exposure to 160 g/m^3 for 72 h was not sufficient to kill *B. fagacearum* on birch, poplar and maple wood blocks. No living fungi were found at 240 g/m^3 for 72 h but shorter exposure of 48 h was not sufficient to kill completely *B. fagacearum* (Tubajika & Barak, 2011). The wood blocks with a size of 2.5 × 2.5 × 1 cm resemble the size of wood chips. The results suggest that the requirements of ISPM 28 - PT 23 are not sufficient for this fungus.

Tubajika and Barak et al. (2006) tested fungal species on poplar and oak wood blocks (10 × 10 × 15 cm and 2.5 × 2.5 × 1 cm) at SF concentrations ranging from 16 to 112 g/m^3 at 21°C. Five species (*Irpex lacteus, Postia placenta, Armillaria mellea, Gloeophyllum trabeum, Ganoderma lucidum*) were killed at concentrations of 80 g/m^3 or higher within 24 h. Five other species (*Heterobasidium annosum, Leptographium wingfieldii*, *Ceratocystis polonica, Ceratocystis fimbriata*, *Ceratocystis fagaceurum*) were recovered at the highest concentration. The CT product of 2804 g × h/m^3 for SF was not effective in killing the fungi. ISPM 28 - PT23 requires CT of 3000 g × h/m^3 at 20°C. It is unknown if these fungi would also have survived 3000 g × h/m^3.

Zhang (2006) observed 100% mortality of all the eight tested fungal species (*Cladosporium herbarum*, *Phlebiopsis gigantea*, *Schizophyllum commune*, *Armillaria novae-zelandiae*, *Botryodiplodia theobromae*, *Ophiostoma novo-ulmi*, *Phytophthora cinnamom, Sphaeropsis sapinea*) after exposure to concentrations of ≥ 30 g/m^3 on petri dishes for 24 h at 15°C.

Overall, it can be concluded that the requirements of ISPM 28 - PT 23 may not be sufficient to kill all fungal species.

7 | QUANTITATIVE ASSESSMENT OF THE PEST FREEDOM OF CONIFER WOOD CHIPS

An EKE for pest freedom of conifer wood chips was conducted for Ambrosia beetles, *Atropellis* species, *Bursaphelenchus xylophilus*, *Choristoneura* species, *Coniferiporia sulphurascens* and *C. weirii*, *Cronartium* species, *Fursarium circinatum*, *Gremmeniella abietina*, *Gymnosporangium* species, *Lycorma delicatula*, *Monochamus* species, *Phytophthora ramorum* (non-EU isolates), *Pissodes* and bark beetles.

The outcome of the quantitative assessment is presented in Table 7 and Figure 4. A detailed description of the scenarios and considerations for the estimates are provided in Appendix E.

Figure 5 provides an explanation of the descending distribution function describing the likelihood of pest freedom of debarked conifer wood chips fumigated with sulfuryl fluoride reduced in the US for *B. xylophilus*.

The parasitic *Arceuthobium* species including their seeds are considered to be largely removed during the wood chip production (i.e. removal of branches, debarking). In addition, as the relevant species are obligatory parasitic plants dependent on living hosts, they will not be able to survive for a long time on wood chips. Therefore, no EKE was conducted for *Arceuthobium* species.

TABLE 7 Likelihood of pest freedom for EU quarantine pests of debarked conifer wood chips fumigated with sulphuryl fluoride produced in the US following an evaluation of all phases of the production. In panel A, the median value for the assessed level of pest freedom for each pest is indicated by 'M', the 5% percentile is indicated by 'L', and the 95% percentile is indicated by 'U'. The percentiles together span the 90% uncertainty range regarding pest freedom. The pest freedom categories are defined in panels A and B of the table.

Number	Group	Pest species	Sometimes pest free	More often than not pest free	Frequently pest free	Very frequently pest free	Extremely frequently pest free	Pest free with some exceptional cases	Pest free with few exceptional cases	Almost always pest free
1	Insects	Ambrosia beetles					**L**	**M**		**U**
2	Fungi	*Atropellis* species				**LM**		**U**		
3	Nematodes	*Bursaphelenchus xylophilus*			**L**	**M**		**U**		
4	Insets	*Choristoneura* species								**LMU**
5	Fungi	*Coniferiporia sulphurascens* and *C. weirii*				**L**	**M**			**U**
6	Fungi	*Cronartium* species				**L**	**M**	**U**		
7	Fungi	*Fusarium circinatum*				**LM**		**U**		
8	Fungi	*Gremmeniella abietina*				**L**	**M**			**U**
9	Fungi	*Gymnosporangium* species						**LM**		**U**
10	Insects	*Lycorma delicatula*							**L**	**MU**
11	Insects	*Monochamus* species						**L**		**MU**
12	Oomycetes	*Phytophthora ramorum* (non-EU isolates)						**LM**		**U**
13	Insects	*Pissodes* and bark beetles						**L**		**MU**

PANEL A

	Pest-freedom category	Pest-free wood chips out of 10,000 m^3
🟥	Sometimes pest free	≤ 5000
🟧	More often than not pest free	5000–≤ 9000
🟧	Frequently pest free	9000–≤ 9500
🟨	Very frequently pest free	9500–≤ 9900
🟨	Extremely frequently pest free	9900–≤ 9950
🟩	Pest free with some exceptional cases	9950–≤ 9990
🟩	Pest free with few exceptional cases	9990–≤ 9995
🟩	Almost always pest free	9995–≤ 10,000

PANEL B

Legend of pest-freedom categories	
L	Pest-freedom category includes the elicited lower bound of the 90% uncertainty range
M	Pest-freedom category includes the elicited median
U	Pest-freedom category includes the elicited upper bound of the 90% uncertainty range

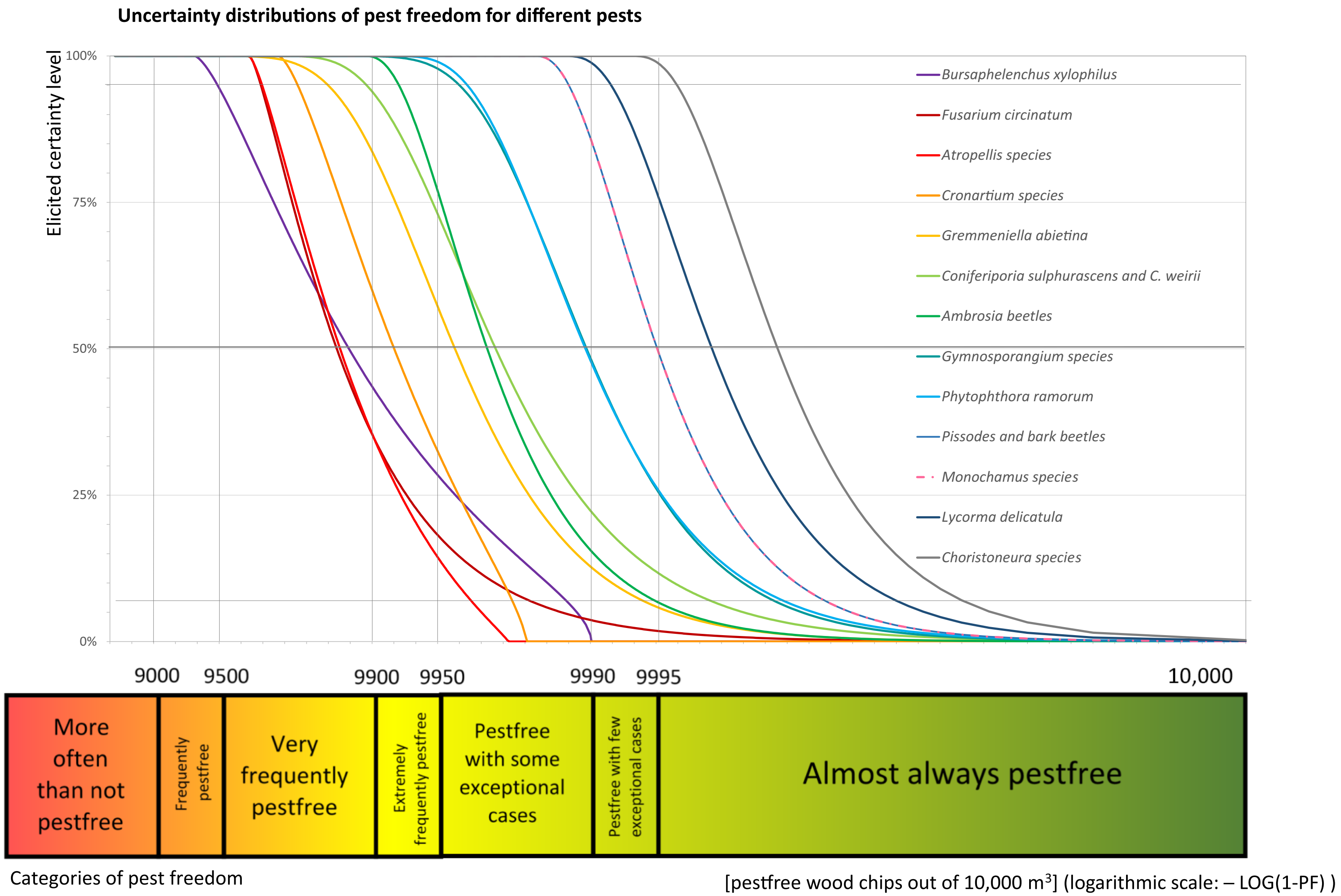
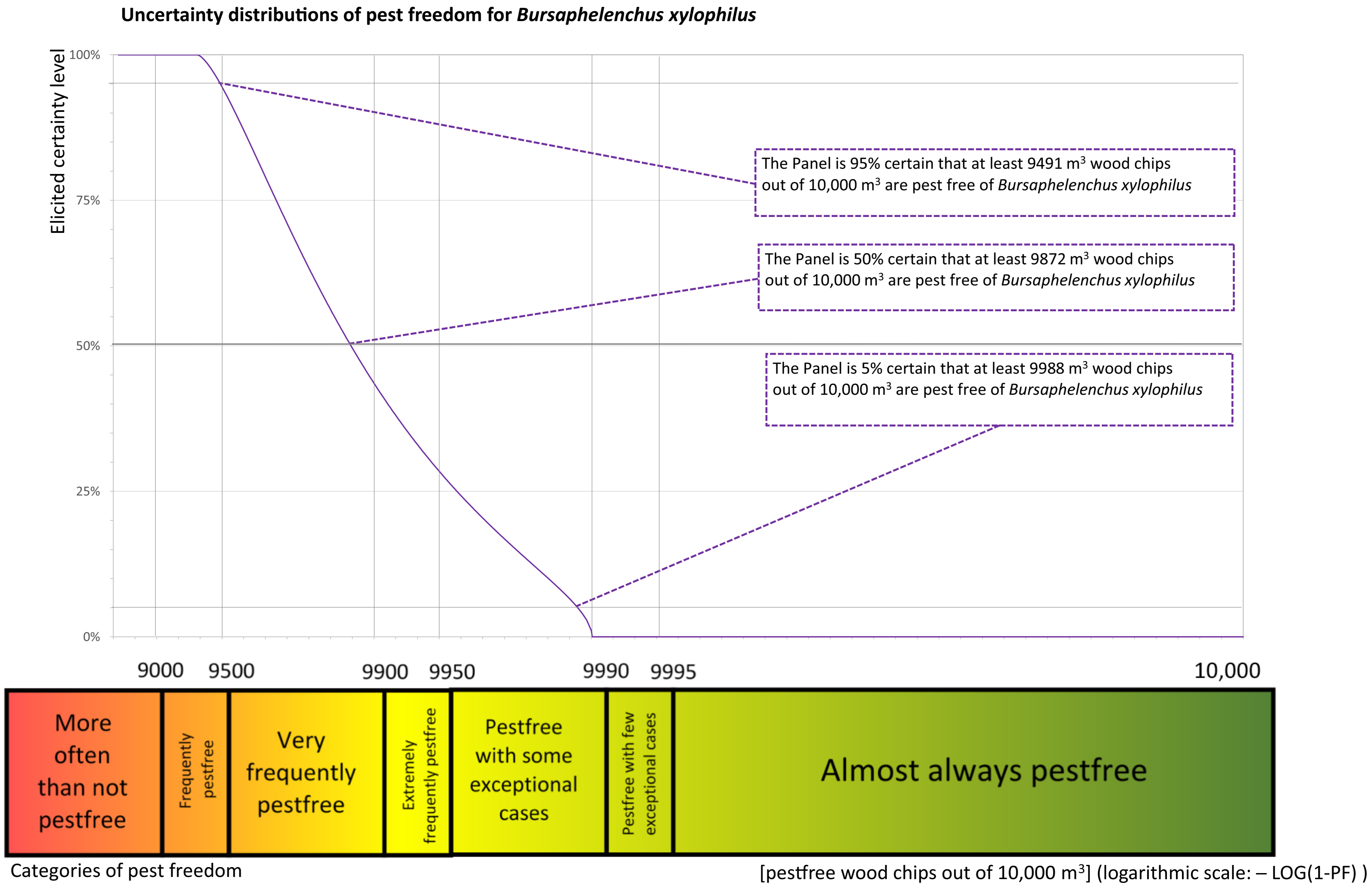


FIGURE 4 Elicited certainty (*y*-axis) of the number of pest-free conifer wood chips m^3 (*x*-axis; log-scaled) out of 10,000 m^3 designated for export to the EU from the US for all evaluated pests visualised as descending distribution function. Horizontal lines indicate the reported certainty levels (starting from the bottom 5%, 25%, 50%, 75%, 95%) Please see the reading instructions below.



The Panel is 95% certain that at least 9491 m^3 wood chips out of 10,000 m^3 are pest free of *Bursaphelenchus xylophilus*

The Panel is 50% certain that at least 9872 m^3 wood chips out of 10,000 m^3 are pest free of *Bursaphelenchus xylophilus*

The Panel is 5% certain that at least 9988 m^3 wood chips out of 10,000 m^3 are pest free of *Bursaphelenchus xylophilus*

FIGURE 5 Explanation of the descending distribution function describing the likelihood of pest freedom of debarked conifer wood chips produced in the US and treated with sulfuryl fluoride for *Bursaphelenchus xylophilus*.

8 | TECHNICAL ELEMENTS CRITICAL FOR A SUCCESSFUL TREATMENT AND FOR MINIMISING THE PRESENCE OF UNION QUARANTINE PESTS ON THE COMMODITY

The available studies with *B. xylophilus* and insects show that in addition to the concentration and duration of sulfuryl fluoride treatment, the wood moisture, size of pieces of treated wood and temperature are crucial factors for successful treatments (Barak et al., 2010; Kim et al., 2024; Mizobuti et al., 1996; Scheffrahn et al., 1992). Several studies indicate lower efficacy of SF treatments at lower temperatures (e.g. Barak et al., 2010; Mizobuti et al., 1996). As the fumigation of wood chips is carried out in shipholds, there could be a substantial difference in the temperature of wood chips placed at the bottom or at the sides of shipholds, closer to the water, and those located in the middle and the top of the pile, and this is particularly true when fumigation occurs during colder seasons. However, dataloggers aimed at checking temperature are placed only at 30–45 cm from the top of piles (Dossier Section 2.0).

Another crucial factor for a successful treatment is that the minimum required SF concentration is ensured in any point of the pile. However, monitoring lines into the pile are foreseen at approximately 3 m from the bottom, 1.82 m from the sides and into the top (Dossier Section 2.0), which may not be enough for a thorough monitoring of the concentration throughout the pile.

From a phytosanitary perspective, although not directly related to the efficacy of the treatment, there are other technical aspects that appear critical in the production of the commodity. A major one refers to the relatively long period of storage (up to 90 days) of wood chips in pile before fumigation. While most of the target pests are not expected to spread from wood chip to wood chip during storage, *B. xylophilus* may easily reproduce and spread throughout the pile under conducive conditions. Hence, the longer the period of storage, the higher the risk that the nematode invades large volumes of wood chips in the pile. This aspect may be crucial because the treatment with SF is not expected to be fully effective against the pest. Therefore, the higher the inoculum pressure in the pile, the greater the risk of survival to the fumigation of fractions of the nematode population.

The quantity of bark still present on the wood chips after the debarking phase may influence treatment efficacy as well. A threshold of 2% of bark present on the wood chips was proposed by the applicant country. Bark still present on the wood chips may host remnants of fruiting bodies of fungal pathogens associated with bark and outer sapwood, along with contaminating spores. This appears to be particularly relevant for rusts, i.e. *Gymnosporangium* spp. and *Cronartium* spp. Such a possibility combined with the limited information and uncertainties on the efficacy of treatments with sulfuryl fluoride against fungal plant pathogens, is worth noting and may deserve attention.

For the same reasons, the threshold of 2% rot that is tolerated on wood chips may also deserve attention because two of the target pests, i.e. *Coniferiporia sulphurascens* and *C. weirii*, are indeed wood decay (i.e. rot) agents. Based on the current distribution of these fungal plant pathogens, the Panel anticipates that this observation is relevant only for wood chips produced with trees harvested in the western US.

9 | CONCLUSIONS

The level of pest freedom of debarked conifer wood chips treated with sulfuryl fluoride (SF) in the US was assessed for *B. xylophilus* and its vectors *Monochamus* spp., as well as for 22 additional EU quarantine pests present in the US and potentially associated with the commodity, some of which are regulated as groups of pests by the Commission Implementing Regulation (EU) 2019/2072. Some of the target pests were evaluated as a group, such as *Atropellis* species, *Coniferiporia sulphurascens* and *C. weirii*, *Choristoneura* species, *Cronartium* species, *Gymnosporangium* species, *Pissodes* and bark beetles, or ambrosia beetles. The assessment considered the different phases in the wood chip production for the reduction of the risk of harmful pests being associated with conifer wood chips, with special emphasis on SF treatment. Some of the wood chip production phases alone, such as branch and stump/root removal, debarking, chipping or SF treatment are expected to be effective against some of the pests.

However, as uncertainties remained about the risk reduction levels associated with several production phases for all the species, pest freedom and uncertainty were evaluated quantitatively in the EKE.

The likelihood of pest freedom from *B. xylophilus* of SF-treated debarked conifer wood chips from the US was estimated as 'very frequently pest free' with the 90% uncertainty range ranging from 'frequently pest free' to 'pest free with some exceptional cases'. For SF-treated debarked conifer wood chips coming from the US, the EKE indicated with 95% certainty that between 9491 and 10,000 m^3 of wood chips per 10,000 will be free from *B. xylophilus*.

The likelihood of pest freedom from *Monochamus* species of SF-treated debarked conifer wood chips from the US was estimated as 'almost always pest free' with the 90% uncertainty range ranging from 'pest free with some exceptional cases' to 'almost always pest free'. For SF-treated debarked conifer wood chips coming from the US, the EKE indicated with 95% certainty that between 9987 and 10,000 m^3 of wood chips per 10,000 will be free from *Monochamus* species.

The likelihood of pest freedom from ambrosia beetles of SF-treated debarked conifer wood chips from the US was estimated as 'pest free with some exceptional cases' with the 90% uncertainty range ranging from 'extremely frequently pest free' to 'almost always pest free'. For SF-treated debarked conifer wood chips coming from the US, the EKE indicated with 95% certainty that between 9925 and 10,000 m^3 of wood chips per 10,000 will be free from ambrosia beetles.

The likelihood of pest freedom from *Atropellis* species of SF-treated debarked conifer wood chips from the US was estimated as 'very frequently pest free' with the 90% uncertainty range ranging from 'very frequently pest free' to 'pest free with some exceptional cases'. For SF-treated debarked conifer wood chips coming from the US, the EKE indicated with 95% certainty that between 9681 and 10,000 m^3 meters of wood chips per 10,000 will be free from *Atropellis* species.

The likelihood of pest freedom from *Choristoneura* species of SF-treated debarked conifer wood chips from the US was estimated as 'almost always pest free' with the 90% uncertainty range remaining within the same estimate: 'almost always pest free'. For SF-treated debarked conifer wood chips coming from the US, the EKE indicated with 95% certainty that between 9996.6 and 10,000 m^3 of wood chips per 10,000 will be free from *Choristoneura* species.

The likelihood of pest freedom from *Coniferiporia sulphurascen*s and *C. weirii* of SF-treated debarked conifer wood chips from the US was estimated as 'extremely frequently pest free' with the 90% uncertainty range ranging from 'very frequently pest free' to 'almost always pest free'. For SF-treated debarked conifer wood chips coming from the US, the EKE indicated with 95% certainty that between 9849 and 10,000 m^3 of wood chips per 10,000 will be free from *C. sulphurascen*s and *C. weirii*.

The likelihood of pest freedom from *Cronartium* species of SF-treated debarked conifer wood chips from the US was estimated as 'extremely frequently pest free' with the 90% uncertainty range ranging from 'very frequently pest free' to 'pest free with some exceptional cases'. For SF-treated debarked conifer wood chips coming from the US, the EKE indicated with 95% certainty that between 9781 and 10,000 m^3 of wood chips per 10,000 will be free from *Cronartium* species.

The likelihood of pest freedom from *Fusarium circinatum* of SF-treated debarked conifer wood chips from the US was estimated as 'very frequently pest free' with the 90% uncertainty range ranging from 'very frequently pest free' to 'pest free with some exceptional cases'. For SF-treated debarked conifer wood chips coming from the US, the EKE indicated with 95% certainty that between 9677 and 10,000 m^3 of wood chips per 10,000 will be free from *F. circinatum*.

The likelihood of pest freedom from *Gremmeniella abietina* of SF-treated debarked conifer wood chips from the US was estimated as 'extremely frequently pest free' with the 90% uncertainty range ranging from 'very frequently pest free' to 'almost always pest free'. For SF-treated debarked conifer wood chips coming from the US, the EKE indicated with 95% certainty that between 9841 and 10,000 m^3 of wood chips per 10,000 will be free from *G. abietina*.

The likelihood of pest freedom from *Gymnosporangium* species of SF-treated debarked conifer wood chips from the US was estimated as 'pest free with some exceptional cases' with the 90% uncertainty range ranging from 'pest free with some exceptional cases' to 'almost always pest free'. For SF-treated debarked conifer wood chips coming from the US, the EKE indicated with 95% certainty that between 9960 and 10,000 m^3 of wood chips per 10,000 will be free from *Gymnosporangium* species.

The likelihood of pest freedom from *Lycorma delicatula* of SF-treated debarked conifer wood chips from the US was estimated as 'almost always pest free' with the 90% uncertainty range ranging from 'pest free with few exceptional cases' to 'almost always pest free'. For SF-treated debarked conifer wood chips coming from the US, the EKE indicated with 95% certainty that between 9992 and 10,000 m^3 of wood chips per 10,000 will be free from *L. delicatula*.

The likelihood of pest freedom from *Phytophthora ramorum* (non-EU isolates) of SF-treated debarked conifer wood chips from the US was estimated as 'pest free with some exceptional cases' with the 90% uncertainty range ranging from 'pest free with some exceptional cases' to 'almost always pest free'. For SF-treated debarked conifer wood chips coming from the US, the EKE indicated with 95% certainty that between 9963 and 10,000 m^3 of wood chips per 10,000 will be free from *Phytophthora ramorum* (non-EU isolates).

The likelihood of pest freedom from *Pissodes* and bark beetles of SF-treated debarked conifer wood chips from the US was estimated as 'almost always pest free' with the 90% uncertainty range ranging from 'pest free with some exceptional cases' to 'almost always pest free'. For SF-treated debarked conifer wood chips coming from the US, the EKE indicated with 95% certainty that between 9987 and 10,000 m^3 of wood chips per 10,000 will be free from *Pissodes* and bark beetles.

The concentration and duration of sulfuryl fluoride treatment, the wood moisture, sizes of pieces of treated wood and temperature are crucial factors for successful treatments. Based on the assessment, the suggested treatment according to ISPM 28 - PT23 does not appear sufficient to kill all the relevant pests, and this is particularly true for fungi. Furthermore, uncertainty remains on whether this treatment is always sufficient to eradicate *B. xylophilus*. It should be noted that the above ISPM was not developed specifically for wood chips nor to target all kinds of pests, but rather it was primary developed for nematodes and insects in debarked wood. The development of a specific standard for the fumigation of wood chips against a wide variety of pests, including fungi, is needed. In addition, adequate measures should be implemented to ensure that the required parameters during fumigation are met. As a final note, the time of storage of wood chips before treatment should be kept as short as possible because *B. xylophilus* may easily reproduce and spread throughout the wood chips pile under conducive conditions.

ABBREVIATIONS

EKE	Expert Knowledge Elicitation
EPPO	European and Mediterranean Plant Protection Organization
FAO	Food and Agriculture Organisation
ISPM	International Standards for Phytosanitary Measures
PLH	Plant Health
PWD	Pine Wilt Disease
PWN	Pine Wood Nematode
SF	Sulfuryl Fluoride

GLOSSARY

Control (of a pest)	Suppression, containment or eradication of a pest population (FAO, 2024a, 2024b).
Entry (of a pest)	Movement of a pest into an area where it is not yet present, or present but not widely distributed and being officially controlled (FAO, 2024b).
Establishment (of a pest)	Perpetuation, for the foreseeable future, of a pest within an area after entry (FAO, 2024b).
Impact (of a pest)	The impact of the pest on the crop output and quality and on the environment in the occupied spatial units.
Introduction (of a pest)	The entry of a pest resulting in its establishment (FAO, 2024b).
Measures	Control (of a pest) is defined in ISPM 5 (FAO, 2024b) as 'Suppression, containment or eradication of a pest population' (FAO, 2024a). Control measures are measures that have a direct effect on pest abundance. Supporting measures are organisational measures or procedures supporting the choice of appropriate risk mitigation measures that do not directly affect pest abundance.
Pathway	Any means that allows the entry or spread of a pest (FAO, 2024b).
Phytosanitary measures	Any legislation, regulation or official procedure having the purpose to prevent the introduction or spread of quarantine pests, or to limit the economic impact of regulated non-quarantine pests (FAO, 2024b).
Quarantine pest	A pest of potential economic importance to the area endangered thereby and not yet present there, or present but not widely distributed and being officially controlled (FAO, 2024b).
Spread (of a pest)	Expansion of the geographical distribution of a pest within an area (FAO, 2024b).

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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APPENDIX A

Pest data sheets

A.1 | *ARCEUTHOBIUM* SPECIES (*A. ABIETINUM*, *A. AMERICANUM*, *A. APACHECUM*, *A. BLUMERI*, *A. CALIFORNICUM*, *A. CAMPYLOPODUM*, *A. CYANOCARPUM*, *A. DIVARICATUM*, *A. DOUGLASII*, *A. GILLII*, *A. LARICIS*, *A. LITTORUM*, *A. MONTICOLA*, *A. OCCIDENTALE*, *A. PUSILLUM*, *A. SISKIYOUENSE*, *A. TSUGENSE* AND *A. VAGINATUM*)

A.1.1 | Organism information

Taxonomic information	***Arceuthobium* species** Name used in the EU legislation: *Arceuthobium* spp. [1AREG] Order: Santalales Family: Santalaceae **1. *Arceuthobium abietinum*** Current valid scientific name: *Arceuthobium abietinum* Synonyms: – Common name: fir dwarf mistletoe Name used in the Dossier: – **2. *Arceuthobium americanum*** Current valid scientific name: *Arceuthobium americanum* Synonyms: – Common name: American dwarf mistletoe, lodgepole-pine dwarf mistletoe Name used in the Dossier: – **3. *Arceuthobium apachecum*** Current valid scientific name: *Arceuthobium apachecum* Synonyms: – Common name: Apache dwarf mistletoe Name used in the Dossier: – **4. *Arceuthobium blumeri*** Current valid scientific name: *Arceuthobium blumeri* Synonyms: – Common name: Blumer's dwarf mistletoe Name used in the Dossier: – **5. *Arceuthobium californicum*** Current valid scientific name: *Arceuthobium californicum* Synonyms: – Common name: Sugar pine dwarf mistletoe Name used in the Dossier: – **6. *Arceuthobium campylopodum*** Current valid scientific name: *Arceuthobium campylopodum* Synonyms: – Common name: western dwarf mistletoe Name used in the Dossier: – **7. *Arceuthobium cyanocarpum*** Current valid scientific name: *Arceuthobium cyanocarpum* Synonyms: – Common name: limber pine dwarf mistletoe Name used in the Dossier: – **8. *Arceuthobium divaricatum*** Current valid scientific name: *Arceuthobium divaricatum* Synonyms: – Common name: pinyon dwarf mistletoe Name used in the Dossier: – **9. *Arceuthobium douglasii*** Current valid scientific name: *Arceuthobium douglasii* Synonyms: – Common name: douglas-fir dwarf mistletoe Name used in the Dossier: – **10. *Arceuthobium gillii*** Current valid scientific name: *Arceuthobium gillii* Synonyms: – Common name: chihuahua pine dwarf mistletoe, huachuca mountain dwarf mistletoe Name used in the Dossier: – **11. *Arceuthobium laricis*** Current valid scientific name: *Arceuthobium laricis* Synonyms: *Arceuthobium campylopodum* subsp. *laricis* Common name: larch dwarf mistletoe Name used in the Dossier: – **12. *Arceuthobium littorum*** Current valid scientific name: *Arceuthobium littorum* Synonyms: –

(Continued)

	Common name: – Name used in the Dossier: – **13. *Arceuthobium monticola*** Current valid scientific name: *Arceuthobium monticola* Synonyms: – Common name: western white pine dwarf mistletoe Name used in the Dossier: – **14. *Arceuthobium occidentale*** Current valid scientific name: *Arceuthobium occidentale* Synonyms: – Common name: digger pine dwarf mistletoe, grey pine dwarf mistletoe Name used in the Dossier: – **15. *Arceuthobium pusillum*** Current valid scientific name: *Arceuthobium pusillum* Synonyms: – Common name: eastern dwarf mistletoe Name used in the Dossier: – **16. *Arceuthobium siskiyouense*** Current valid scientific name: *Arceuthobium siskiyouense* Synonyms: – Common name: knobcone pine dwarf mistletoe Name used in the Dossier: – **17. *Arceuthobium tsugense*** Current valid scientific name: *Arceuthobium tsugense* Synonyms: – Common name: hemlock dwarf mistletoe Name used in the Dossier: – **18. *Arceuthobium vaginatum*** Current valid scientific name: *Arceuthobium vaginatum* Synonyms: – Common name: pineland dwarf mistletoe, southwestern dwarf mistletoe Name used in the Dossier: –
Group	Plants
EPPO code	*Arceuthobium abietinum*: AREAB *Arceuthobium americanum*: AREAM *Arceuthobium apachecum*: AREAP *Arceuthobium blumeri*: AREBL *Arceuthobium californicum*: ARECL *Arceuthobium campylopodum*: ARECP *Arceuthobium cyanocarpum*: ARECY *Arceuthobium divaricatum*: AREDI *Arceuthobium douglasii*: AREDO *Arceuthobium gillii*: AREGI *Arceuthobium laricis*: ARELA *Arceuthobium littorum*: – *Arceuthobium monticola*: – *Arceuthobium occidentale*: AREOC *Arceuthobium pusillum*: AREPU *Arceuthobium siskiyouense*: – *Arceuthobium tsugense*: ARETS *Arceuthobium vaginatum*: AREVA
Regulated status	*Arceuthobium abietinum*, *A. americanum*, *A. apachecum*, *A. blumeri*, *A. californicum*, *A. campylopodum*, *A. cyanocarpum*, *A. divaricatum*, *A. douglasii*, *A. gillii*, *A. laricis*, *A. littorum*, *A. monticola*, *A. occidentale*, *A. pusillum*, *A. siskiyouense*, *A. tsugense* and *A. vaginatum* are members of *Arceuthobium* spp. [1AREG], which are listed in Annex II/A of Commission Implementing Regulation (EU) 2019/2072. *Arceuthobium abietinum*, *A. americanum*, *A. campylopodum*, *A. divaricatum*, *A. douglasii*, *A. laricis*, *A. occidentale*, *A. pusillum*, *A. tsugense* and *A. vaginatum* are included in the EPPO A1 list (EPPO, 2023b).
Pest status in the US	The parasitic plants are present in these US states (USDA, 2024): – Arizona: *A. abietinum, A. apachecum, A. blumeri, A. divaricatum, A. douglasii, A. gillii, A. vaginatum;* – California: *A. abietinum, A. americanum, A. californicum, A. campylopodum, A. cyanocarpum, A. divaricatum, A. douglasii, A. littorum, A. monticola, A. occidentale, A. siskiyouense, A. tsugense;* – Colorado: *A. americanum, A. cyanocarpum, A. divaricatum, A. douglasii, A. vaginatum;* – Connecticut: *A. pusillum;* – Idaho: *A. americanum, A. campylopodum, A. cyanocarpum, A. douglasii, A. laricis;* – Maine: *A. pusillum;* – Massachusetts: *A. pusillum;* – Michigan: *A. pusillum;* – Minnesota: *A. pusillum;* – Montana: *A. americanum, A. campylopodum, A. cyanocarpum, A. douglasii, A. laricis;* – Nevada: *A. abietinum, A. americanum, A. campylopodum, A. cyanocarpum, A. divaricatum, A. douglasii;*

(Continues)

(Continued)

	– New Hampshire: *A. pusillum;* – New Jersey: *A. pusillum;* – New Mexico: *A. abietinum, A. apachecum, A. divaricatum, A. douglasii, A. gillii, A. vaginatum;* – New York state: *A. pusillum;* – Oregon: *A. abietinum, A. americanum, A. californicum, A. campylopodum, A. cyanocarpum, A. douglasii, A. laricis, A. monticola, A. siskiyouense, A. tsugense* – Pennsylvania: *A. pusillum;* – Rhode Island: *A. pusillum;* – Texas: *A. divaricatum, A. douglasii, A. vaginatum;* – Utah: *A. abietinum, A. americanum, A. cyanocarpum, A. douglasii, A. vaginatum;* – Vermont: *A. pusillum;* – Washington state: *A. abietinum, A. americanum, A. campylopodum, A. cyanocarpum, A. douglasii, A. laricis, A. tsugense;* – Wisconsin: *A. pusillum;* – Wyoming: *A. americanum, A. cyanocarpum, A. douglasii.*
Host status on conifers	According to Hawksworth and Wiens (1996) dwarf mistletoes have different classes of hosts according to their susceptibility: (1) principal host (infection level ≥ 90%); (2) secondary host (infection level 90%–50%); (3) occasional host (infection level 50%–5%); (4) rare host (infection level ≤ 5%) and (5) immune (infection level 0%). The following host range consists only of principal hosts. *Arceuthobium abietinum: Abies concolor*, *A. durangensis*, *A. grandis*, *A. magnifica* (Hawksworth & Wiens, 1996; Mathiasen & Kenaley, 2016). *Arceuthobium americanum*: *Pinus banksiana* and *P. contorta* (Hawksworth & Wiens, 1996; Jerome & Ford, 2002). *Arceuthobium apachecum*: *Pinus strobiformis* (Hawksworth & Wiens, 1996; Mathiasen, 1982). *Arceuthobium blumeri*: *Pinus ayacahuite* and *P. strobiformis* (Hawksworth & Wiens, 1996; Mathiasen, 1982). *Arceuthobium californicum*: *Pinus lambertiana* (Hawksworth & Wiens, 1996; Mathiasen & Kenaley, 2016). *Arceuthobium campylopodum*: *Pinus jeffreyi* and *P. ponderosa* (Hawksworth & Wiens, 1996; Mathiasen & Kenaley, 2016). *Arceuthobium cyanocarpum*: *Pinus albicaulis*, *P. aristata*, *P. flexilis* and *P. longaeva* (Hawksworth & Wiens, 1996; Mathiasen & Kenaley, 2016). *Arceuthobium divaricatum*: *Pinus edulis*, *P. monophyla* and *P. quadrifolia* (Hawksworth & Wiens, 1996; Mathiasen & Kenaley, 2016). *Arceuthobium douglasii*: *Pseudotsuga menziesii* (Hawksworth & Wiens, 1996; Mathiasen & Kenaley, 2016). *Arceuthobium gillii*: *Pinus chihuahuana*, *P. herrerae*, *P. leiophylla* and *P. lumholtzi* (Hawksworth & Wiens, 1996; Kenaley & Mathiasen, 2013). *Arceuthobium laricis: Larix occidentalis* and *Tsuga mertensiana* (Hawksworth & Wiens, 1996; Wicker & Leaphart, 1976). *Arceuthobium littorum*: *Pinus muricata* and *P. radiata* (Hawksworth & Wiens, 1996; Mathiasen & Kenaley, 2016). *Arceuthobium monticola*: *Pinus monticola* (Hawksworth & Wiens, 1996; Mathiasen & Kenaley, 2016). *Arceuthobium occidentale*: *Pinus sabiniana* (Hawksworth & Wiens, 1996; Mathiasen & Kenaley, 2016). *Arceuthobium pusillum*: *Picea glauca, P. mariana* and *P. rubens* (Hawksworth & Wiens, 1996; Logan et al., 2013). *Arceuthobium siskiyouense*: *Pinus attenuata* (Hawksworth & Wiens, 1996; Mathiasen & Kenaley, 2016). *Arceuthobium tsugense*: *Abies amabilis*, *A. lasiocarpa*, *A. procera*, *Pinus contorta*, *Tsuga heterophylla* and *T. mertensiana* (Hawksworth & Wiens, 1996; Mathiasen & Kenaley, 2016). *Arceuthobium vaginatum*: *Pinus arizonica*, *P. cooperi*, *P. durangensis*, *P. engelmannii*, *P. hartwegii*, *P. herrerae*, *P. lawsonii*, *P. montezumae*, *P. patula*, *P. ponderosa* and *P. rudis* (Hawksworth & Wiens, 1965; Hawksworth & Wiens, 1996). More information on secondary, occasional and rare hosts can be found in Hawksworth and Wiens (1996).
PRA information	Pest Risk Assessments available: – Scientific opinion on pest categorisation of *Arceuthobium* spp. (non-EU) (EFSA PLH Panel, 2018); – UK Risk Register Details for *Arceuthobium abietinum* (DEFRA, 2020a); – UK Risk Register Details for *Arceuthobium americanum* (DEFRA, 2020b); – UK Risk Register Details for *Arceuthobium campylopodum* (DEFRA, 2020c); – UK Risk Register Details for *Arceuthobium divaricatum* (DEFRA, 2020d); – UK Risk Register Details for *Arceuthobium douglasii* (DEFRA, 2020e); – UK Risk Register Details for *Arceuthobium laricis* (DEFRA, 2020f); – UK Risk Register Details for *Arceuthobium occidentale* (DEFRA, 2020g); – UK Risk Register Details for *Arceuthobium pusillum* (DEFRA, 2020h); – UK Risk Register Details for *Arceuthobium tsugense* (DEFRA, 2020i); – UK Risk Register Details for *Arceuthobium vaginatum* (DEFRA, 2020j).
Other relevant information for the assessment	
Biology – short summary	The species in genus *Arceuthobium* are small flowering plants commonly known as dwarf mistletoes, which are aerial obligate parasites on plants from families of Pinaceae and Cupressaceae (Hawksworth & Wiens, 1996; Wicker & Leaphart, 1976). The mistletoes in order to develop and survive take from their hosts water, carbon and other nutrients. The dwarf mistletoes are obligately dioecious plants, they have both female and male plants (Hawksworth & Wiens, 1996), which can be found on the same host tree (Hoffman, 2010). The plants consist of shoots, simple scale-like leaves, flowers and fruits. They have different colour, varying from yellow, green, orange, red, brown, to near black. Their height is generally less than 20 cm, but some species can have up to 70 cm (Hawksworth & Wiens, 1996).

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	Arceuthobium species are destructive pathogens of commercially valuable coniferous timber trees in the North America (Mexico, western Canada, western US) and parts of Asia (Dogri et al., 2012; Hawksworth & Shaw, 1984; Hawksworth & Wiens, 1996). The value of economic losses in the US on coniferous trees is reported in the literature from 1980' (Drummond, 1982). *Arceuthobium* species cause swellings, cankers, spike-tops, witches'-brooms, crown dieback and mortality. They affect foliage, phenology, and respiration and reduce vigour, growth rate and seed quality of their host plants (Geils & Hawksworth, 2002; Wicker & Leaphart, 1976). The dwarf mistletoes reproduce through seeds, which are forcibly ejected via an explosive mechanism in a berrylike fruit in late summer (Hawksworth & Wiens, 1996; Wicker & Leaphart, 1976) or they are dispersed by birds and mammals to longer distances (Hawksworth & Wiens, 1996). The maximum distance of the spread of the seed by the explosive mechanism is 16 m (Hawksworth & Wiens, 1996), the average is between 5 and 8 m (Wicker & Leaphart, 1976). Dispersed sticky seeds land mainly on the host needles, less commonly on twigs and branches. Seeds usually remain on needles until the first rain, which then pulls the seed to the base of the needle to the shoot surface. In order for the seed to germinate and establish an infection on the host plant it must be attached to a shoot segment, which is usually less than 5 years old (Hawksworth & Wiens, 1996). However, it was observed that *A. americanum* can penetrate through bark of *Pinus contorta* branches as old as 60 years (Hawksworth, 1954). Depending on the mistletoe species, the germination of seeds occurs either in autumn or spring. The seed grows into the host cortex using 'penetration wedge' and then develops rootlike endophytic system. After successful infection, it takes usually between 2 and 5 years for the mistletoe to develop young shoots. The flowers appear 1–2 years after the shoot development. Pollination is done by insects or wind. Fruit maturation may occur in about 4 months up to 1 or more years after pollination (Hawksworth & Wiens, 1996). According to EFSA PLH Panel (2018), the only pathway for dwarf mistletoes are plants for planting (including artificially dwarfed plants) and cut branches.
Association with the plant parts	*Arceuthobium* species are associated with needles (as seeds), shoots, branches, main stems and rarely with roots (Hawksworth & Wiens, 1996).
Presence of asymptomatic plants/ plant parts	The period between infection and appearance of shoots depends on dwarf mistletoe species, the host plant and environment conditions (Hawksworth & Wiens, 1996). This period can last between 2 years (Smith, 1971) up to 12 years (Scharpf & Parmeter, 1982).
Host plant range	*Arceuthobium* species are parasites only on coniferous plants (Pinaceae and Cupressaceae). Therefore, no additional hosts were found. See above section 'Host status on conifers'.
Evidence that the commodity is a pathway	No records of interception of *Arceuthobium* species on conifer wood were found in the EUROPHYT/TRACES-NT database (EUPOPHYT, 2024; TRACES-NT, 2024). *Arceuthobium* species are associated with branches and main stems (Hawksworth & Wiens, 1996). According to Dossier Section 2.0 branches under 5 cm in diameter are excluded from production of wood chips. Some of the *Arceuthobium* species like *A. americanum* can penetrate branches up to 60 years old (Hawksworth, 1954). Therefore, some of the dwarf mistletoes could be present on branches bigger than 5 cm in diameter, which will be used for wood chip production. However, dwarf mistletoes are obligate parasites that require a living host to survive. Once an infected tree or branch is cut, the mistletoe dies (Hawksworth & Wiens, 1996).
Efficacy of sulfuryl fluoride on that specific pest	No experimental results for *Arceuthobium* spp. have been found regarding the efficacy of sulfuryl fluoride.

A.2 | *ATROPELLIS* SPECIES (*A. APICULATA*, *A. PINICOLA*, *A. PINIPHILA*, *A. TINGENS*)

A.2.1 | Organism information

Taxonomic information	***Atropellis* species** Name used in the EU legislation: *Atropellis* spp. [1ATRPG] Order: Helotiales Family: Godroniaceae **1. *Atropellis apiculata*** Current valid scientific name: *Atropellis apiculata* Synonyms: – Common name: twig blight of pine Name used in the Dossier: – **2. *Atropellis pinicola*** Current valid scientific name: *Godronia zelleri* Synonyms: *Atropellis pinicola* (According to Index Fungorum) Common name: branch canker of pine, trunk canker of pine, twig blight of pine Name used in the Dossier: – **3. *Atropellis piniphila*** Current valid scientific name: *Atropellis piniphila* Synonyms: *Atropellis arizonica*, *Atropellis piniphila* var. *arizonica*, *Cenangium piniphilum* (According to Index Fungorum) Common name: branch canker of pine, trunk canker of pine, twig blight of pine Name used in the Dossier: – **4. *Atropellis tingens*** Current valid scientific name: *Atropellis tingens* Synonyms: – Common name: canker of pine, branch canker of pine Name used in the Dossier: –

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Group	Fungi
EPPO code	*Atropellis apiculata*: ATRPAP *Atropellis pinicola*: ATRPPC *Atropellis piniphila*: ATRPPP *Atropellis tingens*: ATRPTI
Regulated status	*Atropellis apiculata*, *A. pinicola*, *A. piniphila* and *A. tingens* are members of *Atropellis* spp. [1ATRPG], which are listed in Annex II/A of Commission Implementing Regulation (EU) 2019/2072. *Atropellis apiculata* and *A. tingens* are on A1 list of the UK (EPPO, 2024c, 2024d). *Atropellis pinicola* and *A. piniphila* are included in the EPPO A1 list (EPPO, 2023d) and in A1 list of Jordan, Kazakhstan, Russia and the UK. *Atropellis pinicola* and *A. piniphila* are quarantine in China, Norway and Tunisia (EPPO, 2024e, 2024f).
Pest status in the US	*Atropellis apiculata* is present in Delaware, North Carolina and Virginia (EFSA PLH Panel, 2014; Lightle & Thompson, 1973; MyCoPortal, 2024). *Atropellis pinicola* is present in California, Georgia, Idaho, Maine, Montana, New Hampshire, New Mexico, Oregon, Pennsylvania, South Carolina and Washington state (CABI, 2019a; EFSA PLH Panel, 2014; EPPO, 2023c; MyCoPortal, 2024). *Atropellis piniphila* is present in Alabama, Arizona, California, Idaho, Montana, New Mexico, North Carolina, Oregon, South Dakota, Tennessee and Washington state (CABI, 2019b; EFSA PLH Panel, 2014; EPPO, 2023d; MyCoPortal, 2024). *Atropellis tingens* is present in Alabama, Arkansas, Connecticut, Delaware, Florida, Georgia, Louisiana, Maine, Maryland, Massachusetts, Minnesota, Missouri, New Hampshire, New Jersey, New York, North Carolina, Ohio, Oklahoma, Pennsylvania, Rhode Island, South Carolina, Tennessee, Texas, Vermont, Virginia and West Virginia (EFSA PLH Panel, 2014; MyCoPortal, 2024).
Host status on conifers	Hosts of *Atropellis* are *Pinus* species: – ***Atropellis apiculata***: *Pinus caribaea*, *P. echinata*, *P. elliottii*, *P. palustris*, *P. taeda* and *P. virginiana* (EFSA PLH Panel, 2017a; Farr & Rossman, 2024; MyCoPortal, 2024); – ***Atropellis pinicola***: *Pinus albicaulis*, *P. contorta*, *P. lambertiana*, *P. monticola*, *P. nigra*, *P. strobus* and *P. sylvestris* (EFSA PLH Panel, 2017a; Farr & Rossman, 2024; MyCoPortal, 2024); – ***Atropellis piniphila***: *Pinus albicaulis*, *P. banksiana*, *P. contorta*, *P. densiflora*, *P. echinata*, *P. jeffreyi*, *P. monticola*, *P. nigra*, *P. ponderosa*, *P. taeda* and *P. virginiana* (EFSA PLH Panel, 2017a; Farr & Rossman, 2024; MyCoPortal, 2024); – ***Atropellis tingens***: *Pinus banksiana*, *P. caribaea*, *P. clausa*, *P. contorta*, *P. densiflora*, *P. echinata*, *P. elliottii*, *P. maritima*, *P. monticola*, *P. mugo*, *P. nigra*, *P. pinaster*, *P. pungens*, *P. resinosa*, *P. rigida*, *P. serotina*, *P. strobus*, *P. sylvestris*, *P. taeda* and *P. virginiana* (EFSA PLH Panel, 2017a; Farr & Rossman, 2024; MyCoPortal, 2024). *Atropellis piniphila* and *A. pinicola* are serious pathogens on *Pinus contorta* (EPPO, 1997a; Baranyay et al., 1973).
PRA information	Pest Risk Assessments available: – Scientific Opinion on the pest categorisation of *Atropellis* spp. (EFSA PLH Panel, 2014); – Pest risk assessment of *Atropellis* spp. for the EU territory (EFSA PLH Panel, 2017a); – UK Risk Register Details for *Atropellis apiculata* (DEFRA, 2020k); – UK Risk Register Details for *Atropellis pinicola* (DEFRA, 2020l); – UK Risk Register Details for *Atropellis piniphila* (DEFRA, 2020m); – UK Risk Register Details for *Atropellis tingens* (DEFRA, 2020n).
Other relevant information for the assessment	
Biology – short summary	*Atropellis apiculata, A. pinicola, A. piniphila* and *A. tingens* are native to North America. They are pathogens of *Pinus* species to which they cause dark blue/black stain wood underneath the infected bark (Lightle & Thompson, 1973) and cankers on twigs, branches, trunks (Hopkins, 1963; Lightle & Thompson, 1973) and rarely on roots. The early symptom of infection is a drop of resin on the bark surface (Hopkins, 1963). Later, other symptoms can be observed – dead branches, abundant resin flow, malformation of stems in the vicinity of cankers, reduced growth and death of smaller trees by gridling trunk cankers (Hopkins, 1969; Hopkins & Callan, 1991; Lightle & Thompson, 1973). Trees of all ages and sizes are affected. Trees with discoloured wood and resin are undesirable for lumber production (Lightle & Thompson, 1973). The reproductive structures of *Atropellis* species produced on the surface of the bark over the cankers are apothecia (containing sexual spores: ascospores) and stromata (containing asexual spores: conidia). However, the role of conidia in the infection cycle is unclear (Lightle & Thompson, 1973). The infection starts with ascospores and occurs in tissues 2 or more than 20 years old (Hopkins, 1963). The ascospores are dispersed by wind to the new hosts from early spring to autumn during moist/rainy weather (Callan, 1997; Lightle & Thompson, 1973). The spread distance by wind is usually up to 100 m away, in some rare cases even further (Hopkins & Callan, 1991). Under the right climatic conditions, ascospores germinate and mycelium penetrates the host via bark (through microscopic cracks), or leaf scars. Depending on the *Atropellis* species, infection can occur (1) in axils of twigs/branches; (2) in the nodes of the main stem; (3) through the base of the needle sheath; or (4) within the needle fascicle (Hopkins, 1963; Lightle & Thompson, 1973). The period from infection to the ascospore production on the new hosts widely varies. It usually takes between 2 and 5 years on small twigs/stems/branches of small, suppressed trees and 20 or more years on stems of large, vigorous trees. Once the ascospore production starts, it continues each year until a few years after death of the host (Hopkins, 1969). The possible pathways of entry for *Atropellis* species are (1) plants (plants for planting, Christmas trees (*Pinus*), ornamental cut branches and bonsais); (2) wood (any form of wood, including wood packaging material); and (3) isolated bark (EFSA PLH Panel, 2017a).
Association with the plant parts	*Atropellis* species affect trees of all ages and sizes. The fungi are associated with twigs, branches, main stem, bark and rarely with roots. They penetrate xylem, cambium, sapwood and heartwood (Hopkins, 1963; Hopkins & Callan, 1991; Lightle & Thompson, 1973).
Presence of asymptomatic plants/plant parts	After the infection of new hosts, an asymptomatic infection phase begins. It can last from 2 to 5 years on small and suppressed trees, up to 20 or more years on large and vigorous trees (Hopkins, 1969).
Host plant range	*Atropellis* species infects only *Pinus*. No additional hosts are known. See above section 'Host status on conifers'.
Evidence that the commodity is a pathway	No records of interception of *Atropellis* species on conifer wood were found in the EUROPHYT/TRACES-NT database (EUPOPHYT, 2024; TRACES-NT, 2024).

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	Atropellis species are associated with twigs, branches, main stem, bark and rarely with roots. They penetrate xylem, cambium, sapwood and heartwood (Hopkins, 1963; Hopkins & Callan, 1991; Lightle & Thompson, 1973). Moreover, according to EFSA PLH Panel (2017a) the possible pathways of entry for *Atropellis* species are any form of wood and isolated bark. The commodity to be exported to the EU from the US is wood chips with less than 2% of bark. Branches under 50 mm in diameter are excluded from production of wood chips (Dossier Section 2.0). Therefore, the stems and the branches bigger than 50 mm can be infected with *Atropellis* (ascospores or mycelium) and used for wood chip production. There is no specific evidence that conifer wood chips are a pathway for *Atropellis* species, however, the possibility that the commodity could be a pathway cannot be excluded.
Efficacy of sulfuryl fluoride on that specific pest	No experimental results for *Atropellis* species have been found regarding the efficacy of sulfuryl fluoride.

A.3 | *CONIFERIPORIA SULPHURASCENS* AND *CONIFERIPORIA WEIRII*

A.3.1 | Organism information

Taxonomic information	**1. *Coniferiporia sulphurascens*** Current valid scientific name: *Coniferiporia sulphurascens* Synonyms: *Inonotus sulphurascens, Phellinidium sulphurascens, Phellinus sulphurascens* (According to Index Fungorum) Name used in the EU legislation: *Coniferiporia sulphurascens* (Pilát) L.W. Zhou & Y.C. Dai [PHELSU] Order: Hymenochaetales Family: Hymenochaetaceae Common name: laminated root rot (LRR) Name used in the Dossier: – **2. *Coniferiporia weirii*** Current valid scientific name: *Coniferiporia weirii* Synonyms: *Fomitiporia weirii, Fuscoporia weirii, Inonotus weirii, Phellinidium weirii, Phellinus weirii, Poria weirii* (According to Index Fungorum) Name used in the EU legislation: *Coniferiporia weirii* (Murrill) L.W. Zhou & Y.C. Dai [INONWE] Order: Hymenochaetales Family: Hymenochaetaceae Common name: laminated butt-rot of conifers, yellow ring rot of conifers Name used in the Dossier: –
Group	Fungi
EPPO code	*Coniferiporia sulphurascens*: PHELSU *Coniferiporia weirii*: INONWE
Regulated status	*Coniferiporia sulphurascens* and *C. weirii* are both quarantine pest for EU listed in Annex II A of Commission Implementing Regulation (EU) 2019/2072 as *Coniferiporia sulphurascens* (Pilát) L.W. Zhou & Y.C. Dai [PHELSU] and *Coniferiporia weirii* (Murrill) L.W. Zhou & Y.C. Dai [INONWE]. *Coniferiporia sulphurescens* is in the A1 list for Switzerland and the UK (EPPO, 2024g). *Coniferiporia weirii* is in the A1 list for Egypt, Chile, Jordan, Georgia, Russia, Switzerland, Türkiye, Ukraine and the UK. It is also quarantine for Morocco, Tunisia, China, Israel, Moldova and Norway (EPPO, 2024h).
Pest status in the US	*Coniferiporia sulphurascens* is currently present in the US in 5 western states: California, Idaho, Montana, Oregon and Washington (EPPO, 2023e). *Coniferiporia weirii* is present in the US only in the states of California, Idaho and Washington (EPPO, 2023f).
Host status on conifers	Both species of *Coniferiporia* infect only conifer trees. Hosts of *C. sulphurascens* are *Abies amabilis, A. concolor, A. grandis, A. lasiocarpa, A. magnifica, A. mariesii, A. procera, A. sachalinensis, A. sibirica, Chamaecyparis* spp., *Juniperus* spp., *Larix gmelinii* var. *japonica, L. gmelinii* var. *principis ruprechtii, L. occidentalis, L. sibirica, Picea abies, P. englemannii, P. jezoensis, P. obovata, P. sitchenisis, Pinus contorta, P. lambertiana, P. monticola, P. ponderosa, Pseudotsuga menziesii, Sequoiadendron giganteum, Taxus brevifolia, Tsuga diversifolia, T. heterophylla, T. mertensiana* and *Thuja plicata* (EPPO, 2024i; EFSA PLH Panel, 2018d; Farr & Rossman, 2024). Hosts of *C. weirii* are *Abies amabilis*, *A. concolor, A. grandis*, *A. lasiocarpa*, *A. magnifica*, *A. mariesii*, *A. procera*, *A. sachalinensis*, *Callitropsis* (= *Cupressus*) *nootkatensis, Calocedrus decurrens*, *Chamaecyparis nootkatensis*, *C. obtuse*, *C. pisifera*, *Larix gmelinii*, *L. leptolepis*, *L. occidentalis*, *Juniperus turcomanica*, *Picea engelmannii*, *P. glehnii*, *P. jezoensis*, *P. sitchensis*, *Pinus contorta*, *P. monticola*, *P. ponderosa*, *Pseudotsuga menziesii*, *P. taxifolia*, *Sabina przewalskii* (current name *Juniperus przewalskii*), *Thuja occidentalis*, *T. plicata*, *Tsuga diversifolia*, *T. heterophylla* and *T. mertensiana* (EPPO, 2024j; Farr & Rossman, 2024). Among the hosts of *C. sulphurascens* the more susceptible species are *Pseudotsuga menziesii, Abies amabilis, A. concolor* and *Tsuga mertensiana*. Intermediate susceptible hosts are considered *Abies lasiocarpa, A. magnifica, A. procera, Larix occidentalis, Picea engelmanni, P. sitchensis, Sequoiadendron giganteum, Taxus brevifolia* and *Tsuga heterophylla*. Low susceptible or tolerant hosts are *Pinus contorta, P. lambertiana, P. monticola* and *P. ponderosa* (Thies & Sturrock, 1995). Several of the above listed conifer species have a large distribution range in North America, and *C. sulphurascens* is therefore considered among the most ecologically and economically important diseases of mixed conifer forests in the western US and Canada (McMurtrey, 2022). It is maybe important to note that *Pinus* species are only low susceptible or tolerant for *C. sulphurascens*, while no species of *Pinus* are reported in the list of *C. weirii* hosts.

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PRA information	Pest Risk Assessments available: – Pest categorisation of *Coniferiporia sulphurascens* and *Coniferiporia weirii* (EFSA PLH Panel, 2018d); – UK risk register details for *Coniferiporia sulphurascens* (DEFRA, 2020o); – UK risk register details for *Coniferiporia weirii* (DEFRA, 2020p).
Other relevant information for the assessment	
Biology – short summary	*Coniferiporia sulphurascens* and *C. weirii* are two closely related basidiomycete fungi, facultative pathogens causing laminated root rot in conifers (Leal et al., 2019; Wang et al., 2022). Both the species are gymnosperm specialists, frequently reported on basal parts of hosts causing butt-rot on living trees of any age, although the disease is most severe in stands 25–125 years old (EFSA PLH Panel, 2018d; Palla et al., 2023). *Coniferiporia sulphurascens* persists as a saprotroph in stumps and dead roots for long time, so infecting healthy trees by root contact when ectotrophic mycelium penetrates through intact bark invading the phloem and cambium. The mycelium often colonises the root collar and may girdle the tree. Mycelial growth occurs between 5°C and 30°C, with optimal temperature 25°C. Although both lignin and cellulose are affected, the pathogen preferentially utilises early wood, leading to a typical laminated pattern observed in the advanced stage of decay. Infected trees may take several years to die, declining slowly over time. Otherwise, they may be rapidly killed after root destruction due to girdling, or as a result of wind-throw or secondary attack by insects, e.g. bark beetles. The fruit bodies (basidiocarps) of *C. sulphurascens* are annual, crust-like, and mature in late summer or autumn, usually on the underside of fallen logs. The basidiospores are wind or water dispersed; however new infection centre from spores or through vegetative dispersal are rarely observed, and the spread by root contacts is largely dominant. *Coniferiporia weirii* has probably a similar general biology but there is poor information on its epidemiology. The perennial basidiocarps are produced at the base of infected trees of *Thuja plicata* only but can occasionally be found up to six feet high. Sporulation occurs in spring and summer (EFSA PLH Panel, 2018d; McMurtrey, 2022; EPPO, 2023g).
Association with the plant parts	Because they cause root rot disease, both *C. sulphurascens* and *C. weirii* are typically associated with roots and lower stems. Wood decay usually spreads up the stem to less than 1 m, occasionally extending to 4–5 m on large trees (EFSA PLH Panel, 2018d; McMurtrey, 2022).
Presence of asymptomatic plants/plant parts	At the early stage of infection by *Coniferiporia* cut tress can remain asymptomatic. Instead, at the advanced stage of infection, the symptoms of wood decay can be seen in the lower stem after cutting.
Host plant range	*Coniferiporia sulphurascens* and *C. weirii* infect only conifers. No additional hosts are known. See above section 'Host status on conifers'.
Evidence that the commodity is a pathway	No records of interception of *C. sulphurascens* and *C. weirii* on conifer wood were found in the EUROPHYT/TRACES-NT database (EUPOPHYT, 2024; TRACES-NT, 2024). Pathways of *C. sulphurascens* and *C. weirii* are non-squared wood of Cupressaceae and Pinaceae, isolated bark and plants for planting (EFSA PLH Panel, 2018d). According to the Dossier Section 2.0, wood chips are produced from fresh or stored wood of stems cut over 152.4 mm over ground, so they may also contain infected wood by *Coniferiporia*. However: – for both the pathogens vegetative dispersal of basidiospores via wind and water is very rarely observed, and the spread mostly occurs by root contacts on very short distances; – no wood portions below ground (stumps, roots) are used for wood chip production; – trees are inspected before harvesting to ensure that they are free from wood/root rotting fungi and other wood defects.
Efficacy of sulfuryl fluoride on that specific pest	No experimental results for *Coniferiporia* species have been found regarding the efficacy of sulfuryl fluoride.

A.4 | *CRONARTIUM* SPECIES (*C. APPALACHIANUM, C. ARIZONICUM, C. BETHELII, C. COLEOSPORIOIDES, C. COMANDRAE, C. COMPTONIAE, C. CONIGENUM, C. FILAMENTOSUM, C. HARKNESSII, C. OCCIDENTALE, C. QUERCUUM, C. STROBILINUM*)

A.4.1 | Organism information

Taxonomic information	***Cronartium* species** Name used in the EU legislation: *Cronartium* spp. [1CRONG] Order: Pucciniales Family: Cronartiaceae **1. *Cronartium appalachianum*** Current valid scientific name: *Cronartium appalachianum* Synonyms: – Common name: Virginia pine blister rust Name used in the Dossier: – **2. *Cronartium arizonicum*** Current valid scientific name: *Cronartium arizonicum* Synonyms: –

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	Common name: Coronado limb rust Name used in the Dossier: – **3. *Cronartium bethelii*** Current valid scientific name: *Cronartium bethelii* Synonyms: *Peridermium bethelii* (According to Index Fungorum) Common name: – Name used in the Dossier: – **4. *Cronartium coleosporioides*** Current valid scientific name: *Cronartium coleosporioides* Synonyms: *Cronartium coleosporioides* f. *album*, *Cronartium stalactiforme*, *Peridermium stalactiforme*, *Uredo coleosporioides* (According to Index Fungorum) Common name: stalactiform blister rust of pine, western gall rust of pine Name used in the Dossier: – **5. *Cronartium comandrae*** Current valid scientific name: *Cronartium comandrae* Synonyms: *Cronartium pyriforme*, *Peridermium pyriforme* (According to Index Fungorum) Common name: comandra blister rust of pine, stem rust of pine Name used in the Dossier: – **6. *Cronartium comptoniae*** Current valid scientific name: *Cronartium comptoniae* Synonyms: *Peridermium comptoniae* (According to Index Fungorum) Common name: sweet fern blister rust Name used in the Dossier: – **7. *Cronartium conigenum*** Current valid scientific name: *Cronartium conigenum* Synonyms: – Common name: Southwestern cone rust Name used in the Dossier: – **8. *Cronartium filamentosum*** Current valid scientific name: *Cronartium filamentosum* Synonyms: – Common name: limb rust of pine, paint brush blister rust of pine Name used in the Dossier: – **9. *Cronartium harknessii*** Current valid scientific name: *Cronartium harknessii* Synonyms: *Aecidium harknessii*, *Endocronartium harknessii*, *Peridermium cerebroides*, *Peridermium harknessii* (According to Index Fungorum) Common name: pine-to-pine gall rust, western gall rust of pine Name used in the Dossier: – **10. *Cronartium occidentale*** Current valid scientific name: *Cronartium occidentale* Synonyms: – Common name: Piñon blister rust Name used in the Dossier: – **11. *Cronartium quercuum*** Current valid scientific name: *Cronartium quercuum* Synonyms: *Aecidium cerebrum*, *Aecidium giganteum*, *Cronartium asclepiadeum* var. *quercuum*, *Cronartium cerebrum*, *Cronartium fusiforme*, *Cronartium quercus*, *Dicaeoma quercus*, *Melampsora quercus*, *Peridermium cerebrum*, *Peridermium fusiforme*, *Peridermium giganteum*, *Peridermium mexicanum*, *Puccinia quercus*, *Uredo quercus*, *Uromyces quercus* (According to Index Fungorum) Common name: eastern gall rust of pine Name used in the Dossier: – **12. *Cronartium strobilinum*** Current valid scientific name: *Cronartium strobilinum* Synonyms: – Common name: Southern cone rust Name used in the Dossier: –
Group	Fungi
EPPO code	*Cronartium appalachianum*: – *Cronartium arizonicum*: – *Cronartium bethelii*: – *Cronartium coleosporioides*: CRONCL *Cronartium comandrae*: CRONCO *Cronartium comptoniae*: CRONCP *Cronartium conigenum*: CRONCN *Cronartium filamentosum*: CRONFI *Cronartium harknessii*: ENDCHA *Cronartium occidentale*: – *Cronartium quercuum*: CRONQU *Cronartium strobilinum*: –

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Regulated status	*Cronartium appalachianum*, *C. arizonicum*, *C. bethelii*, *C. coleosporioides*, *C. comandrae*, *C. comptoniae*, *C. conigenum*, *C. filamentosum*, *C. harknessii*, *C. occidentale*, *C. quercuum* and *C. strobilinum*are members of *Cronartium* spp. [1CRONG], which are listed in Annex II/A of Commission Implementing Regulation (EU) 2019/2072. *Cronartium coleosporioides*, *C. comandrae*, *C. comptoniae*, *C. harknessii* and *C. quercuum* are included in the EPPO A1 list (EPPO, 2023b). *Cronartium coleosporioides* is quarantine in China, Morocco, Norway, Republic of Korea and Tunisia. It is on A1 list of Ukraine (EPPO, 2024k). *Cronartium comandrae* is quarantine in China, Morocco, Norway and Tunisia. It is on A1 list of Ukraine (EPPO, 2024l). *Cronartium comptoniae* is quarantine in Morocco, Norway and Tunisia. It is on A1 list of Ukraine (EPPO, 2024m). *Cronartium conigenum* is quarantine in China (EPPO, 2024n). *Cronartium harknessii* is quarantine in China, Israel, Morocco, Norway and Tunisia. It is on A1 list of Bahrain, Brazil, Chile, Iran, Russia, Türkiye, Ukraine, Uruguay and IAPSC (=Inter-African Phytosanitary Council) (EPPO, 2024o). *Cronartium quercuum* is quarantine in Morocco, Norway and Tunisia. It is on A1 list of Georgia, Russia and Ukraine (EPPO, 2024p).
Pest status in the US	*Cronartium appalachianum* is present in North Carolina, Tennessee, Virginia and West Virginia (Hepting, 1957; Hepting & Cummins, 1951; MyCoPortal, 2024; Zhao et al., 2022). *Cronartium arizonicum* is present in Arizona, California, Colorado, New Mexico and Utah (Fairweather, 2006; MyCoPortal, 2024). *Cronartium bethelii* is present in Arizona, California, Colorado, Florida, Idaho, Montana, Utah, Wyoming (Hawksworth et al., 1983; Zhao et al., 2022). *Cronartium coleosporioides* is present in Alaska, Arizona, California, Colorado, Connecticut, District of Columbia, Idaho, Iowa, Kansas, Michigan, Minnesota, Montana, Nebraska, Nevada, New Mexico, New York state, North Dakota, Oklahoma, Oregon, South Dakota, Utah, Washington state and Wyoming (EPPO, 2023h; MyCoPortal, 2024). *Cronartium comandrae* is present in Alabama, Alaska, Arizona, Arkansas, California, Colorado, Connecticut, Delaware, District of Columbia, Idaho, Illinois, Indiana, Iowa, Kentucky, Maine, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, Montana, Nebraska, Nevada, New Hampshire, New Jersey, New Mexico, New York state, North Dakota, Ohio, Oregon, Pennsylvania, South Carolina, South Dakota, Tennessee, Texas, Utah, Vermont, Virginia, Washington state, Wisconsin and Wyoming (EPPO, 2023i; MyCoPortal, 2024). *Cronartium comptoniae* is present in Alaska, California, Colorado, Connecticut, Delaware, District of Columbia, Georgia, Indiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, Missouri, Montana, New England, New Hampshire, New Jersey, New York state, North Carolina, Ohio, Oregon, Pennsylvania, Rhode Island, Tennessee, Vermont, Virginia, Washington state, Wisconsin and Wyoming (EPPO, 2023j; MyCoPortal, 2024). *Cronartium conigenum* is present in Arizona, Colorado, Connecticut, District of Columbia, Florida, Minnesota, Mississippi, New Mexico, Ohio, Pennsylvania and Washington state (Peterson, 1962; Rayachhetry et al., 1995 citing others; MyCoPortal, 2024). *Cronartium filamentosum* is present in Arizona, California, Colorado, District of Columbia, Idaho, Montana, Nevada, New Mexico, Ohio, Oregon, South Dakota, Utah, Washington state, Wisconsin and Wyoming (Blasdale, 1919; Hawksworth, 1953; MyCoPortal, 2024; Sutherland et al., 1987). *Cronartium harknessii* is present in Alaska, Arizona, California, Colorado, District of Columbia, Idaho, Maine, Maryland, Massachusetts, Michigan, Minnesota, Missouri, Montana, Nebraska, Nevada, New Hampshire, New Mexico, New York state, North Dakota, Oregon, Pennsylvania, South Dakota, Texas, Utah, Virginia, Washington state, Wisconsin and Wyoming (EPPO, 2023k; MyCoPortal, 2024). *Cronartium occidentale* is present in Arizona, California, Colorado, District of Columbia, Florida, Idaho, Kansas, Montana, Nebraska, Nevada, New Mexico, New York state, Oregon, Rhode Island, Utah, Washington state and Wyoming (MyCoPortal, 2024; Stillinger, 1944; Zhao et al., 2022). *Cronartium quercuum* is present in Alabama, Alaska, Arizona, Arkansas, California, Colorado, Connecticut, Delaware, District of Columbia, Florida, Georgia, Idaho, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, Montana, Nebraska, New Hampshire, New Jersey, New York state, North Carolina, Ohio, Oklahoma, Oregon, Pennsylvania, South Carolina, South Dakota, Tennessee, Texas, Vermont, Virginia, Washington state, West Virginia, Wisconsin and Wyoming (EPPO, 2023l; MyCoPortal, 2024). *Cronartium strobilinum* is present in Alabama, Arkansas, California, Colorado, District of Columbia, Florida, Georgia, Illinois, Iowa, Kansas, Louisiana, Minnesota, Mississippi, Missouri, North Carolina, South Carolina, Texas, Virginia and Washington state (MyCoPortal, 2024; Parris, 1959; Sutherland et al., 1987; Zak, 1950; Zhao et al., 2022).
Host status on conifers	Aecial hosts of *Cronartium* species are *Pinus*: – ***Cronartium appalachianum***: *Pinus virginiana* (Farr & Rossman, 2024; Sinclair & Lyon, 2005; Zhao et al., 2022); – ***Cronartium arizonicum***: *P. jeffreyi*, *P. ponderosa*, *P. scopulorum* (Farr & Rossman, 2024; Zhao et al., 2022); – *Cronartium bethelii*: *P. palustris*, *P. strobus* (Zhao et al., 2022); – ***Cronartium coleosporioides***: *P. attenuata*, *P. banksiana*, *P. contorta*, *P. coulteri*, *P. densiflora*, *P. echinata*, *P. halepensis*, *P. jeffreyi*, *P. mugo*, *P. murrayana*, *P. ponderosa*, *P. pumila*, *P. radiata*, *P. sabiniana*, *P. scopulorum*, *P. sylvestris*, *P. tabuliformis* (Farr & Rossman, 2024; Zhao et al., 2022); – ***Cronartium comandrae***: *P. attenuata*, *P. banksiana*, *P. contorta*, *P. echinata*, *P. eldarica*, *P. elliottii*, *P. flexilis*, *P. glabra*, *P. jeffreyi*, *P. mugo*, *P. pinaster*, *P. ponderosa*, *P. pungens*, *P. resinosa*, *P. rigida*, *P. scopulorum*, *P. serotina*, *P. sylvestris*, *P. taeda* (Farr & Rossman, 2024; Zhao et al., 2022); – ***Cronartium comptoniae***: *P. banksiana*, *P. contorta*, *P. coulteri*, *P. densiflora*, *P. echinata*, *P. jeffreyi*, *P. maritima*, *P. mugo*, *P. muricata*, *P. murrayana*, *P. nigra*, *P. pinaster*, *P. ponderosa*, *P. pungens*, *P. radiata*, *P. resinosa*, *P. rigida*, *P. sylvestris*, *P. taeda*, *P. virginiana* (Farr & Rossman, 2024);

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	– ***Cronartium conigenum***: *P. chihuahuana*, *P. leiophylla*, *P. montezumae*, *P. oocarpa*, *P. pseudostrobus* (Farr & Rossman, 2024); – ***Cronartium filamentosum***: *P. ponderosa* (Vogler & Bruns, 1998); – ***Cronartium harknessii***: *P. attenuata*, *P. balfouriana*, *P. banksiana*, *P.contorta*, *P. coulteri*, *P. halepensis*, *P. insignis*, *P. jeffreyi*, *P. mugo*, *P. muricata*, *P. murrayana*, *P. nigra*, *P. pinaster*, *P. ponderosa*, *P. radiata*, *P. resinosa*, *P. sabiniana*, *P. sylvestris* (Farr & Rossman, 2024); – ***Cronartium occidentale***: *P. cembroides*, *P. edulis*, *P. monophylla* (Farr & Rossman, 2024; Zhao et al., 2022); – ***Cronartium quercuum***: *P. armandii*, *P. banksiana*, *P. caribaea*, *P. chihuahuana*, *P. clausa*, *P. densiflora*, *P. divaricata*, *P. echinata*, *P. elliottii*, *P. halepensis*, *P. khasya*, *P. luchuensis*, *P. massoniana*, *P. mugo*, *P. nigra*, *P. palustris*, *P. pinaster*, *P. ponderosa*, *P. pungens*, *P. radiata*, *P. resinosa*, *P. rigida*, *P. serotina*, *P. sylvestris*, *P. tabulaeformis*, *P. tabuliformis*, *P. taeda*, *P. taiwanensis*, *P. teocote*, *P. thunbergia*, *P. virginiana*, *P. yunnanensis* (Farr & Rossman, 2024); – ***Cronartium strobilinum***: *P. caribea*, *P. elliottii*, *P. palustris*, *P. taeda* (Farr & Rossman, 2024; Zhao et al., 2022).
PRA information	Pest Risk Assessments available: – Scientific opinion on pest categorisation of *Cronartium* spp. (non-EU) (EFSA PLH Panel, 2018e); – Scientific Opinion on the pest categorisation of *Cronartium harknessii*, *Cronartium kurilense* and *Cronartium sahoanum* (EFSA PLH Panel, 2018f); – UK Risk Register Details for *Cronartium coleosporioides* (DEFRA, 2020q); – UK Risk Register Details for *Cronartium comandrae* (DEFRA, 2020r); – UK Risk Register Details for *Cronartium comptoniae* (DEFRA, 2020s); – UK Risk Register Details for *Cronartium harknessii* (DEFRA, 2020t); – UK Risk Register Details for *Cronartium quercuum* (DEFRA, 2020u).
Other relevant information for the assessment	
Biology – short summary	*Cronartium* species are macrocyclic heteroecious rust fungi that require aecial (conifers in genus *Pinus*, more specifically two or five-needle pines) and telial hosts (plants from families of Asclepiadaceae, Fagaceae, Gentianaceae, Grossulariaceae, Myricaceae, Paeoniaceae, Santalaceae, Saxifagaceae and Scrophulariaceae) for completing their life cycle (Petersen, 1974; Sinclair & Lyon, 2005; Zhao et al., 2022). *Cronartium* species are biotrophic, obligate plant-parasitic rusts (Zhao et al., 2022), which usually have five different types of spores: (1) spermatia (in spermagonia) (previously known as pycniospores in pycnia) and (2) aeciospores (in aecia) on aecial hosts; (3) urediniospores (in uredinia), (4) teliospores (in telia) and (5) basidiospores (in basidium) on telial hosts (Petersen, 1974; Zhao et al., 2022). Basidiospores formed on telial hosts are wind dispersed during summer/autumn to the aecial hosts, where they infect young needles or young cones. Several weeks up to couple of years after the infection, spermagonia with spermatia are formed on branches and stems of *Pinus* species, usually in the spring. Aecia with yellow, orange or white aeciospores are produced few weeks up to 1 year after the formation of spermagonia, usually in early summer. Aeciospores are then dispersed to the telial hosts over long distances. Infected telial hosts after about 2 weeks start producing uredinia with urediniospores on the underside of leaves or on stems. Urediniospores are produced for the whole summer and can infect new telial hosts. In late summer the telia are produced with teliospores, which then produce basidiospores that infect new aecial hosts. *Cronartium* can overwinter in bark and galls of *Pinus* species. (Sinclair & Lyon, 2005; EPPO, 1997b, 1997c, 1997d, 1997e; EFSA PLH Panel, 2018e; Schoettle et al., 2019). Aeciospores of *Cronartium* species can be carried over long distances, it was recorded that for *C. ribicola* they can be dispersed as far as 480 km (Maloy, 2003). *Cronartium* species cause on *Pinus* species these types of symptoms: galls, cankers, deformation and death of cones, dieback of branches and stems and tree mortality. There are three types of rusts: (1) stem/blister rusts (causing cankers); (2) gall rusts (gall formation without canker); and (3) limb rusts (dieback of branches without canker) (Sinclair & Lyon, 2005). Possible pathways of entry for *Cronartium* species are (1) plants for planting of *Pinus* spp.; (2) cut branches of *Pinus* spp.; and (3) non-squared wood of *Pinus* spp. (EFSA PLH Panel, 2018e).
Association with the plant parts	*Cronartium* spp. are associated with needles, cones, bark, branches and stems of aecial hosts (*Pinus*) (Sinclair & Lyon, 2005; Zhao et al., 2022). They penetrate into cortex, secondary phloem and sapwood (Sinclair & Lyon, 2005).
Presence of asymptomatic plants/plant parts	Symptoms may not be apparent in *Pinus* species for several years after infection (EPPO, 1997b, 1997c, 1997d, 1997e).
Host plant range	Telial hosts of *Cronartium* species are plants from families of Asclepiadaceae, Fagaceae, Gentianaceae, Grossulariaceae, Myricaceae, Paeoniaceae, Santalaceae, Saxifagaceae and Scrophulariaceae: – ***Cronartium appalachianum***: *Bucklyea distichophylla* (Farr & Rossman, 2024; Sinclair & Lyon, 2005; Zhao et al., 2022); – ***Cronartium arizonicum***: *Castilleja integra*, *C. laxa*, *C. linariifolia*, *C. minor*, *C. patriotica* (Farr & Rossman, 2024; Zhao et al., 2022); – ***Cronartium bethelii***: *Quercus emoryi*, *Q. mongolica* (Zhao et al., 2022); – ***Cronartium coleosporioides***: *Castilleja* species, *Lamourouxia cordifolia*, *L. dependens*, *L. rhinanthifolia*, *Melampyrum lineare*, *Orthocarpus luteus*, *Pedicularis bracteosa*, *P. groenlandica*, *P. surrecta*, *Rhinanthus crista-galli*, *R. kyrollae* (Farr & Rossman, 2024; Zhao et al., 2022); – ***Cronartium comandrae***: *Comandra livida*, *C. pallida*, *C. richardsiana*, *C. umbellata*, *Geocaulon lividum* (Farr & Rossman, 2024; Zhao et al., 2022); – ***Cronartium comptoniae***: *Comptonia asplenifolia*, *C. peregrina*, *Myrica asplenifolia*, *M. californica*, *M. gale* (Farr & Rossman, 2024; Zhao et al., 2022); – ***Cronartium conigenum***: *Quercus arizonica*, *Q. dunnii*, *Q. emoryi*, *Q. grisea*, *Q. oblongifolia*, *Q. oocarpa*, *Q. peduncularis*, *Q. rugosa* (Farr & Rossman, 2024);

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	– ***Cronartium filamentosum***: *Castilleja* (Vogler & Bruns, 1998); – ***Cronartium harknessii***: *Melampyrum lineare*; *Rhinanthus crista-galli* (Farr & Rossman, 2024); – ***Cronartium occidentale***: *Ribes aureum, R. cereum, R. gandfalii, R. inebrians, R. inerme, R. leptanthum, R. nigrum, R. odoratum, R. roezlii, R. speciosum, R. velmtinum* (Farr & Rossman, 2024; Zhao et al., 2022); – ***Cronartium quercuum***: *Quercus* species, *Castanea* species, *Castanopsis cuspidata, Cyclobalanopsis glauca, Fagus japonica, Lithocarpus densiflorus, Pasania densiflora, Rhus chinensis* (Farr & Rossman, 2024); – ***Cronartium strobilinum***: *Quercus alba, Q. geminata, Q. laurifolia, Q. macrocarpa, Q. minima, Q. myrtifolia, Q. nigra, Q. stellata, Q. virginiana* (Farr & Rossman, 2024; Zhao et al., 2022).
Evidence that the commodity is a pathway	No records of interception of *Cronartium* species on conifer wood were found in the EUROPHYT/TRACES-NT database (EUPOPHYT, 2024; TRACES-NT, 2024). *Cronartium* species are associated with branches and stems of aecial hosts (*Pinus*) (Sinclair & Lyon, 2005; Zhao et al., 2022). Moreover, according to EFSA PLH Panel (2018e) the possible pathways of entry for *Cronartium* species are non-squared wood and cut branches of *Pinus* species. The commodity to be exported to the EU from the US is wood chips with less than 2% of bark. Branches under 50 mm in diameter are excluded from production of wood chips (Dossier Section 2.0). Therefore, the stems and the branches bigger than 50 mm can be infected with *Cronartium* and used for wood chip production. There is no specific evidence that conifer wood chips are a pathway for *Cronartium* species, however, the possibility that the commodity could be a pathway cannot be excluded (EPPO, 2019). EFSA PLH Panel (2018e) states that 'non-squared wood is listed as a pathway of entry of various non-EU *Cronartium* spp. in EPPO (2024q). However, since these fungi are biotrophs and require live host tissue, they would presumably not survive long in wood after harvest. Nevertheless, some *Cronartium* spp. are reported to be able to overwinter in bark of *Pinus* spp. (EPPO, 1997b). Moreover, even though these are biotrophic fungi, their aecia may be able to survive for some time in wood.'
Efficacy of sulfuryl fluoride on that specific pest	No experimental results for *Cronartium* spp. have been found regarding the efficacy of sulfuryl fluoride.

A.5 | *FUSARIUM CIRCINATUM*

A.5.1 | Organism information

Taxonomic information	Current valid scientific name: *Fusarium circinatum* Synonyms: *Gibberella circinata* (According to Index Fungorum) Name used in the EU legislation: *Fusarium circinatum* Nirenberg & O'Donnell [GIBBCI] Order: Hypocreales Family: Nectriaceae Common name: pitch canker of pine (PPC) Name used in the Dossier: *Fusarium circinatum*
Group	Fungi
EPPO code	GIBBCI
Regulated status	*Fusarium circinatum* is quarantine pest for EU listed in Annex II B of Commission Implementing Regulation (EU) 2019/2072 as *Fusarium circinatum* Nirenberg & O'Donnell [GIBBCI]. *Fusarium circinatum* is included in the EPPO A2 list (EPPO, 2023m), in the A1 list for Argentina, Brazil, Switzerland and Türkiye; and in the A2 list for Chile, Jordan and COSAVE (=the Comité de Sanidad Vegetal del Cono Sur – Argentina, Bolivia, Brazil, Chile, Paraguay, Perù, Uruguay). *Fusarium circinatum* is quarantine pest for China and Morocco (EPPO, 2024r).
Pest status in the US	*Fusarium circinatum* is present in the following 12 states on the southern and western part of the US: Alabama, Arkansas, California, Florida, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, Texas and Virginia (EPPO, 2024s; MyCoPortal, 2024).
Host status on conifers	Main hosts of *F. circinatum* are *Pinus arizonica, P. armandii, P. attenuata, P. ayacahuite, P. banksiana, P. brutia, P. canariensis, P. cembroides, P. clausa, P. contorta, P. coulteri, P. densiflora, P. discolor, P. douglasiana, P. durangensis, P. echinata, P. elliottii, P. estevezii, P. glabra, P. greggii, P. halepensis, P. hartwegii, P. kesiya, P. leiophylla, P. luchuensis, P. maximinoi, P. michoacana, P. montezumae, P. mugo, P. muricata, P. oaxacana, P. nigra, P. occidentalis, P. oocarpa, P. palustris, P. patula, P. pinaster, P. pinea, P. ponderosa, P. pringlei, P. pseudostrobus, P. pungens, P. radiata, P. rigida, P. roxburghii, P. sabiniana, P. serotina, P. strobus, P. sylvestris, P. taeda, P. tecunumanii, P. teocote, P. thunbergii, P. torreyana, P. virginiana* and *P. wallichiana* (EFSA PLH Panel, 2010; EPPO, 2024t; Farr & Rossman, 2024). Other conifer trees known to be only experimental hosts are *Abies alba, Calocedrus decurrens, Larix decidua, L. kaempferi, Picea abies, P. glauca* and *Pseudotsuga menziesii* (Martìn-Garcìa et al., 2018; EPPO, 2024t).
PRA information	Pest Risk Assessments available: – A global climatic risk assessment of pitch canker disease (Ganley et al., 2009); – Risk assessment of *Gibberella circinata* for the EU territory and identification and evaluation of risk management options (EFSA PLH Panel, 2010); – Analizy Zagrożenia Agrofagiem (Ekspres PRA) dla *Fusarium circinatum* (Sadowska et al., 2018); – Prioritisation of invasive alien species with the potential to threaten agriculture and biodiversity in Kenya through horizon scanning (Mulema et al., 2022); – UK risk register details for *Fusarium circinatum* (DEFRA, 2022a); – Assessment of the suitability of Finnish climate for the establishment of *Fusarium circinatum* Nirenberg & O'Donnell (Tuomola & Hannunen, 2023).

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Other relevant information for the assessment	
Biology – short summary	*Fusarium circinatum* is an ascomycete fungus known to be agent of the pitch pine canker (PPC), one of the most important diseases affecting pines. The pest is believed to be native to Mexico and first spreading to southern North America before being introduced to South America (Brazil, Chile, Colombia, Uruguay) South Africa, Europe (Portugal, Spain) and Asia (South Korea, Japan) through trade in seeds and infected plants (EPPO, 2021a). *Fusarium circinatum* mainly propagate asexually through conidia, since perithecia producing ascospores have not been observed under natural conditions. Spores can be disseminated by the wind or vector insects like bark beetles (i.e. *Pityophthorus* spp., *Ips* spp., *Tomicus piniperda)* and the weevil *Pissodes nemorensis* (Sanchez-Lucas, 2022). Feeding activity of insects and other factors (i.e. hail damage) can create wounds serving as entry points for infection also when spores are already present on host surfaces. Other ways of infection are via water splash and contaminated soil (Sanchez-Lucas, 2022). After spore germination the mycelium can rapidly expand with temperatures above 10°C and suitable atmospheric moisture. *Fusarium circinatum* causes cankers which girdle branches, roots and stems, often associated with resin exudates (pitch) in response to the fungal infection (EPPO, 2021a; EFSA PLH Panel, 2010). Repeated infections with extensive production of resin can affect large branches and the main stem, leading to extensive dieback in the canopy. Long distance spread of *F. circinatum* mostly occurs through human-aided movement of infected plant material (EFSA PLH Panel, 2010; EPPO, 2021a).
Association with the plant parts	*Fusarium circinatum* is associated with many vegetative and reproductive parts in all ages of the host plants. Seeds, seedlings roots, stems, cones, branches, as well as logs cut from diseased trees can all carry the pathogen.
Presence of asymptomatic plants/plant parts	Seeds can be cryptically infected, and seedlings, branches and roots may harbour the pest without showing symptoms for long time (EFSA PLH Panel, 2010; Martìn-Garcìa et al., 2018; Sanchez-Lucas, 2022). Only after spore germination and the starting of infection on branches/stems, the presence of *F. circinatum* becomes clearly visible on affected trees.
Host plant range	The wide host range on conifers of *F. circinatum* under natural conditions only covers species in the genus *Pinus* (EFSA PLH Panel, 2010; EPPO, 2024t; Farr & Rossman, 2024). Along few other conifer species known to be experimental hosts (see Section 'Host status on conifers'), *F. circinatum* has been also isolated as endophytic from asymptomatic herbaceous plants as *Anthoxanthum odoratum, Briza maxima, Erhartha erecta, Pentameris pallida, Rubus ulmifolius, Rumex acetosa, Taraxacum officinale* and others (Hernandez-Escribano et al., 2018).
Evidence that the commodity is a pathway	No records of interception of *F. circinatum* on conifer wood were found in the EUROPHYT/TRACES-NT database (EUPOPHYT, 2024; TRACES-NT, 2024). Primary commodity pathways of *F. circinatum* are plant materials such as seeds, seedlings, scions, branches and cones. There is no specific evidence in the literature that wood chips are a pathway of *F. circinatum*. However, the pest can also be present on round wood from which chips are produced. A visual quality check is performed to avoid that infected wood is used in wood chip production (Dossier Section 2.0); however, *F. circinatum* may survive long time (up to 18 months) in logs and in cut wood of branches and chips, also from asymptomatic branches (Gordon et al., 2015; McNee et al., 2002). Although the risk that the pest may disperse via infected wood is considered relatively low (Zamora-Ballesteros et al., 2019; EFSA, 2020c), the possibility that wood chips may be a pathway of *F. circinatum* cannot be excluded.
Efficacy of sulfuryl fluoride on that specific pest	Fumigation with sulfuryl fluoride for 5 days was efficient in eliminating *F. circinatum* from infected logs (Gordon et al., 2000; EFSA PLH Panel, 2010; Gordon et al., 2015).

A.6 | *GREMMENIELLA ABIETINA*

A.6.1 | Organism information

Taxonomic information	Current valid scientific name: *Gremmeniella abietina* Synonyms: *Ascoclyx abietina, Brunchorstia destruens, Brunchorstia pinea, Brunchorstia pinea* var. *cembrae, Brunchorstia pinea* var. *pini, Brunchorstia pini, Crumenula abietina, Crumenula pinea, Excipulina pinea, Godronia abietina, Lagerbergia abietina, Scleroderris abietina, Scleroderris lagerbergii, Septoria pinea* (according to Index Fungorum) Name used in the EU legislation: *Gremmeniella abietina* (Lagerberg) Morelet Order: Helotiales Family: Helotiaceae Common name: Brunchorstia dieback (in Europe), scleroderris canker of conifers (in North America), brunchorstia disease of pine, canker of conifers, dieback of pine, shoot blight of pine Name used in the Dossier: – Note: two varieties of *G. abietina* were previously known, *G. abietina* var. *balsamea* and *G. abietina* var. *abietina*; however, only the latter is currently recognised on the basis of morphological characteristics and molecular markers. Furthermore, three different races (Asian, North American and European) have been described within *G. abietina*, probably forming at least two distinct species (Romeralo et al., 2023).
Group	Fungi
EPPO code	GREMAB

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Regulated status	*Gremmeniella abietina* is protected zone quarantine pest for Ireland listed in Annex III of Commission Implementing Regulation (EU) 2019/2072 as *Gremmeniella abietina* [GREMAB]. The pest is also quarantine for Morocco, Tunisia, Canada, China and Israel; it is in the A1 list for Chile and in the A2 list for COSAVE (=Comité de Sanidad Vegetal del Cono Sur – Argentina, Bolivia, Brazil, Chile, Paraguay, Perù, Uruguay) (EPPO, 2024u).
Pest status in the US	In the US, *Gremmeniella abietina* is present in six northeastern states: Maine, Michigan, Minnesota, New Hampshire, New York state and Wisconsin (EPPO, 2024v; MyCoPortal, 2024).
Host status on conifers	*Gremeniella abietina* mostly infects pines. *Pinus contorta, P. banksiana* and *P. resinosa* are frequently affected in North America, *Pinus sylvestris* in Europe (EPPO, 2023n). The complete list of hosts includes (alphabetically): *Abies alba, A. amabilis A. balsamea*, *A. lasiocarpa*, *A. nordmanniana* subsp. *equitrojani*, *A. sachalinensis*, *Cedrus libani, Larix leptolepis, L. kaempferi, L. lyallii*, *Picea abies*, *P. glauca*, *P. jezoensis*, *P. mariana*, *P. omorika*, *P. rubens*, *P. sitchensis*, *Pinus abies, P. albicaulis, P. aristata P. banksiana*, *P. cembra*, *P. contorta*, *P. densiflora*, *P. divaricata*, *P. excelsa*, *P. flexilis*, *P. griffithi*, *P. halepensis*, *P. koraiensis*, *P. monticola*, *P. mugo*, *P. montana*, *P. monticola*, *P. nigra*, *P. pinaster*, *P. pinea*, *P. ponderosa*, *P. radiata*, *P. resinosa*, *P. rigida*, *P. sabiniana*, *P. strobus*, *P. sylvestris*, *P. thunbergii*, *P. virginiana*, *P. wallichiana* and *Pseudotsuga menziesii* (EFSA PLH Panel, 2017b; EFSA, 2023; EPPO, 2023n; Farr & Rossman, 2024).
PRA information	Pest Risk Assessments available: – Pest categorisation of *Gremmeniella abietina* (EFSA PLH Panel, 2017b); – Analizy Zagrożenia Agrofagiem (Ekspres PRA) dla *Gremmeniella abietina* (Zenelt et al., 2021); – UK risk register details for *Gremmeniella abietina* (DEFRA, 2021a).
Other relevant information for the assessment	
Biology – short summary	*Gremmeniella abietina* is a pathogenic ascomycete fungus causing shoot dieback and cankers on the branches and trunks of conifer trees. It is a serious pest in nurseries, plantations and natural forests throughout the northern hemisphere in Europe, North America and Japan. It is not fully clear whether *G. abietina* is only native to Europe, or native to both Europe and North America. Anyway, its geographical races - see the Section 'Taxonomic information' above - also differ in aggressiveness and host range (Romeralo et al., 2023; Zenelt et al., 2021). The life cycle of *G. abietina* is mainly biennial, and most spores are produced the year after the first infection, or even 2 years later. However, it is known that the pathogen is able to survive at endophytic stage for an undetermined time, so lengthening the cycle (EFSA PLH Panel, 2017b). The infection usually starts during spring particularly on wounded needles, buds and shoots, but the pathogen develops aggressively only in the following winter, on dormant trees, when mycelium spreads destroying the vascular tissues, also under temperatures of −6°C (EPPO, 2023n). Afterwards, cankers on branches and stem may be also observed (EFSA PLH Panel, 2017b). The disease may spread rapidly, infecting the entire crown and causing severe loss of needles and shoots. Weakened trees also may die due to secondary attack by other pathogens or insects. The fruiting bodies (pycnidia and apothecia, respectively producing conidia and ascospores) appear on dead needles and shoots in spring and early autumn. Conidia are more effective in spreading the pathogen on short distances; they are dispersed mainly in water, so that wet air conditions and/or intensive rain may considerably favour the infection (Laflamme & Archambault, 1990; Romeralo et al., 2023; Zenelt et al., 2021). Long-distance dispersal mostly occurs by ascospores, which are moved by air currents and wind; however local and international transport of potentially infected material is also important in spreading the pest. *Gremmeniella abietina* is able to survive for up to 10 days in the branches of 9-year-old *Pinus sylvestris* trees. The survival period of conidia is over 18 months on cut wood of *P. sylvestris*) (Witzell et al., 2006), and 2 years on cut wood of *Pinus resinosa* (Canada) (Laflamme & Rioux, 2015).
Association with the plant parts	*Gremmeniella abietina* may be present on hosts as spores and mycelium on several plant parts, as needles, buds, shoots, branches and stems, as well as wood with or without bark.
Presence of asymptomatic plants/plant parts	The infection by *G. abietina* is usually asymptomatic in the early stages on buds and shoots during spring but becomes evident when the pathogen spreads into the tissues. Needle reddening and falling, exudation of resin in the buds, shoot wilting and branch drying up, cankers on stems, are the main visible symptoms. However, when *G. abietina* is present at endophytic stage, infected plants may be asymptomatic and the pathogen might be moved also over long distances (EFSA PLH Panel, 2017b).
Host plant range	*Gremmeniella abietina* infects only conifer trees. No additional hosts are known. See above section 'Host status on conifers'.
Evidence that the commodity is a pathway	No records of interception of *G. abietina* on conifer wood were found in the EUROPHYT/TRACES-NT database (EUPOPHYT, 2024; TRACES-NT, 2024). There is no evidence that wood chips might be a pathway for *G. abietina*. Main pathways are plants for planting and Christmas trees. The dispersal of the pathogen via infected wood with bark is considered unlikely, but there is uncertainty about wood chips as a pathway of spread (EFSA PLH Panel, 2017b).
Efficacy of sulfuryl fluoride on that specific pest	No experimental results for *G. abietina* have been found regarding the efficacy of sulfuryl fluoride.

A.7 | *GYMNOSPORANGIUM* SPECIES (*G. ASIATICUM, G. AURANTIACUM, G. BERMUDIANUM, G. BETHELII, G. BISEPTATUM, G. BOTRYAPITES, G. CLAVIPES, G. CONICUM, G. CONNERSII, G. CORNICULANS, G. CUNNINGHAMIANUM, G. CUPRESSI, G. DAVISII, G. EFFUSUM, G. EXIGUUM, G. EXTERUM, G. FLORIFORME, G. FRATERNUM, G. GLOBOSUM, G. GRACILENS, G. HARKNESSIANUM, G. HYALINUM, G. INCONSPICUUM, G. JUNIPERI-VIRGINIANAE, G. KERNIANUM, G. MULTIPORUM, G. NELSONII, G. NIDUS-AVIS, G. TRACHYSORUM, G. VAUQUELINIAE, G. YAMADAE*)

A.7.1. | Organism information

Taxonomic information	***Gymnosporangium* species** Name used in the EU legislation: *Gymnosporangium* spp. [1GYMNG] Order: Pucciniales Family: Gymnosporangiaceae Note: four species previously known as *Gymnosporangium*, now with a current name *Gymnotelium* (*Gymnotelium blasdaleanum*, *Gymnotelium myricatum*, *Gymnotelium nootkatense* and *Gymnotelium speciosum*) were not included in this pest data sheet. **1. *Gymnosporangium asiaticum*** Current valid scientific name: *Gymnosporangium asiaticum* Synonyms: *Gymnosporangium chinense*, *Gymnosporangium confusum*, *Gymnosporangium haraeanum*, *Gymnosporangium japonicum*, *Gymnosporangium koreense*, *Gymnosporangium spiniferum*, *Gymnosporangium photiniae*, *Roestelia koreensis*, *Roestelia photiniae* (According to Index Fungorum) Common name: leaf rust of Japanese pear, leaf rust of juniper, rust of oriental pear Name used in the Dossier: – **2. *Gymnosporangium aurantiacum*** Current valid scientific name: *Gymnosporangium aurantiacum* Synonyms: – Common name: – Name used in the Dossier: – **3. *Gymnosporangium bermudianum*** Current valid scientific name: *Gymnosporangium bermudianum* Synonyms: – Common name: – Name used in the Dossier: – **4. *Gymnosporangium bethelii*** Current valid scientific name: *Gymnosporangium bethelii* Synonyms: *Gymnosporangium tubulatum*, *Roestelia tubulata* Common name: – Name used in the Dossier: – **5. *Gymnosporangium biseptatum*** Current valid scientific name: *Gymnosporangium biseptatum* Synonyms: – Common name: – Name used in the Dossier: – **6. *Gymnosporangium botryapites*** Current valid scientific name: *Gymnosporangium botryapites* Synonyms: – Common name: – Name used in the Dossier: – **7. *Gymnosporangium clavipes*** Current valid scientific name: *Gymnosporangium clavipes* Synonyms: *Aecidium germinale*, *Caeoma germinale*, *Gymnosporangium germinale*, *Podisoma clavipes*, *Podisoma gymnosporangium* var. *clavipes* (According to Index Fungorum) Common name: rust of apple, rust of juniper, rust of quince Name used in the Dossier: – **8. *Gymnosporangium conicum*** Current valid scientific name: *Gymnosporangium conicum* Synonyms: – Common name: – Name used in the Dossier: – **9. *Gymnosporangium connersii*** Current valid scientific name: *Gymnosporangium connersii* Synonyms: – Common name: – Name used in the Dossier: – **10. *Gymnosporangium corniculans*** Current valid scientific name: *Gymnosporangium corniculans* Synonyms: –

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Common name: –
Name used in the Dossier: –
11. *Gymnosporangium cunninghamianum*
Current valid scientific name: *Gymnosporangium cunninghamianum*
Synonyms: –
Common name: –
Name used in the Dossier: –
12. *Gymnosporangium cupressi*
Current valid scientific name: *Gymnosporangium cupressi*
Synonyms: –
Common name: –
Name used in the Dossier: –
13. *Gymnosporangium davisii*
Current valid scientific name: *Gymnosporangium davisii*
Synonyms: –
Common name: –
Name used in the Dossier: –
14. *Gymnosporangium effusum*
Current valid scientific name: *Gymnosporangium effusum*
Synonyms: –
Common name: –
Name used in the Dossier: –
15. *Gymnosporangium exiguum*
Current valid scientific name: *Gymnosporangium exiguum*
Synonyms: –
Common name: –
Name used in the Dossier: –
16. *Gymnosporangium exterum*
Current valid scientific name: *Gymnosporangium exterum*
Synonyms: –
Common name: –
Name used in the Dossier: –
17. *Gymnosporangium floriforme*
Current valid scientific name: *Gymnosporangium floriforme*
Synonyms: –
Common name: –
Name used in the Dossier: –
18. *Gymnosporangium fraternum*
Current valid scientific name: *Gymnosporangium fraternum*
Synonyms: *Aecidium transformans*, *Gymnosporangium transformans*, *Roestelia transformans* (According to Index Fungorum)
Common name: –
Name used in the Dossier: –
19. *Gymnosporangium globosum*
Current valid scientific name: *Gymnosporangium globosum*
Synonyms: *Aecidium globosum*, *Gymnosporangium fuscum var. globosum* (According to Index Fungorum)
Common name: American rust of hawthorn, rust of apple, rust of juniper
Name used in the Dossier: –
20. *Gymnosporangium gracilens*
Current valid scientific name: *Gymnosporangium gracilens*
Synonyms: *Aecidium gracilens* (According to Index Fungorum)
Common name: –
Name used in the Dossier: –
21. *Gymnosporangium harknessianum*
Current valid scientific name: *Gymnosporangium harknessianum*
Synonyms: *Roestelia harknessiana* (According to Index Fungorum)
Common name: –
Name used in the Dossier: –
22. *Gymnosporangium hyalinum*
Current valid scientific name: *Gymnosporangium hyalinum*
Synonyms: *Aecidium hyalinum*, *Gymnosporangium hyalinum*, *Roestelia hyalina* (According to Index Fungorum)
Common name: –
Name used in the Dossier: –
23. *Gymnosporangium inconspicuum*
Current valid scientific name: *Gymnosporangium inconspicuum*
Synonyms: –
Common name: –
Name used in the Dossier: –
24. *Gymnosporangium juniperi-virginianae*
Current valid scientific name: *Gymnosporangium juniperi-virginianae*
Synonyms: *Aecidium juniperi-virginianae*, *Aecidium pyratum*, *Caeoma pyratum*, *Gymnosporangium macropus*, *Gymnosporangium virginianum*, *Podisoma juniperi-virginianae*, *Roestelia pyrata* (According to Index Fungorum)

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	Common name: American rust of apple, cedar/apple rust, rust of American cedar, rust of juniper Name used in the Dossier: – **25. *Gymnosporangium kernianum*** Current valid scientific name: *Gymnosporangium kernianum* Synonyms: – Common name: Kern's pear rust Name used in the Dossier: – **26. *Gymnosporangium multiporum*** Current valid scientific name: *Gymnosporangium multiporum* Synonyms: – Common name: – Name used in the Dossier: – **27. *Gymnosporangium nelsonii*** Current valid scientific name: *Gymnosporangium nelsonii* Synonyms: *Aecidium nelsonii*, *Gymnosporangium durum* (According to Index Fungorum) Common name: witches broom rust Name used in the Dossier: – **28. *Gymnosporangium nidus-avis*** Current valid scientific name: *Gymnosporangium nidus-avis* Synonyms: *Aecidium nidus-avis*, *Gymnosporangium juvenescens*, *Puccinia nidus-avis*, *Roestelia nidus-avis*, *Tremella nidus-avis* (According to Index Fungorum) Common name: – Name used in the Dossier: – **29. *Gymnosporangium trachysorum*** Current valid scientific name: *Gymnosporangium trachysorum* Synonyms: – Common name: – Name used in the Dossier: – **30. *Gymnosporangium vauqueliniae*** Current valid scientific name: *Gymnosporangium vauqueliniae* Synonyms: – Common name: – Name used in the Dossier: – **31. *Gymnosporangium yamadae*** Current valid scientific name: *Gymnosporangium yamadae* Synonyms: – Common name: Japanese rust of apple Name used in the Dossier: –
Group	Fungi
EPPO code	*Gymnosporangium asiaticum*: GYMNAS *Gymnosporangium clavipes*: GYMNCL *Gymnosporangium globosum*: GYMNGL *Gymnosporangium juniperi-virginianae*: GYMNJV *Gymnosporangium kernianum*: GYMNKE *Gymnosporangium nelsonii*: GYMNNE *Gymnosporangium yamadae*: GYMNYA *Gymnosporangium aurantiacum, G. bermudianum, G. bethelii, G. biseptatum, G. botryapites, G. conicum, G. connersii, G. corniculans, G. cunninghamianum, G. cupressi, G. davisii, G. effusum, G. exiguum, G. exterum, G. floriforme, G. fraternum, G. gracilens, G. harknessianum, G. hyalinum, G. inconspicuum, G. multiporum, G. nidus-avis, G. trachysorum, G. vauqueliniae*: –
Regulated status	The pathogens are members of *Gymnosporangium* spp. [1GYMNG], which are listed in Annex II/A of Commission Implementing Regulation (EU) 2019/2072. *Gymnosporangium asiaticum* is included in the EPPO A2 list (EPPO, 2023m) and in A1 list of Bahrain, Egypt, Iran, Russia, Ukraine, COSAVE (=Comite de Sanidad Vegetal del Cono Sur) and IAPSC (=Inter-African Phytosanitary Council). It is quarantine in Morocco, New Zealand, Norway, Tunisia and the US (EPPO, 2024w). *Gymnosporangium clavipes*, *G. globosum*, *G. juniperi-virginianae* and *G. yamadae* are included in the EPPO A1 list (EPPO, 2023b). *Gymnosporangium clavipes* is included in A1 list of Egypt, Paraguay, Uruguay, Iran, Jordan, Ukraine, COSAVE (=Comite de Sanidad Vegetal del Cono Sur) and IAPSC (=Inter-African Phytosanitary Council). It is quarantine in China, Mexico, Morocco, Norway, Tunisia (EPPO, 2024x). *Gymnosporangium globosum* is included in A1 list of Egypt, Paraguay, Uruguay, Iran, Jordan, Ukraine and COSAVE (=Comite de Sanidad Vegetal del Cono Sur). It is quarantine in China, Mexico, Morocco, Norway, Tunisia (EPPO, 2024y). *Gymnosporangium juniperi-virginianae* is included in A1 list of Bahrain, Egypt, Iran, Jordan, Paraguay, Ukraine, Uruguay, CAN (=Comunidad Andina), COSAVE (=Comite de Sanidad Vegetal del Cono Sur) and IAPSC (=Inter-African Phytosanitary Council). It is quarantine in China, Mexico, Morocco, New Zealand, Norway and Tunisia (EPPO, 2024z). *Gymnosporangium yamadae* is included in A1 list of Egypt, Georgia, Iran, Jordan, Russia, Ukraine, COSAVE (=Comite de Sanidad Vegetal del Cono Sur) and IAPSC (=Inter-African Phytosanitary Council). It is quarantine in Canada, Morocco, Norway and Tunisia (EPPO, 2024aa).

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Pest status in the US	All the mentioned *Gymnosporangium* species are present in the US (CABI, 2024; EPPO, 2024q; Farr & Rossman, 2024; GBIF, 2024; MyCoPortal, 2024). *Gymnosporangium asiaticum* is present in California, Connecticut, New York state, Oklahoma, Oregon, Washington state, Wisconsin (EPPO, 2023o) *Gymnosporangium clavipes* is present in Alabama, Arizona, Arkansas, California, Connecticut, Delaware, Florida, Georgia, Illinois, Indiana, Iowa, Kentucky, Louisiana, Maine, Massachusetts, Michigan, Mississippi, Missouri, Montana, Nebraska, New Jersey, New York state, North Carolina, North Dakota, Ohio, Oklahoma, Pennsylvania, South Carolina, South Dakota, Texas, Vermont, Virginia, Washington state, West Virginia, Wisconsin and Wyoming (EPPO, 2023p). *Gymnosporangium globosum* is present in Alaska, Colorado, Connecticut, Illinois, Kentucky, Nebraska, North Dakota, Oklahoma, South Dakota and Texas (EPPO, 2023q). *Gymnosporangium juniperi-virginianae* is present in Alabama, Arkansas, California, Colorado, Connecticut, District of Columbia, Florida, Georgia, Illinois, Indiana, Iowa, Kansas, Kentucky, Maryland, Massachusetts, Michigan, Mississippi, Missouri, Nebraska, New York state, North Carolina, North Dakota, Ohio, Oklahoma, Pennsylvania, Rhode Island, South Dakota, Tennessee, Virginia, Washington state, Wisconsin and Wyoming (EPPO, 2023r). *Gymnosporangium yamadae* is present in Connecticut, Delaware, Maine, Maryland, Minnesota, New Hampshire, New Jersey, New York state, Ohio, Pennsylvania, Rhode Island and Wisconsin (EPPO, 2023s). For more details on the distribution in different US states for the rest of the *Gymnosporangium* species see the above-mentioned databases or other scientific literature.
Host status on conifers	Telial hosts: – ***Gymnosporangium asiaticum***: *Juniperus chinensis, J. horizontalis, J. media, J. procumbens, J. rigida, J. sabina, J. sargentii, J. scopulorum, J. squamata* and *J. virginiana* (Farr & Rossman, 2024). – ***Gymnosporangium aurantiacum***: *Juniperus communis* and *Libocedrus decurrens* (current name: *Calocedrus decurrens*) (Farr & Rossman, 2024). – ***Gymnosporangium bermudianum***: *Juniperus bermudiana, J. lucayana, J. silicicola* and *J. virginiana* (Farr & Rossman, 2024). – ***Gymnosporangium bethelii***: *Juniperus flaccida, J. horizontalis, J. mexicana, J. occidentalis* and *J. scopulorum* (Farr & Rossman, 2024). – ***Gymnosporangium biseptatum***: *Chamaecyparis thyoides, Libocedrus decurrens* (current name: *Calocedrus decurrens*) and *Thuja orientalis* (Farr & Rossman, 2024). – ***Gymnosporangium botryapites***: *Chamaecyparis thyoides* (Farr & Rossman, 2024). – ***Gymnosporangium clavipes***: *Juniperus chinensis, J. communis, J. horizontalis, J. phoenicea, J. scopulorum* and *J. virginiana* (Farr & Rossman, 2024). – ***Gymnosporangium conicum***: *Juniperus communis* and *J. virginiana* (MyCoPortal, 2024). – ***Gymnosporangium connersii***: *Juniperus horizontalis* (Farr & Rossman, 2024). – ***Gymnosporangium corniculans***: *Juniperus horizontalis* and *J virginiana* (Farr & Rossman, 2024). – ***Gymnosporangium cunninghamianum***: *Cupressus arizonica, C. bakeri, C. duclouxiana* and *C. torulosa* (Farr & Rossman, 2024). – ***Gymnosporangium cupressi***: *Cupressus arizonica* and *C. bakeri* (Farr & Rossman, 2024). – ***Gymnosporangium davisii***: *Juniperus communis, J. sibirica* and *J. virginiana* (Farr & Rossman, 2024). – ***Gymnosporangium effusum***: *Juniperus virginiana* (Farr & Rossman, 2024). – ***Gymnosporangium exiguum***: *Juniperus ashei, J. californica, J. deppeana, J. excelsa cv. Stricta, J. mexicana, J. pachyphloea, J. scopulorum* and *J. virginiana* (Farr & Rossman, 2024). – ***Gymnosporangium exterum***: *Juniperus virginiana* (Farr & Rossman, 2024). – ***Gymnosporangium floriforme***: *Juniperus virginiana* (Farr & Rossman, 2024). – ***Gymnosporangium fraternum***: *Chamaecyparis pisifera* and *C. thyoides* (Farr & Rossman, 2024). – ***Gymnosporangium globosum***: *Juniperus barbadensis, J. chinensis, J. communis* var. *depressa, J. horizontalis, J. prostrata, J. scopulorum, J. silicicola* and *J. virgiana* (Farr & Rossman, 2024). – ***Gymnosporangium gracilens***: *Juniperus monosperma* and *J. oxycedrus* (MyCoPortal, 2024). – ***Gymnosporangium harknessianum***: *Juniperus occidentalis* and *J. osteosperma* (Farr & Rossman, 2024). – ***Gymnosporangium hyalinum***: *Chamaecyparis thyoides* (Farr & Rossman, 2024). – ***Gymnosporangium inconspicuum***: *Juniperus chinensis, J. deppeana, J. monosperma, J. occidentalis, J. osteosperma, J. scopulorum* and *J. utahensis* (Farr & Rossman, 2024). – ***Gymnosporangium juniperi-virginianae***: *Cedrus, Juniperus chinensis, J. communis var. depressa, J. horizontalis, J. pinchotii, J. scopulorum, J. silicicola, J. utahensis* and *J. virginiana* (Farr & Rossman, 2024). – ***Gymnosporangium kernianum***: *Juniperus californica, J. deppeana, J. monosperma, J. occidentalis, J. osteosperma, J. pachyphloea* and *J. utahensis* (Farr & Rossman, 2024). – ***Gymnosporangium multiporum:*** *Juniperus deppeana, J. monosperma, J. occidentalis, J. osteosperma* and *J. pachyphloea* (Farr & Rossman, 2024). – ***Gymnosporangium nelsonii:*** *Juniperus californica, J. deppeana, J. flaccida, J. horizontalis, J. monosperma, J. occidentalis, J. osteosperma, J. scopulorum* and *J. utahensis* (Farr & Rossman, 2024). – ***Gymnosporangium nidus-avis:*** *Juniperus chinensis, J. horizontalis, J. prostrata, J. scopulorum, J. silicicola* and *J. virginiana* (Farr & Rossman, 2024). – ***Gymnosporangium trachysorum:*** *Juniperus virginiana* (Farr & Rossman, 2024). – ***Gymnosporangium vauqueliniae:*** *Juniperus monosperma* (Farr & Rossman, 2024). – ***Gymnosporangium yamadae:*** *Juniperus chinensis, J. procumbens, J. sargentii, J. squamata* and *Sabina vulgaris* (current name: *Juniperus sabina*) (Farr & Rossman, 2024).

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PRA information	Pest Risk Assessments available: – Rapid Pest Risk Analysis for *Gymnosporangium asiaticum* (FERA, 2014); – Pest categorisation of *Gymnosporangium* spp. (non-EU) (EFSA PLH Panel, 2018g); – UK Risk Register Details for *Gymnosporangium asiaticum* (DEFRA, 2020v); – UK Risk Register Details for *Gymnosporangium globosum* (DEFRA, 2020w); – UK Risk Register Details for *Gymnosporangium juniperi-virginianae* (DEFRA, 2020x); – UK Risk Register Details for *Gymnosporangium yamadae* (DEFRA, 2020y).
Other relevant information for the assessment	
Biology – short summary	*Gymnosporangium* species are heteroecious rust fungi that require telial (conifers in genus *Juniperus, Calocedrus, Chamaecyparis, Cupressus* and *Callitropsis*) and aecial hosts (plants from Rosaceae family) for completing their life cycle. *Gymnosporangium* species usually have four different types of spores: (1) teliospores (in telia) and (2) basidiospores (in basidium) on telial hosts; (3) spermatia (in spermagonia) and (4) aeciospores (in aecia) on aecial hosts (Novick, 2008; Lāce, 2017; EFSA PLH Panel, 2018g). On infected telial hosts, *Gymnosporangium* creates latent mycelium as an overwintering stage. In the spring telia are produced on twigs, branches and stems of telial hosts. Telia germinate and produce basidiospores in moist conditions, which are then wind dispersed over long distances to aecial hosts. From late spring to early summer spermagonia develop on the upper surface of leaves or less likely on fruits of the infected aecial hosts. Later, aeciospores in aecia are produced on the underside of leaves and they are wind dispersed over long distances to the telial hosts, where the overwintering stage develops (EPPO, 1997f, 1997g, 1997h, 1997i; EPPO, 2006; EFSA PLH Panel, 2018g). Symptoms on telial hosts are swelling of stems/branches; and yellow/orange/brown/red galls on twigs/branches/stems/leaves (EPPO, 1997a, 1997b, 1997c, 1977d; EPPO, 2006). Galls of different *Gymnosporangium* species can be either annual (producing telia for one season) or perennial (producing telia for couple of years) (EPPO, 2006). Possible pathways of entry for *Gymnosporangium* species are plants for plating and cut branches (EFSA PLH Panel, 2018g).
Association with the plant parts	*Gymnosporangium* spp. are associated with twigs, branches, stems and occasionally leaves of telial hosts (EPPO, 1997f, 1997g, 1997h, 1997i; EPPO, 2006; EFSA PLH Panel, 2018g).
Presence of asymptomatic plants/plant parts	On telial hosts the infection can be latent during winter and from the previous growing season (EPPO, 1997f, 1997g, 1997h, 1997i; EPPO, 2006; EFSA PLH Panel, 2018g).
Host plant range	In addition to the telial hosts (see above), aecial hosts are: – ***Gymnosporangium asiaticum***: *Chaenomeles, Crataegus, Cydonia, Malus, Photinia, Pourthiaea, Pseudocydonia, Pyrus* and *Sorbus* (Farr & Rossman, 2024). – ***Gymnosporangium aurantiacum***: *Sorbus* (Farr & Rossman, 2024). – ***Gymnosporangium bethelii***: *Crataegus* (Farr & Rossman, 2024). – ***Gymnosporangium biseptatum***: *Amelanchier* (Farr & Rossman, 2024). – ***Gymnosporangium botryapites***: *Amelanchier* (Farr & Rossman, 2024). – ***Gymnosporangium clavipes***: *Amelanchier, Aronia Chaenomeles, Cotoneaster, Crataegus, Cydonia, Malus, Mespilus, Photinia, Pyrus* and *Sorbus* (Farr & Rossman, 2024). – ***Gymnosporangium conicum***: Unknown. – ***Gymnosporangium connersi***: *Amelanchier* and *Crataegus* (Farr & Rossman, 2024). – ***Gymnosporangium corniculans**: Amelanchier* (Farr & Rossman, 2024). – ***Gymnosporangium cunninghamianum***: *Amelanchier, Cotoneaster, Pyrus* (Farr & Rossman, 2024). – ***Gymnosporangium cupressi***: *Amelanchier* (Farr & Rossman, 2024). – ***Gymnosporangium davisii***: *Aronia* and *Pyrus* (Farr & Rossman, 2024). – ***Gymnosporangium effusum***: *Aronia* (Hasselbring, 1913). – ***Gymnosporangium exiguum***: *Crataegus, Heteromeles* and *Photinia* (Farr & Rossman, 2024). – ***Gymnosporangium exterum***: *Gillenia* and *Porteranthus* (Farr & Rossman, 2024). – ***Gymnosporangium floriforme***: *Crataegus* (Farr & Rossman, 2024). – ***Gymnosporangium fraternum***: *Aronia* (Farr & Rossman, 2024). – ***Gymnosporangium globosum***: *Amelanchier, Crataegus, Malus, Pyrus* and *Sorbus* (Farr & Rossman, 2024). – ***Gymnosporangium gracilens***: *Fendlera* and *Philadelphus* (MyCoPortal, 2024) – ***Gymnosporangium harknessianum***: *Amelanchier* (Farr & Rossman, 2024). – ***Gymnosporangium hyalinum***: *Crataegus* and *Pyrus* (Farr & Rossman, 2024). – ***Gymnosporangium inconspicuum***: *Amelanchier, Crataegus, Peraphyllum* and *Photinia* (Farr & Rossman, 2024). – ***Gymnosporangium juniperi-virginianae***: *Crataegus, Malus* and *Pyrus* (Farr & Rossman, 2024). – ***Gymnosporangium kernianum***: *Amelanchier* and *Pyrus* (Farr & Rossman, 2024). – ***Gymnosporangium multiporum***: Unknown. – ***Gymnosporangium nelsonii:*** *Amelanchier, Crataegus, Cydonia, Malus, Peraphyllum, Pyrus* and *Sorbus* (Farr & Rossman, 2024). – ***Gymnosporangium nidus-avis:*** *Amelanchier* and *Cydonia* (Farr & Rossman, 2024). – ***Gymnosporangium trachysorum:*** *Crataegus* (Farr & Rossman, 2024). – ***Gymnosporangium vauqueliniae:*** *Vauquelinia* (Farr & Rossman, 2024). – ***Gymnosporangium yamadae:*** *Malus* and *Pyrus* (Farr & Rossman, 2024).

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Evidence that the commodity is a pathway	No records of interception of *Gymnosporangium* species on conifer wood were found in the EUROPHYT/TRACES-NT database (EUPOPHYT, 2024; TRACES-NT, 2024). *Gymnosporangium* species are associated with branches and stems of telial hosts. Moreover, according to EFSA PLH Panel (2018g) the possible pathway of entry for *Gymnosporangium* species are cut branches of telial hosts. The commodity to be exported to the EU from the US is wood chips with less than 2% of bark. Branches under 50 mm in diameter are excluded from production of wood chips (Dossier Section 2.0). Therefore, the stems and the branches bigger than 50 mm can be infected with *Gymnosporangium* and used for wood chip production.
Efficacy of sulfuryl fluoride on that specific pest	No experimental results for *Gymnosporangium* spp. have been found regarding the efficacy of sulfuryl fluoride.

A.8 | *PHYTOPHTHORA RAMORUM* (NON-EU ISOLATES)

A.8.1 | Organism information

Taxonomic information	Current valid scientific name: *Phytophthora ramorum* Synonyms: – Name used in the EU legislation: *Phytophthora ramorum* (non-EU isolates) Werres, De Cock & Man in 't Veld [PHYTRA] Order: Peronosporales Family: Peronosporaceae Common name: Sudden Oak Death (SOD), ramorum bleeding canker, ramorum blight, ramorum leaf blight, twig and leaf blight Name used in the Dossier: –
Group	Oomycetes
EPPO code	PHYTRA
Regulated status	The pathogen is listed in Annex II of Commission Implementing Regulation (EU) 2019/2072 as *Phytophthora ramorum* (non-EU isolates) Werres, De Cock & Man in't Veld [PHYTRA]. The EU isolates of *P. ramorum* are listed as regulated non-quarantine pest (RNQP). The pathogen is included in the EPPO A2 list (EPPO, 2023m). *Phytophthora ramorum* is quarantine in Canada, China, Israel, Mexico, Morocco, South Korea and the UK. It is on A1 list of Brazil, Chile, Egypt, Kazakhstan, Switzerland, Türkiye and EAEU (=Eurasian Economic Union: Armenia, Belarus, Kazakhstan, Kyrgyzstan and Russia) (EPPO, 2024ab).
Pest status in the US	*Phytophthora ramorum* is an introduced pathogen in the US. It is present in the natural environment in California and Oregon with restricted distribution (EPPO, 2024ac). Due to the movement of nursery stocks from California and Oregon, it has been detected in nurseries, residential/commercial landscaping or streams in many other states between 2003 and 2021 (USDA, 2023). The pathogen, however, is not considered to be established in the US outside of California and Oregon (USDA, 2023). According to EPPO (2024ac), *P. ramorum* is present, with few occurrences in Alabama, Colorado, Florida, Georgia, Illinois, Indiana, Iowa, Louisiana, Nebraska, New Mexico, North Carolina, Oklahoma, South Carolina, Tennessee and Texas. It is reported as absent or eradicated in Arizona, Arkansas, Connecticut, Kansas, Maryland, Mississippi, Missouri, New Jersey, New York state, Pennsylvania, Virginia and Washington state (EPPO, 2024ac).
Host status on conifers	Proven coniferous hosts of *P. ramorum* (confirmed by Koch's postulates) are *Abies grandis*, *A. magnifica*, *Chamaecyparis lawsoniana*, *Larix* × *eurolepis*, *L. decidua*, *L. kaempferi*, *Pseudotsuga menziesii* var. *menziesii*, *Sequoia sempervirens* and *Taxus baccata* (APHIS USDA, 2022). Associated coniferous plants with *P. ramorum* (without Koch's postulates) are *Abies alba*, *A. concolor*, *A. procera*, *Larix occidentalis*, *Picea sitchensis*, *Pinus ponderosa*, *Taxus* × *media*, *T. brevifolia*, *Torreya californica* and *Tsuga heterophylla* (APHIS USDA, 2022).
PRA information	Pest Risk Assessments available: – Risk analysis for *Phytophthora ramorum* Werres, de Cock & Man in't Veld, causal agent of sudden oak death, ramorum leaf blight and ramorum dieback (Cave et al., 2008); – Risk analysis of *Phytophthora ramorum*, a newly recognised pathogen threat to Europe and the cause of sudden oak death in the USA (Sansford et al., 2009); – Scientific opinion on the pest risk analysis on *Phytophthora ramorum* prepared by the FP6 project RAPRA (EFSA PLH Panel, 2011); – Pest risk management for *Phytophthora kernoviae* and *Phytophthora ramorum* (EPPO, 2013); – UK Risk Register Details for *Phytophthora ramorum* (DEFRA, 2022b); – Risk of *Phytophthora ramorum* to the United States (USDA, 2023); – Updated pest risk assessment of *Phytophthora ramorum* in Norway (Thomsen et al., 2023).

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Other relevant information for the assessment	
Biology – short summary	*Phytophthora ramorum* is present in Asia, Europe, North and South America (EPPO, 2024ac). So far there are 12 known lineages of *P. ramorum*: NA1 and NA2 from North American, EU1 from Europe (including the UK) and North America (Grünwald et al., 2009), EU2 from Northern Ireland and western Scotland (Van Poucke et al., 2012), IC1 to IC5 from Vietnam and NP1 to NP3 from Japan (Jung et al., 2021). *Phytophthora ramorum* is heterothallic oomycete species belonging to clade 8c (Blair et al., 2008) with two mating types: A1 and A2 (Boutet et al., 2010). *Phytophthora* species generally reproduce through a) dormant (resting) spores which can be either sexual (oospores) or asexual (chlamydospores); and b) fruiting structures (sporangia) which contain zoospores (Erwin & Ribeiro, 1996). *Phytophthora ramorum* produces sporangia on the surfaces of infected leaves and twigs of host plants. These sporangia can be splash-dispersed to other close or carried by wind and rain to longer distances. The sporangia germinate to produce zoospores that penetrate and initiate an infection on new hosts. In infected plant material the chlamydospores are produced and can serve as resting structures (Davidson et al., 2005; Grünwald et al., 2008). The pathogen is also able to survive in soil (Shishkoff, 2007). In the west of Scotland, it persisted in soil for at least 2 years after its hosts were removed (Elliot et al., 2013). Oospores were only observed in pairing tests under controlled laboratory conditions (Brasier & Kirk, 2004). Optimal temperatures under laboratory conditions were 16–26°C for growth, 14–26°C for chlamydospore production and 16–22°C for sporangia production (Englander et al., 2006). *Phytophthora ramorum* is mainly a foliar pathogen, however it was also reported to infect shoots, stems and occasionally roots of various host plants (Grünwald et al., 2008; Parke & Lewis, 2007). According to Brown and Brasier (2007), *P. ramorum* commonly occupies xylem beneath phloem lesions and may spread within xylem and possibly recolonise the phloem from the xylem. *Phytophthora ramorum* can remain viable within xylem for two or more years after the overlying phloem had been excised. *Phytophthora ramorum* can disperse by aerial dissemination, water, movement of infested plant material and soil containing propagules on footwear, tires of trucks and mountain bikes, or the feet of animals (Brasier, 2008; Davidson et al., 2002). Infected foliar hosts can be a major source of inoculum, which can lead to secondary infections on nearby host plants. Important foliar hosts in Europe are *Rhododendron* spp. and *Larix kaempferi* (Brasier & Webber, 2010; Grünwald et al., 2008). Main foliar hosts in the US include California bay laurel (*Umbellularia californica*) and tanoak (*Lithocarpus densiflorus*), which drive the disease epidemic in California and Oregon (USDA, 2023). *Phytophthora ramorum* caused rapid decline of *Lithocarpus densiflorus* and *Quercus agrifolia* in forests of California and Oregon (Rizzo et al., 2005) and *Larix kaempferi* in plantations of southwest England (Brasier & Webber, 2010). *Phytophthora ramorum* caused following symptoms on proven conifer hosts: – on *Larix kaempferi*: wilted shoot tips with blackened needles and stem lesions with resin bleeding (Brasier & Webber, 2010); – on *Abies magnifica*: wilting and dieback of new shoot growth (Chastagner & Riley, 2010); – on *Abies grandis* and *Pseudotsuga menziesii*: wilting and dieback of new shoots, brown discoloration of needles and needle loss on young shoots (LeBoldus et al., 2018); – on *Chamaecyparis lawsoniana*: dead and dying foliage and stem resinosis (Brasier & Webber, 2012); – on *Larix decidua*, *Larix kaempferi* and *Larix* × *eurolepis*: brown and chlorotic needles (Harris & Webber, 2016); – on *Sequoia sempervirens*: discoloured leaves and cankers on small branches (Maloney et al., 2002); – on *Taxus baccata*: shoot dieback (Lane et al., 2004). Possible pathways of entry for *P. ramorum* are plants for planting (excluding seed and fruit) of known susceptible hosts; plants for planting (excluding seed and fruit) of non-host plant species accompanied by contaminated attached growing media; soil/growing medium (with organic matter) as a commodity; soil as a contaminant; foliage or cut branches; seed and fruits; susceptible (isolated) bark and susceptible wood (EFSA PLH Panel, 2011).
Association with the plant parts	*Phytophthora ramorum* is associated with leaves, shoots, stems and roots (Grünwald et al., 2008; Parke & Lewis, 2007). *Phytophthora ramorum* can penetrate bark and colonise phloem and xylem (Brown & Brasier, 2007).
Presence of asymptomatic plants/plant parts	Plants with infected roots can be without aboveground symptoms for months until developmental or environmental factors trigger disease expression (Roubtsova & Bostock, 2009; Thompson et al., 2021). Application of some fungicides may reduce symptoms and therefore mask infection, making it more difficult to determine whether the plant is pathogen-free (DEFRA, 2008).
Host plant range	*Phytophthora ramorum* has a very wide host range, which is expanding. Main host plants include *Kalmia* spp., *Kalmia latifolia*, *Larix decidua*, *L. kaempferi*, *Notholithocarpus densiflorus*, *Pieris* spp., *Quercus agrifolia*, *Rhododendron* spp., *Syringa vulgaris* and *Viburnum* spp. (EPPO, 2024ad). Further proven non-coniferous hosts confirmed by Koch's postulates are *Acer circinatum*, *A. macrophyllum*, *A. pseudoplatanus*, *Adiantum aleuticum*, *A. jordanii*, *Aesculus californica*, *A. hippocastanum*, *Arbutus menziesii*, *A. unedo*, *Arctostaphylos columbiana*, *A. glauca*, *A. hooveri*, *A. manzanita*, *A. montereyensis*, *A. morroensis*, *A. pilosula*, *A. pumila*, *A. silvicola*, *A. viridissima*, *Berberis aquifolium*, *Calluna vulgaris*, *Camellia* spp., *Castanea sativa*, *Ceanothus thyrsiflorus*, *Chrysolepis chrysophylla*, *Cinnamomum camphora*, *Corylus cornuta*, *Fagus sylvatica*, *Frangula californica*, *F. purshiana*, *Fraxinus excelsior*, *Gaultheria procumbens*, *G. shallon*, *Griselinia littoralis*, *Hamamelis virginiana*, *Heteromeles arbutifolia*, *Laurus nobilis*, *Lonicera hispidula*, *Lophostemon confertus*, *Loropetalum chinense*, *Magnolia* × *loebneri*, *M. doltsopa*, *M. stellata*, *Maianthemum racemosum*, *Parrotia persica*, *Phoradendron serotinum* subsp. *macrophyllum*, *Photinia* × *fraseri*, *Prunus laurocerasus*, *Quercus cerris*, *Q. chrysolepis*, *Q. falcata*, *Q. ilex*, *Q. kelloggii*, *Q. parvula* var. *shrevei*, *Rosa gymnocarpa*, *Salix caprea*, *Trientalis latifolia*, *Umbellularia californica*, *Vaccinium myrtillus*, *V. parvifolium*, *V. ovatum*, *Viburnum* spp. and *Vinca minor* (APHIS USDA, 2022).

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Evidence that the commodity is a pathway	No records of interception of *Phytophthora ramorum* on conifer wood were found in the EUROPHYT/TRACES-NT database (EUPOPHYT, 2024; TRACES-NT, 2024). *Phytophthora ramorum* is associated with shoots, stems, bark, phloem and xylem (Brown & Brasier, 2007). The pathogen was detected in unspecified wood chips in Scotland (Elliot et al., 2013) and in 2 out of 84 tested plant chips from collection bins in California (Shelly et al., 2005). Moreover, according to EFSA PLH Panel (2011) the possible pathway of entry for *P. ramorum* is susceptible (isolated) bark and susceptible wood. The commodity to be exported to the EU from the US is wood chips with less than 2% of bark. Branches under 50 mm in diameter are excluded from production of wood chips (Dossier Section 2.0). Stems and branches bigger than 50 mm can be infected with *P. ramorum* and used for wood chip production. Therefore, *P. ramorum* could be present in the wood chips as well as on residual bark pieces.
Efficacy of sulfuryl fluoride on that specific pest	Sulfuryl fluoride fumigations were conducted in 10-litre glass chambers at six target concentrations (40, 80, 120, 160, 200, 240 mg/L) at 15°C and 20°C for 24-, 48- and 72-h exposure times. Different *Phytophthora ramorum* isolates grown on sterilised barley grain were tested. Some of the isolates were killed at the 120 mg/L dose in 24 h (CT = 2′787 gxh/m^3 at 20°C), others at the 160 mg/L dose in 24 h (CT = 3′683 gxh/m^3 at 20°C) and 80 mg/L dose in 72 h (CT 5′669 gxh/m^3 at 20°C) (Uzunovic et al., 2017).

A.9 | AMBROSIA BEETLES (EXAMPLE OF *GNATHOTRICHUS SULCATUS*)

A.9.1 | Organism information

Taxonomic information	Current valid scientific name: *Gnathotrichus sulcatus* Synonyms: *Crypturgus sulcatus*, *Cryphalus sulcatus*, *Gnathotrichus aciculatus* Name used in the EU legislation: Scolytinae spp. (non-European) [1SCOLF] Order: Coleoptera Family: Curculionidae Common name: western hemlock wood stainer, Douglas-fir ambrosia beetle Name used in the Dossier: –
Group	Insects
EPPO code	GNAHSU
Regulated status	*Gnathotrichus sulcatus* is a member of the Scolytinae spp. (non-European) [1SCOLF], which are listed in Annex II/A of Commission Implementing Regulation (EU) 2019/2072. *Gnathotrichus sulcatus* is included in the EPPO A1 list (EPPO, 2023b) and in the A1 list for Türkiye. The pest is quarantine in Israel, Morocco and Tunisia (EPPO, 2024ae).
Pest status in the US	*Gnathotrichus sulcatus* is present in Alaska, Arizona, California, Colorado, Idaho, Nevada, New Mexico, Oregon, South Dakota, Utah and Washington state (Wood, 1982; Wood & Bright, 1992; CABI, 2019c; Atkinson, 2024; EPPO, 2024af).
Host status on conifers	Conifer hosts of *Gnathotrichus sulcatus* are *Abies abies*, *A. concolor*, *A. grandis*, *A. magnifica*, *A. religiosa*, *Chamaecyparis nootkatensis* (current name: *Callitropsis nootkatensis*), *Picea engelmanni*, *P. sitchensis*, *Pinus ayacahuite*, *P. duranguensis*, *P. engelmannii*, *P. gregii*, *P. hartwegii*, *P. leiophylla*, *P. montezumae*, *P. patula*, *P. ponderosa*, *P. pseudostrobus*, *P. rudis*, *Pseudotsuga menziesii*, *P. taxifolia* (current name: *Pseudotsuga menziesii* var. *menziesii*), *Sequoia sempervirens*, *S. washingtoniana*, (current name: *Sequoiadendron giganteum*), *Thuja plicata*, *Tsuga heterophylla* and *T. mertensiana* (Atkinson, 2024; Blackman, 1931; Doane & Galliland, 1929; Prebble & Graham, 1957; Wood, 1982; Wood & Bright, 1992).
PRA information	Pest Risk Assessments available: – Pest categorisation of non-EU Scolytinae of coniferous hosts (EFSA PLH Panel, 2020b); – UK Risk Register Details for *Gnathotrichus sulcatus* (DEFRA, 2020z).
Other relevant information for the assessment	
Biology – short summary	*Gnathotrichus sulcatus* is an ambrosia beetle, which is present in Central America (El Salvador, Guatemala, Honduras) and North America (Canada, Mexico, the US) (Wood, 1982; Wood & Bright, 1992; CABI, 2019c; Atkinson, 2024; EPPO, 2024af). *Gnathotrichus sulcatus* together with *G. retusus* were considered the second most important conifer ambrosia beetles in British Columbia, after *Trypodendron lineatum* (Furniss & Carolin, 1977). The beetle causes damage to the lumber and logs by production of tunnels in sapwood and their blackening by fungal symbionts (Funk, 1970). *Gnathotrichus sulcatus* was found to be associated with fungi (*Ambrosiella sulcati, Ceratostomella* sp., *Graphium* sp. and *Raffaelea sulcati*), which are introduced into the galleries and become a food source for developing larvae and adult beetles (Doane & Gilliland, 1929; Funk, 1970). The beetle has four stages of development: egg, larva (unknown number of instars), pupa and adult (Doane & Gilliland, 1929). *Gnathotrichus* species are monogamous (EPPO, 1996; Smith & Hulcr, 2015). Females are reddish/dark brown (Blackman, 1931; Wood, 1982), 2.8–3.5 mm long and 3.1 times as long as wide (Wood, 1982). Males are very similar in proportions, but the pronotum is more broadly rounded in front and the anterior margin not extended. Males do not have long hairs on the antennal club and funicle compared to females (Blackman, 1931).

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	The beetles are attracted by (1) ethanol, which is released together with other chemicals by stressed or dying plants; and (2) sulcatol, which is an aggregation pheromone produced by males of *G. sulcatus* (Byrne et al., 1974; Cade et al., 1970; McLean & Borden, 1977). *Gnathotrichus sulcatus* was found to attack and complete its life cycle in recently felled trees, logs, stumps (Doane & Gilliland, 1929; Prebble & Graham, 1957) and freshly sawn lumber (McLean & Borden, 1975). There are two flights in the season, the first one is in the spring and the second one in the late summer-autumn (Prebble & Graham, 1957). Flight activity starts when the temperature reaches between 58 and 60°F (= about 14.44–15.56°C) (Rudinsky & Schneider, 1969). The beetles attack felled trees, first the top then the trunks. Males and females create together galleries boring into the bark and the sapwood. The male creates an entrance tunnel and a main gallery. The female creates secondary galleries and egg niches (Prebble & Graham, 1957). Galleries may be 10–25 cm long and they are kept clean of boring dust. The accumulation of white powdery material at the entrance hole is a characteristic symptom of the attack by ambrosia beetles (Bright & Stark, 1973). Mating occurs in the main and secondary galleries. Immediately after the mating, the eggs are laid into the egg niches alongside of the secondary galleries (one egg per niche). The eggs are white and ellipsoidal (Prebble & Graham, 1957), they are covered with sawdust by the female (Doane & Gilliland, 1929). Up to 60 eggs can be found in one gallery system (Prebble & Graham, 1957). The eggs hatch in 7–8 days. The larvae are white and legless, they feed on the introduced fungi and enlarge their egg niches. When the larvae are fully grown, they rest their head towards the secondary gallery and pupate (Doane & Gilliland, 1929; Prebble & Graham, 1957). All stages of *G. sulcatus* can overwinter inside the log. Eggs laid in late summer turn into emerging young beetles the following spring (Prebble & Graham, 1957). *Gnathotrichus sulcatus* has one generation per year in Canada and most probably two generations per year with overlapping broods in California (Bright & Stark, 1973). Possible pathways of entry for *G. sulcatus* are sawn wood, non-squared wood, wood packaging material, unseasoned raw logs, lumber and dunnage (EPPO, 1996; CABI, 2019c; DEFRA, 2020z).
Association with the plant parts	All life stages of *G. sulcatus* are associated with dying, recently dead or cut trees, mainly logs, stumps and lumber. Even if the species reproduces and develops only in sapwood, bark is needed for tree/log colonisation. The beetles can be found inside stems and larger branches of conifer trees (Doane & Gilliland, 1929; Prebble & Graham, 1957; McLean & Borden, 1975; Bright & Stark, 1973).
Presence of asymptomatic plants/plant parts	No specific information on presence of asymptomatic plants is found. Similarly, like other ambrosia beetles, initial phases of infestation are associated with few external symptoms. While there is no visible injury in the bark at early stage of colonisation, white and dry frass is produced and examination of the wood under the infested spot bored by the beetle, reveals the brownish staining of the xylem and necrosis caused by the fungus (Mendel et al., 2012).
Host plant range	*Gnathotrichus sulcatus* is a pest only on coniferous plants (*Abies*, *Callitropsis, Picea*, *Pinus*, *Pseudotsuga*, *Sequoia*, *Thuja* and *Tsuga*). Therefore, no additional hosts were found. See above section 'Host status on conifers'.
Evidence that the commodity is a pathway	No records of interception of *G. sulcatus* on conifer wood were found in the EUROPHYT/TRACES-NT database (EUPOPHYT, 2024; TRACES-NT, 2024). All life stages of *G. sulcatus* (eggs, larvae, pupae and adults) are associated with trunks and larger branches (Bright & Stark, 1973). There is evidence that *G. sulcatus* was intercepted in New Zealand in sawn wood imported from British Columbia, Canada (Bain, 1974). Moreover, adults of *G. sulcatus* can survive in green lumber for at least 2 months (McLean & Borden, 1975). Therefore, the logs used for the wood chip production may be infested with any of the life stage of *G. sulcatus*. There is no specific evidence that conifer wood chips are a pathway for *G. sulcatus*. However, considering that the wood chip maximum size in three dimensions is 102 mm (Dossier Section 2.0) and that the adult stage is between 2.8 and 3.5 mm long, the possibility that the commodity could be a pathway cannot be excluded.
Efficacy of sulfuryl fluoride on that specific pest	No experimental results for *G. sulcatus* have been found regarding the efficacy of sulfuryl fluoride. Study results on sulfuryl fluoride fumigation efficacy on other ambrosia beetles (*Euwallacea validus*, *Xylosandrus germanus*, *Xyleborus pfeilii*) and bark beetles (*Cryphalus fulvus*, *Hylastes ater*, *Ips cembrae*, *Phloeosinus perlatus*, *Scolytoplatypus tycoon*, *Scolytoplatypus micado*) can be found in a summary table of a Scientific opinion on Commodity risk assessment of ash logs from the US treated with sulfuryl fluoride to prevent the entry of the emerald ash borer *Agrilus planipennis* (EFSA PLH Panel, 2023).

A.10 | *CHORISTONEURA* SPECIES (EXAMPLE OF *CHORISTONEURA FUMIFERANA*)

A.10.1 | Organism information

Taxonomic information	Current valid scientific name: *Choristoneura fumiferana* Synonyms: *Archips fumiferana, Cacoecia fumiferana, Harmologa fumiferana, Tortrix fumiferana* Name used in the EU legislation: *Choristoneura* spp. (non-European) [1CHONG]. Order: Lepidoptera Family: Tortricidae Common name: Spruce budworm Name used in the Dossier: *Choristoneura fumiferana* Note: although recent studies (Brunet et al., 2017; Nelson et al., 2022) have confirmed that *C. fumiferana* is a distinct species, it should still be considered as a member of a complex of nine phylogenetically closely related species (SBW complex) also including *C. pinus, C. retiniana, C. carnana, C. lambertiana, C. occidentalis occidentalis, C. occidentalis biennis* and *C. orae*. (Bird, 2013; Dupuis et al., 2017). This relationship is considered relevant from the standpoint of forest health (EFSA PLH Panel, 2019).

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Group	Insects
EPPO code	CHONFU
Regulated status	*Choristoneura fumiferana* is listed in Annex II/A of Commission Implementing Regulation (EU) 2019/2072 as *Choristoneura* spp. (non- European) [1 CHONG]. *Choristoneura fumiferana* is included in the EPPO A1 list (EPPO, 2023b). The pest is quarantine in China and Morocco. It is also on A1 list of Kazakhstan, Russia, Switzerland, Ukraine, the UK and EAEU (= Eurasian Economic Union - Armenia, Belarus, Kazakhstan, Kyrgyzstan and Russia) (EPPO, 2024ag).
Pest status in the US	*Choristoneura fumiferana* is present in the US mostly in the northern states: Alaska, Washington, Oregon, Idaho, Montana, North Dakota, Minnesota, Wisconsin, Iowa, Michigan, Maine, New York, New Hampshire, Pennsylvania, Ohio, Vermont, Virginia, West Virginia; it is also present in Utah and Arizona (EPPO, 2023t) and in North Carolina (Dossier Section 2.0). Pest status of other SBW complex members in the US according to EPPO (2023u, 2023v, 2023w, 2023x, 2023y, 2023z, 2023aa) is: – *Choristoneura carnana*: California; – *Choristoneura lambertiana*: California, Colorado, Idaho, Montana, Oregon Wyoming; – *Choristoneura occidentalis occidentalis*: Arizona, California, Colorado, Idaho, Montana, New Mexico, Oregon, Utah, Washington, Wyoming; – *Choristoneura orae*: Alaska; – *Choristoneura pinus*: Michigan, Minnesota, Wisconsin (also present in North Carolina: Dossier Section 2.0); – *Choristoneura retiniana*: California, Nevada, Oregon, Utah; – *Choristoneura occidentalis biennis* is present only in Canada (Dupuis et al., 2017).
Host status on conifers	Major hosts of *C. fumiferana* are *Abies balsamea* and *Picea glauca* (EPPO, 2024ah); other hosts are *Abies alba, A. amabilis, A. concolor, A. grandis, A. lasiocarpa, Abies* sp., *Juniperus* sp. *Larix laricina, L. occidentalis, Larix* sp., *Picea abies, P. engelmannii, P. mariana, P. pungens, P. rubens, P. sitchensis, Picea* sp., *Pinus banksiana, P. contorta, P. monticola, P. resinosa, P. strobus, P. sylvestris, Pinus* sp., *Pseudotsuga menziesii, Thuja occidentalis, Tsuga canadensis, T. heterophylla, T. mertensiana, Tsuga* sp. (EFSA PLH Panel, 2019; EPPO, 2024ah). According to EFSA PLH Panel (2019), other hosts from the SBW complex are: – *Pseudostuga macrocarpa* (*C. carnana*); – *Abies magnifica, Pinus albicaulis, P. flexilis, P. lambertiana, P. ponderosa* (*C. lambertiana*); – *Pinus rigida, P. virginiana* (*C. pinus*); – *Abies magnifica* (*C. retiniana*).
PRA information	Pest Risk Assessments available: – Scientific Opinion on the pest categorisation of non-EU *Choristoneura* spp. (EFSA PLH Panel, 2019); – Analizy Zagrożenia Agrofagiem (Ekspres PRA) dla *Choristoneura fumiferana* (Kubasik et al., 2020); – UK Risk Register Details for *Choristoneura fumiferana* (DEFRA, 2021b).
Other relevant information for the assessment	
Biology – short summary	*Choristoneura fumiferana* is a nearctic boreal moth known in North America as a major defoliator of conifer trees. Regionally synchronised outbreaks recurring every 30–40 years cause severe damage (growth reduction and tree mortality) to million hectares of forest (EPPO, 2022g). Important economic losses are recorded mostly in the second half of the past century, but dendrochronological studies have shown that outbreaks of *C. fumiferana* periodically occurred in Canadian forests over the past 400 years (Boulanger et al., 2012). *Choristoneura fumiferana* is a univoltine species with four life stages (egg; larva – six instars; pupa; adult). A two-year cycle is rare, but typically observed in the subalpine species *C. occidentalis biennis* only occurring in Canada (EPPO, 2022g; Furniss & Carolin, 1977). Adults fly in summer (July–August) and 20 to 80 eggs are laid in masses on the underside of needles. From 80 to 220 eggs can be totally laid by a single female (Nealis, 2016). The young larvae do not feed after hatching and move to seek overwintering sites in bark crevices and lichens, where they spin silken shelters. 2nd instar larvae are the overwintering stage. Next spring larvae resume activity initially feeding on old needles and buds. Later they web the new needles and begin feeding on them under a silken cover. Pupation usually occurs on branches near the last feeding sites and the pupal stage lasts 10 days (EPPO, 2022g). Being a boreal insect, *C. fumiferana* has high capacity of survival in winter months, and the 2nd instar diapausing larvae can withstand low temperatures up to −42°C (Delisle et al., 2022). *Choristoneura fumiferana* has a remarkable dispersal capability not only at adult stage. Moths are active flyers (20 km - up to 450 km when supported by winds) but also larvae can be passively dispersed by air currents when they hang on silken threads, both in late summer and early spring (Anderson & Sturtevant, 2011; EPPO, 2022g). However, long range dispersal of *C. fumiferana* is mostly due to 2nd instar diapausing larvae transported on living plants, cut foliage and bark of host trees (EFSA PLH Panel, 2019; EPPO, 2022g).
Association with the plant parts	*Choristoneura fumiferana* is primarily associated with conifer needles as a source of food during springtime and early summer. However, the larvae can also attack unopened buds and staminate flowers before the new needles appear at the end of winter. Both pupae and overwintering 2nd instar larvae are found on the bark of branches and stems, respectively in early summer and winter months. Fresh and mature cones can occasionally host inactive stages of the pest too (EFSA PLH Panel, 2019).

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Presence of asymptomatic plants/plant parts	There is no data about the presence of asymptomatic plants/plant parts. Eggs in the underside of needles can be difficult to detect, but damage and other life stages of the pest are usually well visible. Larvae feeding on needles are easily detectable in spring inside their silken covers; pupae can be observed on the bark of branches/stems for a short time before the adult appearance; hibernating 2nd instar larvae can be detected in the bark crevices of branches/stems, but a careful inspection is required.
Host plant range	*Choristoneura fumiferana* is a polyphagous species. In addition to the list of conifer hosts reported above, including 26 species in eight genera (34 species considering the whole SBW complex), the moth is also found on *Impatiens* sp. and *Populus balsamifera* (EFSA PLH Panel, 2019).
Evidence that the commodity is a pathway	No records of interception of *C. fumiferana* on conifer wood were found in the EUROPHYT/TRACES-NT database (EUPOPHYT, 2024; TRACES-NT, 2024). Pathways of entry are plants for planting, cut branches, fruits including cones, round wood with bark and bark of host plants (EFSA PLH Panel, 2019). The commodity consists in chips produced from wood having less than 2% bark. Considering that a minimal percentage of bark remains present in the wood chips, the possibility that the commodity is a pathway is low but cannot be excluded.
Efficacy of sulfuryl fluoride on the pest	No information was found about the efficacy of sulfuryl fluoride on *C. fumiferana* (or other *Choristoneura* species), at any stage of life.

A.11 | *LYCORMA DELICATULA*

A.11.1 | Organism information

Taxonomic information	Current valid scientific name: *Lycorma delicatula* Synonyms: *Aphaena delicatula, Lycorma delicatulum* Name used in the EU legislation: *Lycorma delicatula* (White) [LYCMDE]. Order: Hemiptera Family: Fulgoridae Common name: spotted lanternfly (SLF), spot clothing wax cicada, Chinese blistering cicada. Name used in the Dossier: *Lycorma delicatula*
Group	Insects
EPPO code	LYCMDE
Regulated status	*Lycorma delicatula* is quarantine pest for EU listed in Annex II A of Commission Implementing Regulation (EU) 2019/2072 as *Lycorma delicatula* (White) [LYCMDE]. It is also quarantine for Morocco and Canada and included in the EPPO A1 list (EPPO, 2024ai).
Pest status in the US	*Lycorma delicatula* is present in the US with restricted distribution in 16 states: Connecticut, Delaware, Illinois, Indiana, Iowa, Kentucky, Maryland, Massachusetts, Michigan, New Jersey, North Carolina, Ohio, Pennsylvania, Tennessee, Virginia, West Virginia. The pest was only intercepted in Kansas, Maine, New York, Oregon, Rhode Island; it was eradicated in Vermont (EPPO, 2024aj).
Host status on conifers	Conifers are not considered within the preferred host plants of *Lycorma delicatula* (Leach et al., 2021). Currently, only four species (*Platycladus orientalis, Juniperus chinensis, Pinus strobus* and *Thuja occidentalis*) are listed in the host range of the pest, which includes more than 100 host plants (EPPO, 2016; Barringer & Ciafré, 2020; Kim et al., 2023; EPPO, 2024ak).
PRA information	Pest Risk Assessments available: – Pest risk analysis for *Lycorma delicatula* (EPPO, 2016); – The establishment risk of *Lycorma delicatula* (Hemiptera: Fulgoridae) in the United States and globally (Wakie et al., 2019); – Pest risk assessment: *Lycorma delicatula* (spotted lanternfly) (Burne, 2020); – Spotted lanternfly predicted to establish in California by 2033 without preventative management (Jones et al., 2022); – Quick assessments of the potential for establishment in Sweden for a selection of new quarantine pests in 2022 (Björklund & Boberg, 2023); – Host preferences of Spotted Lanternfly and risk assessment of potential tree hosts in managed and semi-natural landscapes (Kim et al., 2023); – UK risk register details for *Lycorma delicatula* (DEFRA, 2024).
Other relevant information for the assessment	
Biology – short summary	*Lycorma delicatula* is native to Asia; it is widespread in China but also present in Taiwan, Korea, Japan and Vietnam (EPPO, 2024aj). The pest has been recently introduced in North America (2014) where it is rapidly spreading and currently it is present in 16 states of the US (EPPO, 2024aj). *Lycorma delicatula* is a sap sucker feeding on the phloem of host plants causing foliage withering, branch wilting and occasionally plant death (Kim et al., 2011; Dara et al., 2015; EPPO, 2016). Feeding activity also produces large amount of honeydew that covers the leaves, on which sooty moulds develop reducing photosynthesis and crop production (Dara et al., 2015).

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	Lycorma delicatula has three development stages: eggs, nymphs (four instars) and adults. It is a univoltine species overwintering at egg stage, which is crucial in the life cycle of the pest (Lee et al., 2019). Cold tolerance of overwintering eggs varies among different populations and over time, and the egg mortality threshold lasts from −12.72°C to −3.44°C (Lee et al., 2011). According to Park (2015), lethal temperature causing 100% mortality of eggs is −20°C. Warmer winter temperatures occurring as consequence of global warming can improve overwintering of *L. delicatula*, favouring its spread (Lee et al., 2011). The first instar nymphs emerge from April to May (Burne, 2020; Lee et al., 2019) and the immature stages can be found from May to late July–early August. Adults emerge from July to October. They often move in autumn to crops as orchards and nurseries, and die after mating before winter (Park et al., 2012; EPPO, 2021b). The females lay eggs not only on trunks and branches of host plants but also on non-host plants, inert materials such as stones, walls, metal sheeting, fence posts, etc. (Barringer et al., 2015). The short-range dispersal behaviour of *L. delicatula* mostly depends on the presence of suitable host plants for adults (Park et al., 2013; EPPO, 2016). Adults are not strong flyers and generally prefer to move by walking; single flight distances range from 2 to 20–24 m (EPPO, 2016; Wolfin et al., 2019) and up to 40–80 m (EPPO, 2021b; Parra et al., 2017). Distances greater than 3 km can be covered by females repeating short flights in a short time (Wolfin et al., 2019). *Lycorma delicatula* can spread on long distances by human support and a variety of pathways are reported, mainly referred to egg deposition on plants for planting, round and sawn wood, wood packaging material and other inert and man-made items. Adults can also be transported as hitchhikers in vehicles, vessels, planes and containers (EPPO, 2016; Lee et al., 2019; Burne, 2020).
Association with the plant parts	The nymphs of *Lycorma delicatula* often aggregate in large numbers to suck sap on leaves and young shoots, progressively moving to branches and trunks during the development. Adults mainly feed on branches and trunks where females lay eggs after mating. Oviposition usually occurs on the upper part of the trunk and the branches, due to smoother surface of bark (Burne, 2020). Trees larger than 15 cm in diameter are preferred; trunks and branches of less than 1 cm in diameter are considered not suitable for oviposition (EPPO, 2016).
Presence of asymptomatic plants/plant parts	All life stages of *L. delicatula* causing damage to plants are usually very visible. However, eggs and early instars nymphs (1st to 3rd) having a weak feeding pressure on the host plants cannot produce visible symptoms on leaves/shoots or the bark of branches/trunks (EPPO, 2021b).
Host plant range	*Lycorma delicatula* is a polyphagous pest feeding on more than 100 species, mainly woody plants (Barringer & Ciafré, 2020). Among them, conifers are considered not suitable hosts (Leach et al., 2021). Tree of heaven, *Ailanthus altissima*, is a key host for *L. delicatula*; other preferred hosts are *Tetradium daniellii, Vitis* sp. and *Phellodendron amurense* (Burne, 2020). The host preference of *L. delicatula* is not fully clear, as some hosts are recorded for all stages, whereas other hosts are only known for oviposition or feeding (Avanesyan et al., 2019; EPPO, 2021b). Immature stages (1st to 3rd instar nymphs) feed on a wider host range than 4th instar nymphs, plant herbs included (Leach et al., 2021) and the preference of adults is even more restricted to few hosts (Kim et al., 2011; EPPO (2016)). Among shrub and tree genera and species, some important hosts of *Lycorma delicatula* are *Acer* spp., *Alnus incana, Betula platyphylla, Castanea crenata, Fagus grandiflora, Fraxinus* spp., *Hibiscus, Juglans* spp., *Magnolia* spp., *Platanus* spp., *Populus* spp., *Prunus* spp., *Quercus* spp., *Robinia pseudoacacia, Salix* spp., *Sorbus* spp., *Ulmus* spp. and *Zelkova serrata*. For exhaustive lists of hosts of *Lycorma delicatula* see Dara et al. (2015), EPPO (2016), Parra et al. (2017), Burne (2020) and Barringer and Ciafré (2020).
Evidence that the commodity is a pathway	No records of interception of *L. delicatula* on conifer wood were found in the EUROPHYT/TRACES-NT database (EUPOPHYT, 2024; TRACES-NT, 2024). Main pathways for *L. delicatula* are plants for planting and cut branches carrying feeding nymphs and adults. However, egg masses of *L. delicatula* may be associated with any woody plant, also non-host, so that various wood products, wood chips included, must be considered as pathways too. Eggs may be laid on bark of host plants before harvest, and it is believed that some eggs may survive chipping. No survival of eggs has been observed on wood chips under the 2.5 × 2.5 cm standard size also adopted in quarantine safe mitigation for other pests, as ALB and EAB (EPPO, 2016, DEFRA, 2024; Cooperband et al., 2018). However, the maximum size reported in the Dossier Section 2.0 is 102 mm in any one direction, with a maximum of 5% of wood chips not exceeding 45 mm in length. Although females are not expected to lay eggs on already processed material (EPPO, 2016), there is evidence that the commodity may be a pathway.
Efficacy of sulfuryl fluoride on that specific pest	No experimental results for *L. delicatula* have been found regarding the efficacy of sulfuryl fluoride. However, the ovicidal potential of SF (and other fumigants) has been recently proven by Powell et al. (2023) comparing the size of SF molecules (0.259 nm) with the diameter of chorionic pores on the egg surface of *L. delicatula* (18,900 nm). Considering that there are about 1600 pores in a single egg, it is expected that SF may easily permeate the chorion and kill the egg.

A.12 | *PISSODES* AND BARK BEETLES (EXAMPLE OF *PISSODES NEMORENSIS*)

A.12.1 | Organism information

Taxonomic information	Current valid scientific name: *Pissodes nemorensis* Synonyms: *Pissodes approximatus, Pissodes canadensis, Pissodes deodarae* Name used in the EU legislation: *Pissodes nemorensis* Germar [PISONE]. Order: Coleoptera Family: Curculionidae Common name: deodar weevil, northern pine weevil Name used in the Dossier: – Note: since hybrids *P. nemorensis/P. strobi* producing fertile offspring may be found in natural conditions in the US, for a reliable identification of *P. nemorensis* molecular tools are recommended (EFSA, 2020d; EPPO, 2023ab).

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Group	Insects
EPPO code	PISONE
Regulated status	*Pissodes nemorensis* is quarantine pest for EU listed in Annex II A of Commission Implementing Regulation (EU) 2019/2072 as *Pissodes nemorensis* Germar [PISONE]. *Pissodes nemorensis* is included in the EPPO A1 list (EPPO, 2023b) and in A1 list for Argentina, Jordan, Georgia, Russia, Switzerland, Türkiye, Ukraine and the UK. The pest is quarantine for Morocco, Norway and Tunisia (EPPO, 2024al).
Pest status in the US	*Pissodes nemorensis* is present in the central and south-eastern US, where it is found in 29 states: Alabama, Arkansas, Connecticut, Florida, Georgia, Illinois, Indiana, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, New Hampshire, New Jersey, New York, North Carolina, Ohio, Oklahoma, Pennsylvania, South Carolina, Tennessee, Texas, Virginia, West Virginia, Wisconsin. It is also present in the District of Columbia (EPPO, 2024am).
Host status on conifers	Conifers are the only hosts of *P. nemorensis*. The pest mostly breeds on pines, on which it is known for 17 native and non-native species, but occasionally may also reproduce on *Picea* sp. and introduced *Cedrus* species (EPPO, 2023ab). For a complete list, refer to the Host plant range Section below.
PRA information	Pest Risk Assessments available: • Pest categorisation of non-EU *Pissodes* spp. (EFSA PLH Panel, 2018h); • UK risk register details for *Pissodes nemorensis* (DEFRA, 2020aa); • Pining away and at home: global utilisation of *Pinus radiata* by native and non-native insects (Brockerhoff et al., 2023).
Other relevant information for the assessment	
Biology – short summary	*Pissodes nemorensis* is a Nearctic weevil broadly spread in the eastern part of North America from Canada to Florida and Texas. The beetle usually attacks only weakened trees in both natural forests and plantations, but adults can also be found in nurseries, causing damage on seedlings. *Pissodes nemoremsis* is a univoltine species and has four development stages: egg, larva (up to five instars), pupa, adult. In the northern part of its range, adults of *P. nemorensis* overwinter in the litter or in stumps/logs and emerge in spring-early summer, whereas in the southern-central US they do not overwinter and are active from autumn to late winter (EPPO, 2023ab). After mating, females lay 180–264 eggs, singly or in small groups, which hatch in about 8 days. Young larvae feed in the cambium and phloem, while mature larvae bore a chamber in the sapwood where develop to pupae in about 36 days. Pupae need about 2 weeks to mature in adults. Depending on the date of egg laying and temperature (25°C is optimal T for oviposition) the total development time from eggs to adults may last from 7 to 25 weeks (EPPO, 2023ab). *Pissodes nemorensis* is vector of two pathogenic fungi: *Fusarium circinatum*, the causal agent of pitch canker, and *Leptographium procerum*, the causal agent of procerum root disease (Wondafrash et al., 2016). Adults of *P. nemorensis* are long-lived as all *Pissodes* species, but no specific life duration is known. No precise data is even available about the natural spreading capacity of *P. nemorensis*; however, *Pissodes* species are generally known to be strong flyers and good walkers, able to move more than 10 km per year. Human-assisted spread of all life stages is possible via international trading of living host plants, cut branches and wood products, with or without bark (in case of pupae). Adults may be also passively dispersed by hitchhiking, e.g. within containers (EFSA PLH Panel, 2018h; EPPO, 2023ab).
Association with the plant parts	Adults: before mating, adults feed for 2–3 weeks by puncturing the shoots, the terminal leaders or the underbark tissues in bark crevices on branches and stems. Punctures are 1–2 mm in diameter. Eggs: oviposition occurs on living trees (stems more than 1.25 cm diameter, usually in the lower portion and the root collar), as well as on cut logs and stumps. One to two (five) eggs are laid in small holes chewed by females through the bark to the phloem and covered by faeces. Larvae and pupae: larvae develop by feeding on cambium and phloem, boring galleries mostly longitudinally oriented; mature larvae excavate a pupal cell in a chip cocoon in the sapwood under the bark. Exit holes of adults are circular, 3–5 mm diameter (EFSA, 2020d).
Presence of asymptomatic plants/plant parts	As a rule, no asymptomatic plants are found. Living plants attacked by *P. nemorensis* usually show symptoms as needle discoloration and dropping, resin flow, shoot wilting. Crown symptoms may be also emphasised by the infection of pathogenic fungi. Other signs of presence of *P. nemorensis*, as larval galleries, pupal cocoons, emergence holes, are always clearly visible. However, seedlings in nurseries and young trees in plantations may be partly asymptomatic in the early time of attack by adults, and a careful examination is needed to discover the feeding punctures.
Host plant range	The host plant list of *P. nemorensis* includes 15 native pine species (*Pinus banksiana*, *P. clausa*, *P. contorta*, *P. echinata*, *P. elliottii*, *P. glabra*, *P. palustris*, *P. pungens*, *P. radiata*, *P. resinosa*, *P. rigida*, *P. serotina*, *P. strobus*, *P. taeda*, *P. virginiana*) and 2 introduced pines (*P. nigra* and *P. sylvestris*). The weevil may also reproduce on 3 native spruces (*Picea glauca, P. mariana, P. pungens*) and the European *Picea abies*, introduced in plantations (EPPO, 2023ab) *Pissodes nemorensis* was intercepted in Japan in 1964 on hemlock logs from the US (Yoshitake et al., 2014) but *Tsuga* sp. is not known as a host.
Evidence that the commodity is a pathway	There is no specific evidence that conifer wood chips are a pathway for *Pissodes nemorensis*. No records of interception of *Pissodes* species on conifer wood were found in the EUROPHYT/TRACES-NT database (EUPOPHYT, 2024; TRACES-NT, 2024). However, considering that: • the chips contain a maximum 2.0% bark or less and maximum size of chips in three dimensions is 102 mm (Dossier Section 2.0); • debarked logs and bark pieces may contain mature larvae and pupae (EFSA PLH Panel, 2018h); • adults of *P. nemorensis* are long-lived, strong flyers and easily disperse by hitchhiking (EFSA PLH Panel, 2018h; EFSA, 2020d; EPPO 2024al); the possibility that the commodity could be a pathway cannot be excluded.

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Efficacy of sulfuryl fluoride on that specific pest	No experimental results for *P. nemorensis* have been found regarding the efficacy of sulfuryl fluoride. However, 100% mortality of larvae of the similar species *Pissodes nitidus* was observed in logs 8 cm diameter of *Pinus densiflora*, treated with SF at a minimal concentration 30 mg/m^3 for 24 h at 25°C; under the same conditions of duration and temperature, mortality of the eggs of *P. nitidus* was 98.1% and 99.5% at concentration of respectively 30 and 50 mg/m^3 (EFSA PLH Panel, 2023).

APPENDIX B

Information retrieved from literature review on the efficacy of sulfuryl fluoride treatment

The searches were conducted in September 2024 in SCOPUS and Web of Science. The total number of studies retrieved after de-duplation was 85 for which a title and abstract screening was performed.

Studies were included when they contained information on treatment of wood or wood related commodities with sulfuryl fluoride. Studies were excluded if the exposure was not relevant or comparable to the suggested treatment of wood chips (e.g. treatment against termites in houses or museum collections) or the study was not focussed on treatment against pests but rather on investigating chemical properties of sulfuryl fluoride.

All of the studies considered relevant were already found previously and included in EFSA PLH Panel (2020a) and EFSA PLH Panel (2023). Only five additional studies were identified which could be of relevance in the context of the current opinion. The results of these studies were added to the tables in Appendix C.

TABLE B.1 Search strings for *B. xylophilus*, *Monochamus* and other pest species identified as relevant for conifer wood chips. Additional searches were conducted combining the search terms efficacy, wood chips and sulfuryl fluoride.

Web of Science and SCOPUS All databases	**TOPIC:** “Bursaphelenchus” or “xylophilus” or “Aphelenchoides” or “lignicolus” or “pine wood nematode” or “pinewood nematode” or “pine wilt disease” or “Monochamus” or “Choristoneura” or “Ambrosia” or “Lycorma” or “Pissodes” or “Bark” or “Coniferiporia” or “Fusarium” or “Gremmeniella” or “Phytophthora” or “Atropellis” or “Cronartium” or “Gymnosporangium” or “Arceuthobium” **AND** **TOPIC:** “sulfuryl fluoride” or “sulfurylfluoride” or “sulphuryl fluoride” or “sulphurylfluoride”
Web of Science and SCOPUS All databases	**TOPIC:** efficacy **AND** **TOPIC:** “sulfuryl fluoride” or “sulfurylfluoride” or “sulphuryl fluoride” or “sulphurylfluoride”
Web of Science and SCOPUS All databases	**TOPIC:** “Woodchip*” or “wood-chip*” or “wood chip*” **AND** **TOPIC:** “sulfuryl fluoride” or “sulfurylfluoride” or “sulphuryl fluoride” or “sulphurylfluoride”

APPENDIX C

Results from studies with sulfuryl fluoride from EFSA PLH Panel (2020a) and EFSA PLH Panel (2023) and the literature review on efficacy of sulfuryl fluoride treatment for pests relevant to the current opinion

Plant/ material	Pest category	Pest	Life stage E = eggs L = larvae P = pupae N=nymph A = adults	Type of sample	Concentration [g/m^3]/ concentration × time product [g × h/m^3]	Duration [h]	Temperature [°C]	Wood moisture [%]	Mortality [%]/efficacy on reducing mycelial growth [%]/LC50 /recovered pathogen	Reference
Fraxinus	Insect	***Agrilus planipennis***	L	Logs with bark and large branches cut 70–72 cm up to 30 cm diameter	104	48	15.6	32.75	99.9%	Barak et al. (2010)
					104	48	21.1		100%	
					112	48	10.0		99.9%	
					128	48	15.6		100%	
					128	24	21.1		100%	
					136	24	15.6		100%	
					144	24	10.0		99.9%	
					144	24	15.6		100%	
					104	48	26.0	No data	100%	
					128	24	23.5		100%	
					128	48	24.8		100%	
					144	24	23.9		100%	
			E	Eggs on filter paper	79.3	48	21.1	Not applicable	98.3%	
					94.9	48	21.1		100%	
					129.6	24	21.1		91.7%	
					145.5	24	21.1		93.5%	
No wood	Insect	***Anagasta kuhniella***	L	Exposed insects in vaults	10	16	26	Not applicable	1.1 LC50	Kenaga (1957)
No wood			A		10	16	26		1.35 LC50	
Infested wood	Insect	***Anobium punctatum***	E-L-P-A	Debarked wood < 20 cm cross section	93	24	15	75	99.7%	ISPM 28 – FAO (2017)
					67		20			
					44		25			
					41		30			

(Continued)

Plant/ material	**Pest category**	**Pest**	**Life stage E = eggs L = larvae P = pupae N=nymph A = adults**	**Type of sample**	**Concentration [g/m^3]/ concentration × time product [g × h/m^3]**	**Duration [h]**	**Temperature [°C]**	**Wood moisture [%]**	**Mortality [%]/efficacy on reducing mycelial growth [%]/LC50 /recovered pathogen**	**Reference**
WPM *Populus*	Insect	***Anoplophora glabripennis***	L	Timbers 10 × 10 × 115 cm	68.8	24	21.1	44.4	99.9%	Barak et al. (2006)
					81–3					
					87.6					
					77.5		15.6			
					95.1					
					104.2					
					90.0		10.0			
					110–3					
					120.7					
					113.8		4.4			
					140.4					
					154.3					
Infested wood			L-P	Debarked wood < 20 cm cross section	93	24	15	75	99.9%	ISPM 28 – FAO (2017)
					67		20			
					44		25			
					41		30			
No wood	Insect	***Anthrenus flavipes***	E	Insects in metal cages	5-to-60	22	26.5 ± 0.5	No applicable	15.97 (13.15–18.44) LC50	Su and Scheffrahn (1990)
			L		3.0-to-5.2			No applicable	4.30 (4.09–4.54) LC50	
			A		2.0-to-4.2			No applicable	2.30 (2.12–2.43) LC50	
Infested wood	Insect	***Arhopalus tristis***	E-L-P-A	Debarked wood < 20 cm cross section	93	24	15	75	99.0%	ISPM 28 – FAO (2017)
					67		20			
					44		25			
					41		30			
No wood			A	Exposed insects	15	24	15	Not applicable	100%	Zhang (2006)
					30				100%	
					60				100%	
					120				100%	
			E		15				99.3%	
					30				99.6%	
					60				98.9%	
					120				100%	

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Plant/ material	Pest category	Pest	Life stage E = eggs L = larvae P = pupae N = nymph A = adults	Type of sample	Concentration [g/m^3]/ concentration × time product [g × h/m^3]	Duration [h]	Temperature [°C]	Wood moisture [%]	Mortality [%]/efficacy on reducing mycelial growth [%]/LC50 /recovered pathogen	Reference
Populus, Quercus rubra	Fungi	***Armillaria mellea*** ***Ceraoscystis polonica*** ***Ceratocystis fagaceareum*** ***Ceratocystis fimbriata*** ***Ganoderma lucidum*** ***Gloeophyllum trabeum*** ***Heterobasidium annosum*** ***Irpex lacteus*** ***Leptographium wingfieldii*** ***Postia placenta*** ***Serpula lacrymans***	Not applicable	Artificially inoculated wood blocks of red oak and poplar sapwood	16 32 48 64 80 96 112	0.5 1 2 4 24	21 ± 2	28 (red oak) 18 (poplar)	SF fumigation was not effective in soil block tests, all tested fungi were recovered at all concentrations. The dose of 80 g/m^3 is not effective in killing all wood-inhabiting fungi	Tubajika and Barak (2006)
No wood	Fungi	***Armillaria novae-zelandiae***	Not applicable	Exposed fungi	15	24	15	Not applicable	80%	Zhang (2006)
			Not applicable	Exposed fungi	30			Not applicable	100%	
			Not applicable	Exposed fungi	60			Not applicable	100%	
			Not applicable	Exposed fungi	120			Not applicable	100%	
No wood	Insect	***Attagenus megatoma***	E	Insects in metal cages	5-to-60	22	26.5 ± 0.5	No applicable	29.93 (25.28–34.48) LC50	Su and Scheffrahn (1990)
			L		2.0-to-4.2			No applicable	2.19 (2.03–2.30) LC50	
			A		2.0-to-2.4			No applicable	0.79 (0.66–0.90) LC50	
No wood			L	Exposed insects in vaults	10	16	26	Not applicable	42.3 LC50	Kenaga (1957)
			E	Exposed insects in vaults	10	16	26	Not applicable	2.08 LC50	Kenaga (1957)
No wood	Insect	***Blattella germanica***	A	Exposed insects in vaults	10	16	26	Not applicable	0.77 LC50	Kenaga (1957)

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Plant/ material	Pest category	Pest	Life stage E = eggs L = larvae P = pupae N = nymph A = adults	Type of sample	Concentration [g/m^3]/ concentration × time product [g × h/m^3]	Duration [h]	Temperature [°C]	Wood moisture [%]	Mortality [%]/efficacy on reducing mycelial growth [%]/LC50 /recovered pathogen	Reference
Quercus ellipsoidalis	Fungi	***Bretziella fagacearum***	Not applicable	Naturally infected logs; artificially inoculated logs (1 and 2 years)	240	72	15.6	No data	Pathogen is not present	Yang et al. (2019)
					280	72	15.6	No data	Pathogen is present	
					320	72	15.6	No data	Pathogen is present	
					128	96	15.6	83	Pathogen is present	
					240	96	15.6	83	Pathogen is present	
Betula, *Pinus resinosa*, *Acer*, *Populus*			Not applicable	Artificially inoculated wood blocks	160	24	21 ± 2	No information	21.22 ± 1.90% pathogen recovered	Tubajika and Barak (2011)
						48		No information	6.09 ± 1.80% pathogen recovered	
						72		No information	0.94 ± 0.25% pathogen recovered	
					240	24		No information	4.38 ± 1.66% pathogen recovered	
						48		No information	1.90 ± 0.85% of pathogen recovered	
						72		No information	0.00 ± 0.00% of pathogen recovered	
Quercus rubra			Not applicable	Logs with bark coming from 5 naturally infected trees and discs	27,400 g × h/m^3	72	10–20	63–106	Pathogen is not present	Schmidt et al. (1997)
					35,010 g × h/m^3		10–20	63–106	Pathogen is not present	
Quercus rubra			Not applicable	in vitro trial and logs from naturally infected trees	Fungal culture					Woodward and Schmidt (1995)
					16	24	21–23	Not applicable	100% mycelial growth	
					16	48		Not applicable	100% mycelial growth	
					40	24		Not applicable	100% mycelial growth	
					40	48		Not applicable	71% mycelial growth	
					60	24		Not applicable	99% mycelial growth	
					60	48		Not applicable	2% mycelial growth	
					80	24		Not applicable	38% mycelial growth	
					80	48		Not applicable	0% mycelial growth	
					100	24		Not applicable	7% mycelial growth	
					100	48		Not applicable	0% mycelial growth	
					120	24		Not applicable	0% mycelial growth	
					120	48		Not applicable	0% mycelial growth	
					Logs					
					160	72	Ambient temperature	No information	15% mycelial growth	
					220			No information	7% mycelial growth	
					280			No information	0% mycelial growth	

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Plant/ material	Pest category	Pest	Life stage E = eggs L = larvae P = pupae N=nymph A = adults	Type of sample	Concentration [g/m^3]/ concentration × time product [g × h/m^3]	Duration [h]	Temperature [°C]	Wood moisture [%]	Mortality [%]/efficacy on reducing mycelial growth [%]/LC50 /recovered pathogen	Reference
No wood	Fungi	***Botryodiplodia theobromae***	Not applicable	Exposed fungi	15	24	15	Not applicable	80%	Zhang (2006)
			Not applicable	Exposed fungi	30			Not applicable	100%	
			Not applicable	Exposed fungi	60			Not applicable	100%	
			Not applicable	Exposed fungi	120			Not applicable	100%	
Pinus virginiana and *P. strobus*	Nematode	***Bursaphelenchus xylophilus***	Not applicable	Chips, blocks and logs with bark, artificially inoculated	Chips	24	20.0 ± 0.5	133	Effective the 70–90 concentration	Seabright et al. (2020)
					50, 60, 70, 80, 90	48				
					Blocks	24			Ineffective on the blocks	
					80—180	48				
Pinus pinaster			JIII	Boards cut from dead, naturally infested trees	3169–4407 g × h/m^3	24 72 12 days	15	25 to 32	100–100-100%	Bonifácio et al. (2013)
					1901–4051 g × h/m^3	24 72 12 days	20		99–99%-99%	
					1385–2141 g × h/m^3	24 72 12 days	30		100–100%–100%	
Pinus echinata			Not applicable	Naturally infested pine sticks and logs	30 and 60	24	20	84 to 90	70% and 10% (control is 100%)	Dwinell et al. (2003)
					60	24	25 and 30		0 (control is 100%)	
					60	24	30		Trial 3: at 997–1751 g-h/m^3 and 35.3°C on average (max 40.9°C), 0 positive.	
Pinus			Not applicable	Naturally infected conifer wooden board and lumber	30	24	15	No data	No data (board tchick)	Soma et al. (2001)
					30	48	15	No data	No data (board tchick)	
					60	24	15	27.3	20,400 (control is 39,00) (board tchick)	
					60	48	15	27.3	20,400 (control is 39,00) (board tchick)	
					30	24	15	27.7	20,500 (control is 38,600) (lumber)	
					60	24	15	20.1	22,700 (control is 38,600) (lumber)	
					60	48	15	20.1	22,700 (control is 38,600) (lumber)	
Chamaecyparis obtusa and *Cryptomeria japonica*	Insect	***Callidiellum rufipenne***	E	Eggs on glass container covered with filter paper	30	24	25	Not applicable	100%	Soma et al. (1997)
			L	Logs 5–10 cm diameter	15		25	No data	100%	
			A		10				100%	
			L-P-A	Logs 5–10 cm diameter	5.0–40.0	24	15	No data	100%	Soma et al. (1996)

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Plant/ material	Pest category	Pest	Life stage E = eggs L = larvae P = pupae N = nymph A = adults	Type of sample	Concentration [g/m^3]/ concentration × time product [g × h/m^3]	Duration [h]	Temperature [°C]	Wood moisture [%]	Mortality [%]/efficacy on reducing mycelial growth [%]/LC50 /recovered pathogen	Reference
No wood	Insect	***Captotermes formosanus***	A	Termites in petri dishes	10, 20, 30, 40, 50, 60	1, 2, 3, 4, 6, 8, 10, 12, 24, 48, 72,96	Not provided	Not applicable	From 10 to 100 (from low to higher concentration)	Su et al. (1989)
Pinus elliottii	Insect	***Coptotermes formosanus*** ***Cryptotermes cavifrons*** ***Incisitermes schwarzi***	L-A	Termites in petri dishes and wooden enclosures removed from each structure at 2-h intervals for 20 h.	3 6 12	2–20	30	Elevate moisture (not indicated)	*I. schwarzi* and *C. cavifrons*: 100% mortality from accumulated dosages of 28–49 mg-h/L after 72 h. *C. formosanus*: 100% mortality in wood enclosures at higher dosages of ~95 mg-h/L.	Su & Scheffrahn (1986)
No wood	Fungi	***Ceratocystis fagacearum (Bretziella fagacearum)*** ***C. polonica*** ***Chlara fraxinea*** ***Fomitopsis pinicola*** ***Geosmithia morbida*** ***G. obscura*** ***Gloeophyllum sepiarium*** ***Heterobasidion annosum*** ***H. occidentalis*** ***Hyphoderma praetermissum*** ***Leptographium longiclavatum*** ***L. wageneri*** ***L. wingfieldii*** ***Mycosphaerella populorum*** ***Ophiostoma clavigerum*** ***O. montium*** ***Pachnocybe ferrigunea*** ***Phellinus sulphurascens*** ***Phytophthora alni subp. multiformis*** ***P. quercina*** ***P. ramorum*** ***Rosselinia necatrix***	Not applicable	Experiment conducted in borosilicate glass tube	40	24–48-72	15 and 20	Not applicable	Maximum efficacy observed at 72 h	Uzunovic et al. (2017)
					80	24–48-72	15 and 20		*P. ramorum* and *P. sulphurascens* were killed at the 120 dose in 24 h	
					120	24–48-72	15 and 20		The two isolates of *B. fagacearum* survived at any SF dosage	
					160	24–48-72	15 and 20			
					200	24–48-72	15 and 20			
					240	24–48-72	15 and 20			
Bambusa	Insect	***Chlorophorus annularis***	L	Bamboo poles 116 cm lenght	96	24	15.9	No data	100%	Yu et al. (2010)
					80		21.5		100%	
					64		26		100%	
			L-P-A		64		23		100%	

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Plant/ material	Pest category	Pest	Life stage E = eggs L = larvae P = pupae N=nymph A = adults	Type of sample	Concentration [g/m^3]/ concentration × time product [g × h/m^3]	Duration [h]	Temperature [°C]	Wood moisture [%]	Mortality [%]/efficacy on reducing mycelial growth [%]/LC50 /recovered pathogen	Reference
No wood	Fungi	***Cladosporium herbarum***	Not applicable	Exposed fungi	15	24	15	Not applicable	100%	Zhang (2006)
			Not applicable	Exposed fungi	30			Not applicable	100%	
			Not applicable	Exposed fungi	60			Not applicable	100%	
			Not applicable	Exposed fungi	120			Not applicable	100%	
Pinus densiflora	Insect	***Cryphalus fulvus***	E	Eggs on glass container covered with filter paper	10	24	25	Not applicable	90.3%	Soma et al. (1997)
					20				100%	
					30					
Pinus densiflora			E	In pieces of bark	86.4	48	15	No data	95.0%	Soma et al. (1996)
					130				100%	
No wood	Insect	*Curculio caryae*	L	Glass container	1052 g × h/m^3	24	25	Not applicable	99%	Cottrell et al. (2020)
No wood	Insect	10 termite species Hodotermitidae, Kalotermitidae, Rhinotermitidae: ***Cryptotermes cavifrons*** ***C. formosanus*** ***Incisitermes snyderi*** ***I. minors*** ***Kalotermes approximatus*** ***Neotermes jouteli*** ***Prorhinotermes simplex*** ***Reculitermes tibialis*** ***Reticulitermes flavipes*** ***Zootermopsis angusticollis***	L	30 termites/group	0.1–1.5	22	27	Not applicable	Species sensitivity Max: *R. flavipes* and *R. tibialis* Min: *I. minor* Post-fumigation grand mean time of mortality Max: *R. tibialis* Min: *I. snyderi*	Osbrink et al. (1987)
No wood	Insect	***Cynaeus angustus***	L	Exposed insects in vaults	10	16	26	Not applicable	1.8 LC50	Kenaga (1957)
			A	Exposed insects in vaults	10	16	26	Not applicable	2.17 LC50	Kenaga (1957)
No wood	Insect	***Dermestes maculatus***	E	Insects in metal cages	6-to-39	22	26.5 ± 0.5	No applicable	19.12 (17.36–20.78) LC50	Su & Scheffrahn (1990)
			L		0.15-to-1.80			No applicable	0.67 (0.60–0.74) LC50	
			A		0.1-to-1.2			No applicable	0.68 (0.59–0.77) LC50	
WPM - pine and oak wood	Insect	***Dinoderus ocellaris***	E-L-P-A	Pallets 114 × 102 × 12 cm	40	24	28	25	100%	Rajendran & Lalith Kumar (2008)
					50					
No wood	Insect	***Epilachna varivestes***	E	Exposed insects in vaults	10	16	26	Not applicable	17.98 LC50	Kenaga (1957)
No wood	Insect	***Euvrilletta peltata***	E	Eggs survival during tent fumigations of a house - Eggs from 1 to 7 day-old	289 mg-h/L (= 3.2 times drywood termite dosage)	24	22.2	Not applicable	6.4% survived all ages	Williams and Sprenkel (1990)
					470 mg-h/L (= 5.2 times drywood termite dosage)				9.0% all ages survived	

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Plant/ material	Pest category	Pest	Life stage E = eggs L = larvae P = pupae N=nymph A = adults	Type of sample	Concentration [g/m^3]/ concentration × time product [g × h/m^3]	Duration [h]	Temperature [°C]	Wood moisture [%]	Mortality [%]/efficacy on reducing mycelial growth [%]/LC50 /recovered pathogen	Reference
No wood	Insect	***Hylastes ater***	A	Exposed insect	15	24	15	Not applicable	100%	Zhang (2006)
					30				100%	
			L		60				100%	
					120				100%	
No wood	Insect	*Halymorpha halys*	A	Insect in cage	43.4 g × h/m^3	12	10 ± 0.5	Not applicable	99%	Abrams et al. (2020)
			A (diapause)		39.9 g × h/m^3				99%	
Larch	Insect	***Ips cembrae***	E	Eggs on glass container covered with filter paper	10	24	25	Not applicable	98.1%	Soma et al. (1997)
					20				100%	
					30				71.4–100%	
					40				93.0%	
					50				98.1%	
					60				100%	
					70				97.6%	
					80				97.1%	
			L-P-A	Exposed insects	5.0–40.0	24	15	Not applicable	100%	Soma et al. (1996)
No wood	Insect	***Lasioderma serricorne***	E	Insects in metal cages	9-to-42	22	26.5 ± 0.5	No applicable	16.90 (15.11–18.50) LC50	Su & Scheffrahn (1990)
			L		1.7-to-2.8			No applicable	1.83 (1.73–1.90) LC50	
			A		0.5-to-1.6			No applicable	0.88 (0.81–0.94) LC50	
			A	Exposed insects in vaults	10	16	26	Not applicable	0.71 LC70	Kenaga (1957)
WPM pine and oak wood	Insect	***Lyctus africanus***	E-L-P-A	Pallets 114 × 102 × 12 cm	40	24	28	25	100%	Rajendran & Lalith Kumar (2008)
					50					
No wood	Insect	***Lyctus brunneus***	E	Eggs survival during tent fumigations of a house - Eggs from 1 to 7 day-old	289 mg-h/L (= 3.2 times drywood termite dosage)	24	22.2	Not applicable	11.6% survived all ages	Williams & Sprenkel (1990)
					470 mg-h/L (= 5.2 times drywood termite dosage)				3.9% all ages survived	
Pinus densiflora	Insect	***Monochamus alternatus***	E	Eggs on glass container covered with filter paper	100	24	25	Not applicable	100%	Soma et al. (1997)
			L	Logs 10 cm diameter	20			No data	100%	
			P		20				100%	
			L	Exposed insects	5.0–40.0	24	15	No data	100%	Soma et al. (1996)
Not wood	Insect	***Musca domestica***	P	Exposed insects in vaults	10	16	26	Not applicable	0.96 LC50	Kenaga (1957)
No wood			A	Exposed insects in vaults	10	16	26	Not applicable	0.54 LC50	Kenaga (1957)
Not wood	Insect	***Oryzaephilus surinamensis***	A	Exposed insects in vaults	10	16	26	Not applicable	0.78 LC50	Kenaga (1957)

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Plant/ material	Pest category	Pest	Life stage E = eggs L = larvae P = pupae N = nymph A = adults	Type of sample	Concentration [g/m^3]/ concentration × time product [g × h/m^3]	Duration [h]	Temperature [°C]	Wood moisture [%]	Mortality [%]/efficacy on reducing mycelial growth [%]/LC50 /recovered pathogen	Reference
No wood	Fungi	***Ophiostoma novo-ulmi***	Not applicable	Exposed fungi	15	24	15	Not applicable	100%	Zhang (2006)
			Not applicable	Exposed fungi	30			Not applicable	100%	
			Not applicable	Exposed fungi	60			Not applicable	100%	
			Not applicable	Exposed fungi	120			Not applicable	100%	
Not wood	Insect	***Periplaneta americana***	E	Exposed insects in vaults	10	16	26	Not applicable	19.41 LC50	Kenaga (1957)
Not wood			A	Exposed insects in vaults	10	16	26	Not applicable	0.41 LC50	Kenaga (1957)
No wood	Fungi	***Phlebiopsis gigantean***	Not applicable	Exposed fungi	15	24	15	Not applicable	80%	Zhang (2006)
			Not applicable	Exposed fungi	30			Not applicable	100%	
			Not applicable	Exposed fungi	60			Not applicable	100%	
			Not applicable	Exposed fungi	120			Not applicable	100%	
Chamaecyparis obtusa	Insect	***Phloeosinus perlatus***	E	Eggs on glass container covered with filter paper	10	24	15	Not applicable	85%	Soma et al. (1997)
					20				100%	
					30					
			E	In pieces of bark	61.3	48	15	No data	95%	Soma et al. (1996)
			L-P-A	Logs 2–5 cm diameter	5.0–40.0	24	15	No data	100%	
No wood	Fungi	***Phytophthora cinnamom***	Not applicable	Exposed fungi	15	24	15	Not applicable	80%	Zhang (2006)
			Not applicable	Exposed fungi	30			Not applicable	100%	
			Not applicable	Exposed fungi	60			Not applicable	100%	
			Not applicable	Exposed fungi	120			Not applicable	100%	
Pinus densiflora	Insect	***Pissodes nitidus***	E	Eggs on glass container covered with filter paper	30	24	25	Not applicable	98.1%	Soma et al. (1997)
					50				99.5%	
			L	Logs 8 cm diameter	30			No data	100%	
					50					
Quercus crispula	Insect	***Platypus quercivorus* and *P. calamus***	E-L-P-A	Logs 15 cm diameter	10	24	25	No data	100%	Soma et al. (1997)
					20				(99.7) 100%	
					30				100%	
			L-A	Logs 10–20 cm diameter	15	24	15	No data	100%	Mizobuti et al. (1996)
Not applicable	Insect	***Prodenia eridania***	E	Exposed insects in vaults	10	16	26	Not applicable	18.21 LC50	Kenaga (1957)
Pine	Insect	***Rhyzhopertha dominica***	A	Glass containers	401.9 g × h/m^3	24	5	Not applicable	LCT 99	Kim et al. (2024)
					42.53 g × h/m^3	24	23	Not applicable	LCT 99	
				Inside wood blocs, 10 × 10 × 10 cm with a chamber inside of 2 × 2 × 2 cm	53.34 g × h/m^3	24	23	Not reported	LCT 99	

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Plant/ material	Pest category	Pest	Life stage E = eggs L = larvae P = pupae N=nymph A = adults	Type of sample	Concentration [g/m^3]/ concentration × time product [g × h/m^3]	Duration [h]	Temperature [°C]	Wood moisture [%]	Mortality [%]/efficacy on reducing mycelial growth [%]/LC50 /recovered pathogen	Reference
Not applicable	Insect	***Sitotroga cerealella***	E	Exposed insects in vaults	10	16	26	Not applicable	8.45 LC50	Kenaga (1957)
			P	Exposed insects in vaults	10	16	26	Not applicable	0.60 LC50	
			A	Exposed insects in vaults	10	16	26	Not applicable	0.19 LC50	
No wood	Fungi	***Schizophyllum commun***	Not applicable	Exposed fungi	15	24	15	Not applicable	100%	Zhang (2006)
					30				100%	
					60				100%	
					120				100%	
No wood	Insect	***Sitophilus granarius***	E	Exposed insects in vaults	10	16	26	Not applicable	24.9 LC50	Kenaga (1957)
			L	Exposed insects in vaults	10	16	26	Not applicable	0.36 LC50	Kenaga (1957)
			P	Exposed insects in vaults	10	16	26	Not applicable	0.76 LC50	Kenaga (1957)
			A	Exposed insects in vaults	10	16	26	Not applicable	0.68 LC50	Kenaga (1957)
	Insect	***Sitotroga cerealella***	E	Exposed insects in vaults	10	16	26	Not applicable	4.81 LC50	Kenaga (1957)
			L	Exposed insects in vaults	10	16	26	Not applicable	0.82 LC50	Kenaga (1957)
			A	Exposed insects in vaults	10	16	26	Not applicable	0.74 LC50	Kenaga (1957)
No wood	Fungi	***Sphaeropsis sapinea***	Not applicable	Exposed fungi	15	24	15	Not applicable	80%	Zhang (2006)
					30				100%	
					60				100%	
					120				100%	
Lindera triloba	Insect	***Scolytoplatypus tycon* and *S. mikado***	E-L-P-A	Logs 2–5 cm	10	24	25	No data	100%	Soma et al. (1997)
					20					
					30					
No wood	Insect	**Semanotus japonicus**.	E	Eggs on glass container covered with filter paper	40	24	25	Not applicable	100%	Soma et al. (1997)
			E	Eggs on glass container covered with filter paper	39.6	48	15	Not applicable	95.0%	Soma et al. (1996)
			L	Exposed insects	5.0–40.0	24	15		100%	
WPM pine and oak wood	Insect	**Sinoxylon sp**.	E-L-P-A	Pallets 114 × 102 × 12 cm	40	24	28	25	100%	Rajendran & Lalith Kumar (2008)
					50				100%	
Pinus sp.	Insect	**Sirahoshizo sp**.	L	Pine logs 10–15 cm diameter	5.0–40.0	24	15	No data	100	Soma et al. (1996)

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Plant/ material	Pest category	Pest	Life stage E = eggs L = larvae P = pupae N=nymph A = adults	Type of sample	Concentration [g/m^3]/ concentration × time product [g × h/m^3]	Duration [h]	Temperature [°C]	Wood moisture [%]	Mortality [%]/efficacy on reducing mycelial growth [%]/LC50 /recovered pathogen	Reference
	Insect	***Tribolium confusum***	E	Exposed insects in vaults	10	16	26	Not applicable	42.7 LC50	Kenaga (1957)
			A	Exposed insects in vaults	10	16	26	Not applicable	3.14 LC50	Kenaga (1957)
No wood	Insect	***Trogoderma granarium***	E	Glass container	2335.7–3325.1 g × h/m^3	72	25	Not applicable	100%	Myers et al. (2021)
			E		1429.8 g × h/m^3	48	30		97.9%	
			L (diapause)		222.9 g × h/m^3	4	20	Not applicable	LD 95	
			L		161.2 g × h/m^3				LD 95	
			P		138.4 g × h/m^3				LD 95	
			A		81.5 g × h/m^3				LD 95	
			L (diapause)		127.2 g × h/m^3		30		LD 95	
			L		112.1 g × h/m^3				LD 95	
Pine wood	Insect	***Xyleborus pfeilii***	E	Eggs on glass container covered with filter paper	100	24	25	Not applicable	39.3%	Soma et al. (1997)
No wood			E	Exposed insects in artificial diet	40	48	15	Not applicable	11.1%	Mizobuti et al. (1996)
					50				23.1%	
					80	24			19.0%	
			L		20	48			91.1%	
					30				90.4%	
					40				97.6%	
					50				98.8%	
			P		20	48			100%	
					30					
					40					
					50					
			A		10	24			100%	
					20	48			100%	
					30					
					40					
					50					

(Continued)

Plant/ material	Pest category	Pest	Life stage E = eggs L = larvae P = pupae N=nymph A = adults	Type of sample	Concentration [g/m^3]/ concentration × time product [g × h/m^3]	Duration [h]	Temperature [°C]	Wood moisture [%]	Mortality [%]/efficacy on reducing mycelial growth [%]/LC50 /recovered pathogen	Reference
Pine wood			L	Exposed insects in artificial diet	5	24	25	Not applicable	77.1%	Soma et al. (1997)
					10				84.2%	
					20				90.6%	
					30				93.2%	
					40				93.5%	
					50				98.1%	
					100				99.3%	
				Pine logs 10 cm diameter	30			No data	85.7%	
					50				84.1%	
			P	Exposed insects in artificial diet	5			Not applicable	64.7%	
					10				91.3%	
					20				97.4%	
					30				99.3%	
					40				100%	
					50				100%	
					100				100%	
				Pine logs 10 cm diameter	30			No data	100%	
					50				100%	
			A	Exposed insects in artificial diet	5			Not applicable	100%	
					10				100%	
					20				100%	
					30				100%	
					40				100%	
					50				100%	
					100				100%	
				Pine logs 10 cm diameter	30			No data	100%	
					50				100%	
No wood	Insect	***Xyleborus validus***	A	Exposed insects in artificial diet	5	24	15	Not applicable	100%	Mizobuti et al. (1996)
			L		40				11.1%	
Pine wood			A	Pine logs 10–20 cm diameter	10	24	25	No data	100%	Soma et al. (1997)
					30					
Chamaecyparis obtusa and *Cryptomeria japonica*	Insect	***Xylosandrus germanus***	A	Logs 10–20 cm diameter	10	24	25	No data	100%	Soma et al. (1997)
					30					
No wood			A	Logs 10–20 cm diameter	5	24	15	No data	100%	Mizobuti et al. (1996)
			L		40				11.1%	

(Continues)

(Continued)

Plant/ material	Pest category	Pest	Life stage E = eggs L = larvae P = pupae N=nymph A = adults	Type of sample	Concentration [g/m^3]/ concentration × time product [g × h/m^3]	Duration [h]	Temperature [°C]	Wood moisture [%]	Mortality [%]/efficacy on reducing mycelial growth [%]/LC50 /recovered pathogen	Reference
Wood		Review on fumigants for New Zealand export logs		Fumigation of logs for export	80	16	≥ 15		Penetrability On hydrated < dry wood On hydrated wood MB > SF On dry wood SF > MB Toxic to insects under all temperature and exposure conditions, non-flammable, non-explosive, easily dispersed, non-reactive with a wide range of materials, non-sorptive in commodities, rapid penetration, no impact on the atmospheric ozone layer. Very low effectiveness against insect eggs, requires greater concentrations to obtain adequate level of control.	Armstrong et al. (2014)
					120		≤ 15			
No wood	Arthropods	42 arthropod species	E	Experimental container	64–1519 g × h/m^3	4–22	21–27	Not applicable	100% or LD95 Eggs require 4–54-fold the dosage of SF needed to kill adults of the same species.	Thoms & Scheffrahn (1994)
			L/N		14–156 g × h/m^3	8–22	21–27	Not applicable	100% or LD95	
			P		14–128 g × h/m^3	8–20	21–27	Not applicable	100% or LD95	
			A		9–186 g × h/m^3	4–22	21–30	Not applicable	100% or LD95	
Nothofagus fusca	Fungi	Grey stain causal agent	Not applicable	Red beech logs	250	72	Not reported	Not reported	51.85%	Schmidt et al. (2001)
					375				70. 48%	
					Not treated control				85. 97%	

APPENDIX D

Summary of the evaluation of different phases in the production of the commodity with reference to the reduction of risks associated with target pests

N	Pest name	Group	(1) Trees are inspected before harvest	(2) Removal of branches, no roots entering the wood chip production	(3) Debarking	(4) chipping	(5) Quality control after chipping	(6) SF fumigation	(7) Final conclusion
Plants									
1	*Arceuthobium* species	Plants	*Arceuthobium* plants may be detected, but seeds may be overlooked. Uncertainties: - None	*Arceuthobium* plants will be removed, but seeds may grow also on thicker branches/stems. Uncertainties: - None	Seeds will be removed, but part of the parasitic plant can remain in the wood. Uncertainties: - None	Chipping will be effective. *Arceuthobium* plants are obligatory parasites and therefore they will not be able to survive on wood chips for a long time as the xylem of the host plant will be completely dysfunctional after chipping. Uncertainties: - None	Probably not detectable in the quality control. Uncertainties: - None	Information on the efficacy of SF against *Arceuthobium* was not available, but SF is toxic to plants. Uncertainties: - None	Effective.
Fungi and Oomycetes									
2	*Atropellis* species	Fungi	Inspection is partially effective. Asymptomatic trees exist. Uncertainties: - Duration of asymptomatic phase - The efficiency of inspections	Partially effective, the pathogen can also be associated with the main stem. Uncertainties: - None	Partially effective, the pathogen can be associated with sapwood and heartwood. Uncertainties: - None	Not effective. Uncertainties: - None	Partially effective. The pathogen causes stain and could be detected during quality control, although quality control is visually performed targeting only wood chips present on the top of piles. Uncertainties: - None	No specific information is available on the efficacy on *Atropellis* species. The proposed SF treatment could be effective in reducing the inoculum. Uncertainties: - The susceptibility of *Atropellis* species to SF	Partially effective.
3	*Coniferiporia sulphurascens* and *Coniferiporia weirii*	Fungi	Inspection is generally effective, at least in trees showing evident wood decay. Uncertainties: - The prevalence of trees with early stages of infection without obvious symptoms - The efficiency of inspections	Partially effective. No roots are entering the wood chip production. However, the pathogen can also be associated with the main stem. Uncertainties: - None	Not effective. The pathogen is mainly associated with sapwood and heartwood. Uncertainties: - None	Not effective. Uncertainties: - None	Poorly effective. The pathogen causes wood decay which could go undetected during quality control, which targets only wood chips present on the top of piles. In addition, up to 2% rot is tolerated in wood chips. Uncertainties: - None	No specific information is available on the efficacy on *Coniferiporia* species. The proposed SF treatment could be effective in reducing the inoculum. Uncertainties: - The susceptibility of *Coniferiporia* species to SF	Partially effective.

(Continues)

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N	Pest name	Group	(1) Trees are inspected before harvest	(2) Removal of branches, no roots entering the wood chip production	(3) Debarking	(4) chipping	(5) Quality control after chipping	(6) SF fumigation	(7) Final conclusion
4	*Cronartium* species	Fungi	Partially effective. Inspection could be effective, but it has a long asymptomatic phase. Uncertainties: • The efficiency of inspections	Partially effective. No small branches are entering the wood chip production. However, the pathogen can also be associated with the main stem and larger branches. Uncertainties: • None	Partially effective. The majority of sporulating tissue will be reduced. However, contaminating spores could remain on the wood. Uncertainties: • None	Chipping could be effective. *Cronartium* species are obligatory parasites and will not be able to survive on wood chips for a long period of time. Remnants of sporulating tissue could still be present on the 2% of tolerated bark. In addition, contaminating spores could remain on the wood chips. Uncertainties: • There is uncertainty on how long it can survive in the wood chips	Not effective. Uncertainties: • None	No specific information is available on the efficacy on *Cronartium* species. The proposed SF treatment could be effective in reducing the inoculum. Uncertainties: • The susceptibility of *Cronartium* species to SF	Partially effective.
5	*Fusarium circinatum*	Fungi	Partially effective. Inspection could be effective if symptoms such as branch dieback, cankers and/or resin flow are expressed. However, trees can harbour the pest without showing symptoms for long time. Uncertainties: • The efficiency of inspections	Partially effective. Infections on smaller branches will be removed. However, the pathogen can also be associated with the main stem and larger branches. Uncertainties: • None	Partially effective. The majority of bark infections will be removed. However, the mycelium could be present in the outer sapwood. Uncertainties: • None	Not effective. Uncertainties: • None	Not effective. Uncertainties: • None	Partially effective. Fumigation with SF for 5 days was efficient in eliminating *F. circinatum* from infected logs. Uncertainties: • Whether the fumigation process used for the wood chips will be fully effective in eliminating the pathogen	Partially effective.
6	*Gremmeniella abietina*	Fungi	Partially effective. Inspection could be effective, when symptoms are expressed. Asymptomatic stages are reported. Uncertainties: • The efficiency of inspections	Partially effective. No small branches are entering the wood chip production. However, the pathogen can also be associated with the main stem and larger branches. Uncertainties: • None	Partially effective. The majority of sporulating tissue will be reduced. However, the mycelium could be present in the outer sapwood. Uncertainties: • None	Not effective. Uncertainties: • None	Not effective. Uncertainties: • None	No specific information is available on the efficacy on *G. abietina*. The proposed SF treatment could be effective in reducing the inoculum. Uncertainties: • The susceptibility of *G. abietina* species to SF	Partially effective.

(Continued)

N	Pest name	Group	(1) Trees are inspected before harvest	(2) Removal of branches, no roots entering the wood chip production	(3) Debarking	(4) chipping	(5) Quality control after chipping	(6) SF fumigation	(7) Final conclusion
7	*Gymnosporangium* species	Fungi	Partially effective. Inspection could be effective if symptoms are clearly expressed. Uncertainties: • The efficiency of inspections	Partially effective. No small branches are entering the wood chip production. However, the pathogen can also be associated with the main stem and larger branches. Uncertainties: • None	Partially effective. The majority of sporulating tissue will be reduced. However, contaminating spores could remain on the wood. Uncertainties: • None	Chipping could be effective. *Gymnosporangium* species are obligatory parasites and will not be able to survive on wood chips for a long period of time. Remnants of sporulating tissue could still be present on the 2% of tolerated bark. In addition, contaminating spores could remain on the wood chips. Uncertainties: • None	Not effective. Uncertainties: • None	No specific information is available on the efficacy on *Gymnosporangium* species. The proposed SF treatment could be effective in reducing the inoculum. Uncertainties: • The susceptibility of *Gymnosporangium* species to SF	Partially effective.
8	*Phytophthora ramorum*	Oomycetes	Partially effective. Inspection could be effective if symptoms are clearly expressed. Uncertainties: • Except for Larix spp., conifers are only minor hosts, if at all for *P. ramorum* and it remains uncertain if infections will be recognised during inspections • The efficiency of inspections	Partially effective. Infections on smaller branches and needles will be removed. However, the pathogen can also be associated with the main stem and larger branches. Uncertainties: • None	Partially effective. The majority of bark infections will be removed. However, mycelium could be present in the outer sapwood. Uncertainties: • None	Not effective. Uncertainties: • None	Not effective. Uncertainties: • None	Partially effective. When *P. ramorum*, grown on barely grains was exposed to SF fumigation, killing CT values at 20ºC ranged from 2’787 to 5’669 gh/m3 depending on the isolate. Uncertainties: • Whether the fumigation process used for the wood chips (minimum required CT value 3’000 gh/m3 at 20 C) will be fully effective in eliminating the pathogen potentially present in the chips.	Partially effective.

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N	Pest name	Group	(1) Trees are inspected before harvest	(2) Removal of branches, no roots entering the wood chip production	(3) Debarking	(4) chipping	(5) Quality control after chipping	(6) SF fumigation	(7) Final conclusion
Insects									
9	Ambrosia beetles (example of *Gnathotrichus sulcatus*)	Insects	Partially effective. The accumulation of white powdery material (frass, more or less compact) at the entrance hole is a characteristic symptom of the attack by ambrosia beetles. These signs of presence of ambrosia beetles, although present, may be difficult to detect. In addition, initial phases of infestation are associated with little frass that can be removed by rain. Uncertainties: • The efficiency of inspections	Partially effective. *G. sulcatus* is mainly associated with big branches, logs, stumps and lumber. This measure could only be effective against the beetles present within the branches. Uncertainties: • None	Not effective Uncertainties: • None	Partially effective. Chipping will affect most galleries but considering the dimensions of the chips and the size of the beetles, survival of some specimens within the chips cannot be excluded. Uncertainties: • None	Partially effective. Galleries and larvae may be overlooked if they are not on the outside of wood chips. In addition, the pest could go undetected during quality control, which targets only wood chips present on the top of piles. Uncertainties: • None	No experimental results for *G. sulcatus* have been found regarding the efficacy of sulfuryl fluoride. However, different study results on SF fumigation efficacy on other ambrosia beetles show a high efficacy. Uncertainties: • If the treatment will be fully effective in killing all life stages, especially eggs	Effective. However, there is uncertainty on whether all the conditions regarding the fumigation will be fulfilled (concentrations reached and maintained, temperature and moisture content).
10	*Choristoneura* species (example of *Choristoneura fumiferana*)	Insects	Partially effective. In low population densities, defoliation is restricted to new buds and foliage, especially in the upper crown. Eggs laid on the underside of needles may be difficult to detect visually. Overwintering second instar larvae within crevices within branches and the trunk of host plants are also difficult to observe. Uncertainties: • Timing of inspection. Depending on the time of inspection it will be easier or less easy to detect the different signs of the pest. • The efficiency of inspections	Partially effective. Eggs and pupae will be affected by the removal of branches, but not second instar larvae (overwintering structure). Uncertainties: • None	Partially effective. Effective against the second instar larvae (overwintering structure on the bark). Uncertainties: • The amount of bark remaining after debarking	Not effective. Uncertainties: None	Partially effective. If any remaining bark, second instar larvae (overwintering structure), may be overlooked as they are difficult to detect. Uncertainties: • None	No specific information is available on the efficacy on *Choristoneura* species. The proposed SF treatment could be effective against the pest. Insect eggs are more resistant to SF treatment, but eggs are laid at the needles, not on the bark or wood. Uncertainties: • None	Effective. Although branch removal and debarking are partially effective, both treatments together should be complementary and therefore fully effective against the different stages of the pest.

(Continued)

N	Pest name	Group	(1) Trees are inspected before harvest	(2) Removal of branches, no roots entering the wood chip production	(3) Debarking	(4) chipping	(5) Quality control after chipping	(6) SF fumigation	(7) Final conclusion
11	*Lycorma delicatula*	Insects	Partially effective. All life stages causing damage to plants are usually very visible. High feeding activity produces flagging and wilting, weeping wounds on tree trunks and branches and also large amount of honeydew that covers the leaves and sooty moult. Conifers are considered not good hosts. However, eggs and early instars nymphs (1st to 3rd) having a weak feeding pressure are difficult to be detected. Uncertainties: • Level of thoroughness of visual inspections, especially in cases of initial or low-intensity attacks • The efficiency of inspections	Partially effective. Removal of branches may be effective against nymphs and adults, but not against eggs. Uncertainties: • None	Partially effective against eggs. Eggs are expected to be laid on the bark of trunks and branches, but can also be laid on any woody, non-host plant, so that various wood products (including wood chips) could contain eggs. Uncertainties: • The frequency of egg deposition on the trunks after debarking	Partially effective. If eggs are present on the wood, some eggs could survive the chipping. Uncertainties: • Although females are not expected to lay eggs on already processed material, there is uncertainty on if this situation can be fully excluded	Partially effective. If eggs are present on the chips, a visual inspection looking for insect signs might have an effect on detecting them, although others may be overlooked. In addition, the pest could go undetected during quality control, which targets only wood chips present on the top of piles. Uncertainties: • None	Effective against eggs. Recent published information states that SF may easily permeate the chorion and kill the egg. Uncertainties: • If the treatment will be fully effective in killing all life stages	Effective. The combination of all treatments should be effective in eliminating the pest.
12	*Pissodes* and bark beetles (example of *Pissodes nemorensis*)	Insects	Partially effective. Living plants attacked by *P. nemorensis* usually show symptoms as needle discoloration and dropping, resin flow, shoot wilting. Other signs of presence of *P. nemorensis*, as larval galleries, pupal cocoons, emergence holes, are always clearly visible. However, in the case of initial or low-intensity attacks, the signs of presence may be very difficult to detect. Uncertainties: • Level of thoroughness of visual inspections, especially in cases of initial or low-intensity attacks • The efficiency of inspections	Partially effective. Removal of branches may be effective against part of the population, but not to the part of the population colonising stems. Uncertainties: • None	Partially effective. Effective only against larvae. Larvae develop by feeding on cambium and phloem, mature larvae excavate a pupal cell in the sapwood. Uncertainties: • None	Partially effective. Chipping will affect most galleries but considering the dimensions of the chips and the size of the beetles, survival of some specimens within the chips cannot be excluded. Uncertainties: • None	Partially effective. Galleries and larvae may be overlooked if they are not on the outside of wood chips. In addition, the pest could go undetected during quality control, which targets only wood chips present on the top of piles. Uncertainties: • None	No specific information is available on the efficacy on *Pi. nemorensis*. However, different study results on SF fumigation efficacy on other Pissodes species and bark beetles show a high efficacy. Uncertainties: • If the treatment will be fully effective in killing all life stages	Effective. However, there is uncertainty on whether all the conditions regarding the fumigation will be fulfilled (concentrations reached and maintained, temperature and moisture content). Uncertainties: • None

(Continues)

(Continued)

N	Pest name	Group	(1) Trees are inspected before harvest	(2) Removal of branches, no roots entering the wood chip production	(3) Debarking	(4) chipping	(5) Quality control after chipping	(6) SF fumigation	(7) Final conclusion
13	*Monochamus* species	Insects	Effective. Symptoms of infestations are visible. Symptoms are not clearly visible during first weeks after oviposition. Uncertainties: - Timing of inspection. If conducted in early season it will be difficult to detect symptoms. - The efficiency of inspections	Partially effective. The treetop is preferably infested. However, *Monochamus* species can also be found on larger branches and the stem. Uncertainties: - Differences in species with regard to their preference of thickness of branches/ stems.	Partially effective. If debarking occurs early in the season early life stages will be removed. However, later in the season the larvae will be in the wood. Uncertainties: - Time at which harvesting/ debarking occurs.	Partially effective. It is effective against early life stages as they will not be able to finalise their life cycle. Although larger larvae are more likely to be killed during chipping, they could escape chipping and pupate in the wood chips. Uncertainties: - Time at which harvesting/ chipping occurs	Partially effective. Galleries and larvae may be overlooked if they are not on the outside of wood chips. In addition, the pest could go undetected during quality control, which targets only wood chips present on the top of piles. Uncertainties: - None	Effective. Insect eggs are more resistant to SF treatment and from available information it is not fully clear if the proposed treatment is sufficient. However emerging larvae would not be able to develop further in wood chips. Uncertainties: - If the treatment will be fully effective in killing all life stages	Effective. However, there is uncertainty on whether all the conditions regarding the fumigation will be fulfilled (concentrations reached and maintained, temperature and moisture content).
Nematodes									
14	*Bursaphelenchus xylophilus*	Nematodes	Partially effective. Some conifer species do not show symptoms. Uncertainties: - The efficiency of inspections	Partially effective. By removing branches nematodes will also be removed, especially during maturation feeding in spring. However later in the year the nematodes will mainly be in the stem. Uncertainties: - Time of harvesting/ removal of branches	Not effective. Uncertainties: - None	Not effective. Uncertainties: - None	Partially effective. The pathogen could be associated with blue stain and could be detected during quality control. In addition, the pest could go undetected during quality control, which targets only wood chips present on the top of piles. Uncertainties: - None	Partially effective. Available information suggests that the proposed treatment is borderline to eradicate *B. xylophilus*. Uncertainties: - If the treatment will be fully effective in killing *B. xylophilus*	Partially effective.

APPENDIX E

Elicited values for pest freedom

This Appendix E provides the rating based on expert judgement on the likelihood of pest freedom for conifer wood chips. The estimates take into account possible reduction or removal of pests during the different steps in the production of wood chips such as:

1. Inspection of trees before harvest
2. Removal of branches and no roots are entering the production
3. Debarking (a maximum of 2% bark is allowed in the wood chips)
4. Chipping
5. Quality control after chipping
6. Fumigation with sulfuryl fluoride

The effects of the different production steps for reducing the risk of relevant pests or groups of pests being present in the commodity is included in Appendix D.

E.1 | OVERALL LIKELIHOOD OF PEST FREEDOM OF *BURSAPHELENCHUS XYLOPHILUS* FOR CONIFER WOOD CHIPS

E.1.1 | Reasoning for a scenario which would lead to a reasonably low number of infested conifer wood chips

This scenario assumes that the pest has a low prevalence in the areas where the wood chips are harvested. It also assumes that symptoms are present of susceptible hosts showing discoloration of the canopy with chlorosis, greyish colour followed by reddening/browning of needles. Removal of branches also will remove nematodes recently transmitted by beetles. It further assumes that the pest is absent from bark pieces in the chip, and in addition that the multiplication and spread of the pest in wood chip piles before loading the vessel is restricted due to a short storage time. This scenario also assumes that the SF treatment is effective in killing nematodes in chips in the holds of the vessel.

E.1.2 | Reasoning for a scenario which would lead to a reasonably high number of conifer wood chips

This scenario assumes the pest to be widely distributed in the areas where the wood chips are harvested. It also assumes that harvested trees belong to species not showing symptoms of the pest. Removal of branches has no effect on the occurrence of the pest since the pest already has invaded the stems. Further this scenario assumes the pest to be present in bark pieces and that it multiplies to high densities and spreads in the wood chip piles before loading of the vessel. In this scenario the SF treatment is considered inefficient in killing the pest.

E.1.3 | Reasoning for a central scenario equally likely to over- or underestimate the number of infested conifer wood chips (Median)

The central scenario assumes the pest not to be highly prevalent in the areas from which the trees are harvested. It also assumes some symptoms to be visible in trees infected with the pest, and that such trees will be sorted out. Further the scenario assumes that the multiplication and spread of the pest in wood chip piles before loading of the vessel is limited. It is also assumed that the SF treatment is effective.

E.1.4 | Reasoning for the precision of the judgement describing the remaining uncertainties (1st and 3rd quartile/interquartile range)

The precision of the judgement is affected by uncertainties related to the prevalence of the pest in the field, the degree to which asymptomatic trees are harvested, the degree of multiplication and spread of the pest in wood chip piles before loading the vessel and the degree to which the SF-fumigant may reach the entire cargo. This leads to maximal uncertainties on both sides of the mean.

E.1.5 | Elicitation outcomes of the assessment of the pest freedom for *Bursaphelenchus xylophilus* on conifer wood chips

The following Tables show the elicited and fitted values for pest infestation (Table E.1) and pest freedom (Table E.2).

TABLE E.1 Elicited and fitted values of the uncertainty distribution of pest infestation by *Bursaphelenchus xylophilus* per 10,000 m^3 wood chips.

Percentile	1%	2.5%	5%	10%	17%	25%	33%	50%	67%	75%	83%	90%	95%	97.5%	99%
Elicited values	10					55		100		300					600
EKE	9.99	10.4	11.5	15.7	24.9	41.5	63.9	128	221	282	357	434	509	559	600

Note: The EKE results is the BetaGeneral (0.54717, 1.5227, 9.9650) distribution fitted with @Risk version 7.6.

Based on the numbers of estimated infested wood chips the pest freedom was calculated (i.e. = 10,000 m^3 – number of infested wood chips per 10,000 m^3). The fitted values of the uncertainty distribution of the pest freedom are shown in Table E.2.

TABLE E.2 The uncertainty distribution of wood chips free of *Bursaphelenchus xylophilus* per 10,000 m^3 wood chips calculated by Table E.1.

Percentile	1%	2.5%	5%	10%	17%	25%	33%	50%	67%	75%	83%	90%	95%	97.5%	99%
Values	9400					9700		9900		9945					9990
EKE results	9400	9441	9491	9566	9643	9718	9779	9872	9936	9958	9975	9984	9988	9989.6	9990.0

Note: The EKE results are the fitted values.

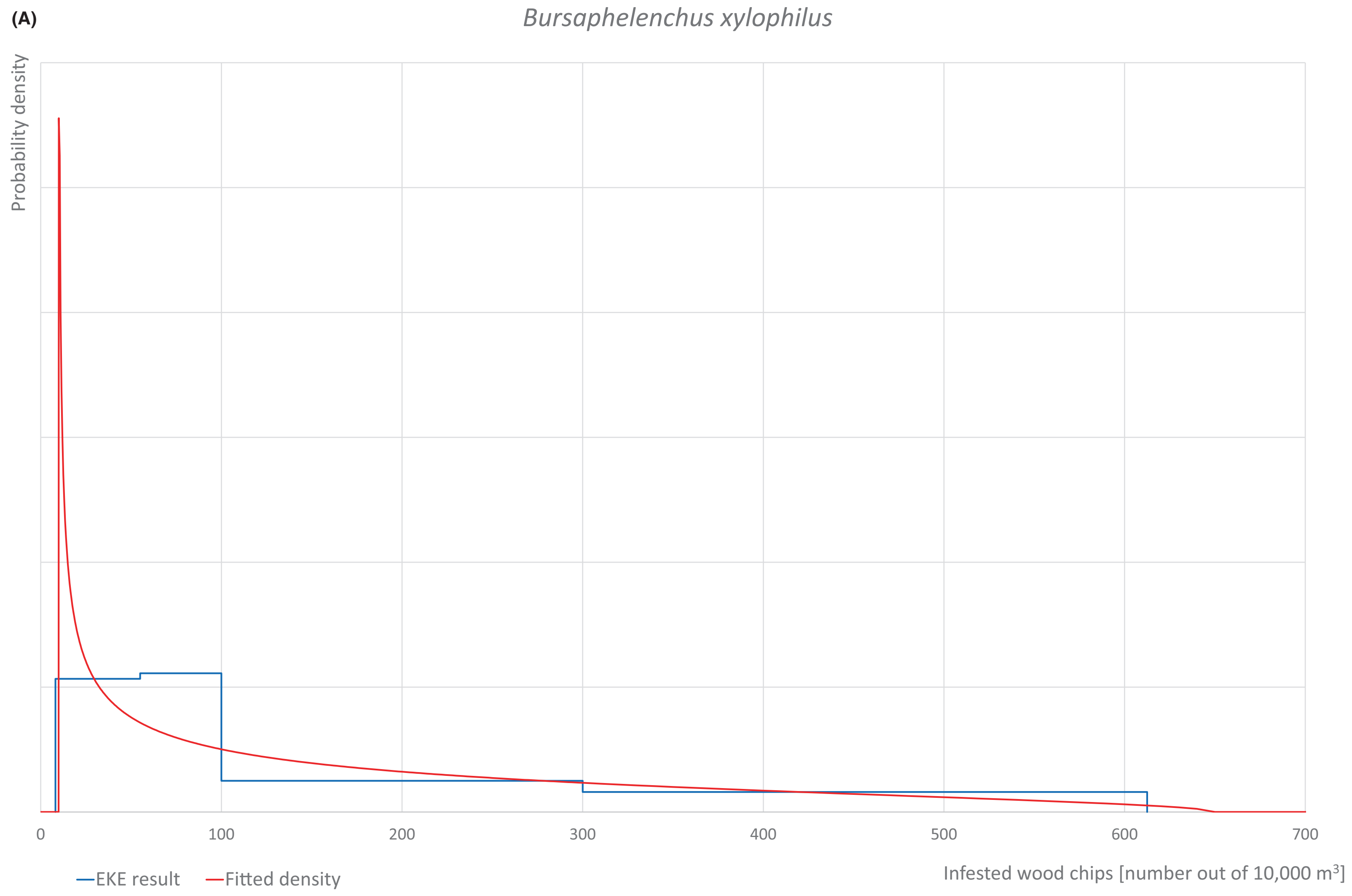


FIGURE E.1 (Continued)

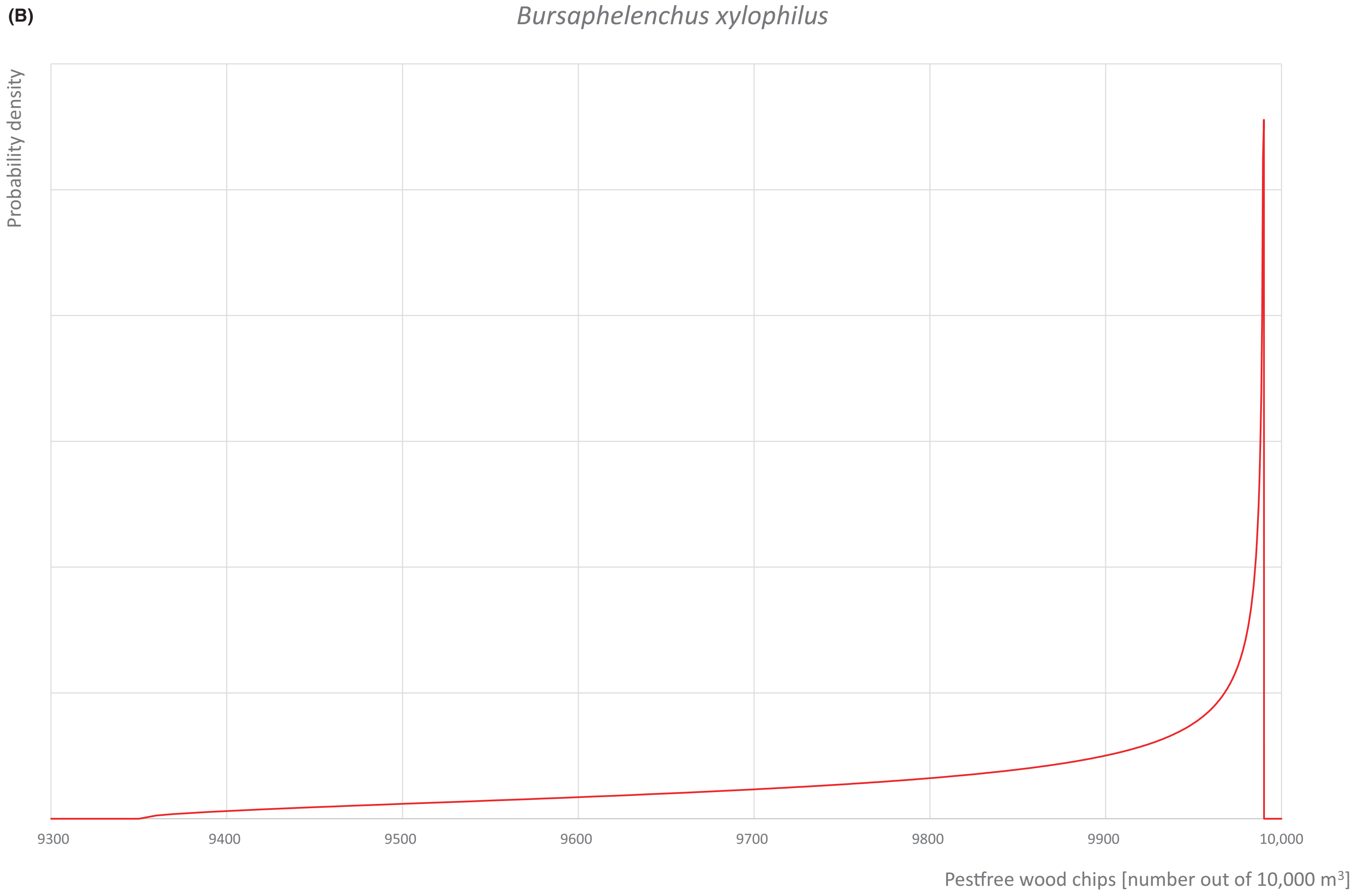


FIGURE E.1 (Continued)

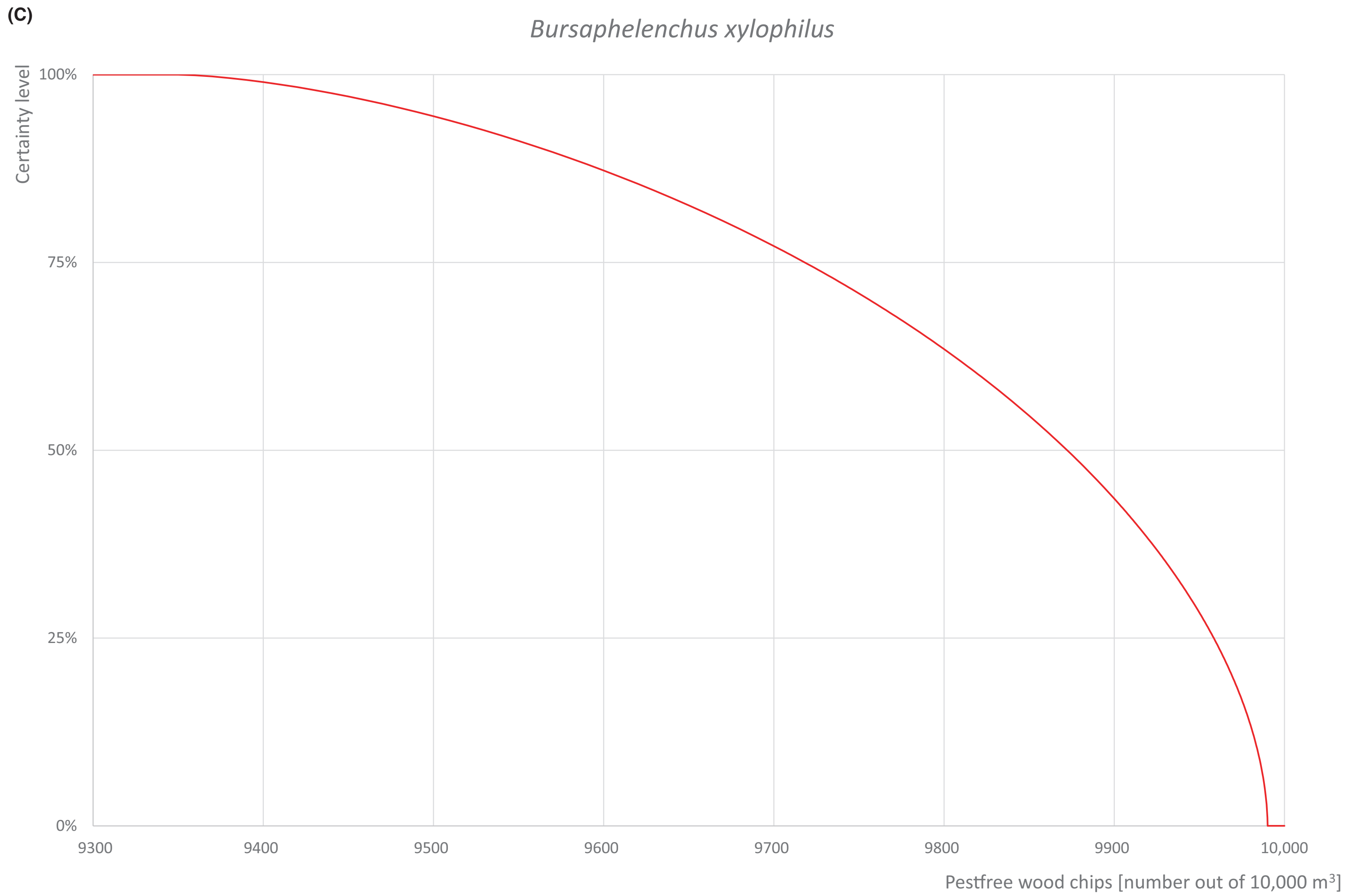


FIGURE E.1 (A) Elicited uncertainty of pest infestation per 10,000 m^3 wood chips (histogram in blue – vertical blue line indicates the elicited percentile in the following order: 1%, 25%, 50%, 75%, 99%) and distributional fit (red line); (B) uncertainty of the proportion of pest-free wood chips per 10,000 m^3 (i.e. = 1 – pest infestation proportion expressed as percentage); (C) descending uncertainty distribution function of pest infestation per 10,000 m^3 wood chips.

E.2 | OVERALL LIKELIHOOD OF PEST FREEDOM OF *MONOCHAMUS* SPECIES FOR CONIFER WOOD CHIPS

E.2.1 | Reasoning for a scenario which would lead to a reasonably low number of infested conifer wood chips

The scenario assumes that the risk mitigation measures, including the SF fumigation, are correctly performed and then fully effective in eliminating the pest in the wood chips.

E.2.2 | Reasoning for a scenario which would lead to a reasonably high number of conifer wood chips

The scenario assumes a high prevalence of the pest in the area where the trees used for wood chip production are harvested and the existence of that some dying trees in stands that could be more likely to be infested by the beetle. The risk mitigation measures, including the SF fumigation are not fully effective in eliminating the pest in the wood chips (SF fumigation treatment could be not fully standardised, and the gas may not reach all the chips).

E.2.3 | Reasoning for a central scenario equally likely to over- or underestimate the number of infested conifer wood chips (Median)

The scenario assumes that the pest is very unlikely to survive all treatments. Only if the SF cannot reach all the chips the commodity could be infested. The scenario also assumes that overall prevalence of the pest is not expected to be high on the trees used for wood chip production.

E.2.4 | Reasoning for the precision of the judgement describing the remaining uncertainties (1st and 3rd quartile/interquartile range)

The pest presence in the wood chips is expected to be moderate, and the SF treatment is expected to be effective, this results in a high level of uncertainties for infestation rates below the median and less uncertainties for rates above the median.

E.2.5 | Elicitation outcomes of the assessment of the pest freedom for *Monochamus* species on conifer wood chips.

The following Tables show the elicited and fitted values for pest infestation (Table E.3) and pest freedom (Table E.4).

TABLE E.3 Elicited and fitted values of the uncertainty distribution of pest infestation by *Monochamus* species per 10,000 m^3 wood chips.

Percentile	1%	2.5%	5%	10%	17%	25%	33%	50%	67%	75%	83%	90%	95%	97.5%	99%
Elicited values	0					2.5		5		8					15
EKE	0.175	0.365	0.643	1.14	1.77	2.53	3.30	4.95	6.88	8.05	9.46	11.0	12.6	13.8	15.0

Note: The EKE results is the BetaGeneral (1.2563, 2.8559, 0, 18.2) distribution fitted with @Risk version 7.6.

Based on the numbers of estimated infested wood chips the pest freedom was calculated (i.e. = 10,000 m^3 – number of infested wood chips per 10,000 m^3). The fitted values of the uncertainty distribution of the pest freedom are shown in Table E.4.

TABLE E.4 The uncertainty distribution of wood chips free of *Monochamus* species per 10,000 m^3 wood chips calculated by Table E.3.

Percentile	1%	2.5%	5%	10%	17%	25%	33%	50%	67%	75%	83%	90%	95%	97.5%	99%
Values	9985					9992		9995		9998					10,000
EKE results	9985	9986	9987	9989	9991	9992	9993	9995	9996.7	9997.5	9998.2	9998.9	9999.4	9999.6	9999.8

Note: The EKE results are the fitted values.

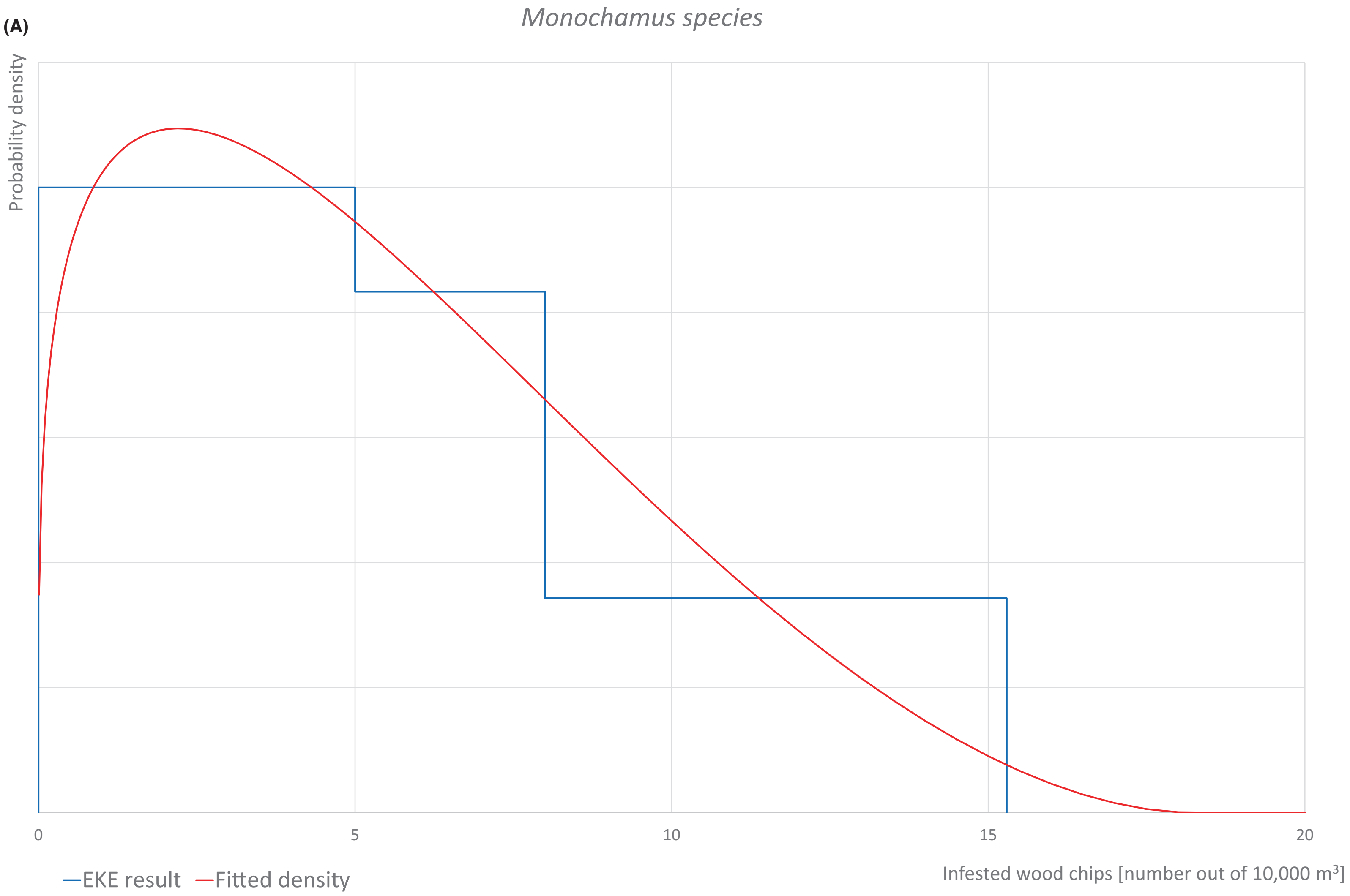


FIGURE E.2 (Continued)

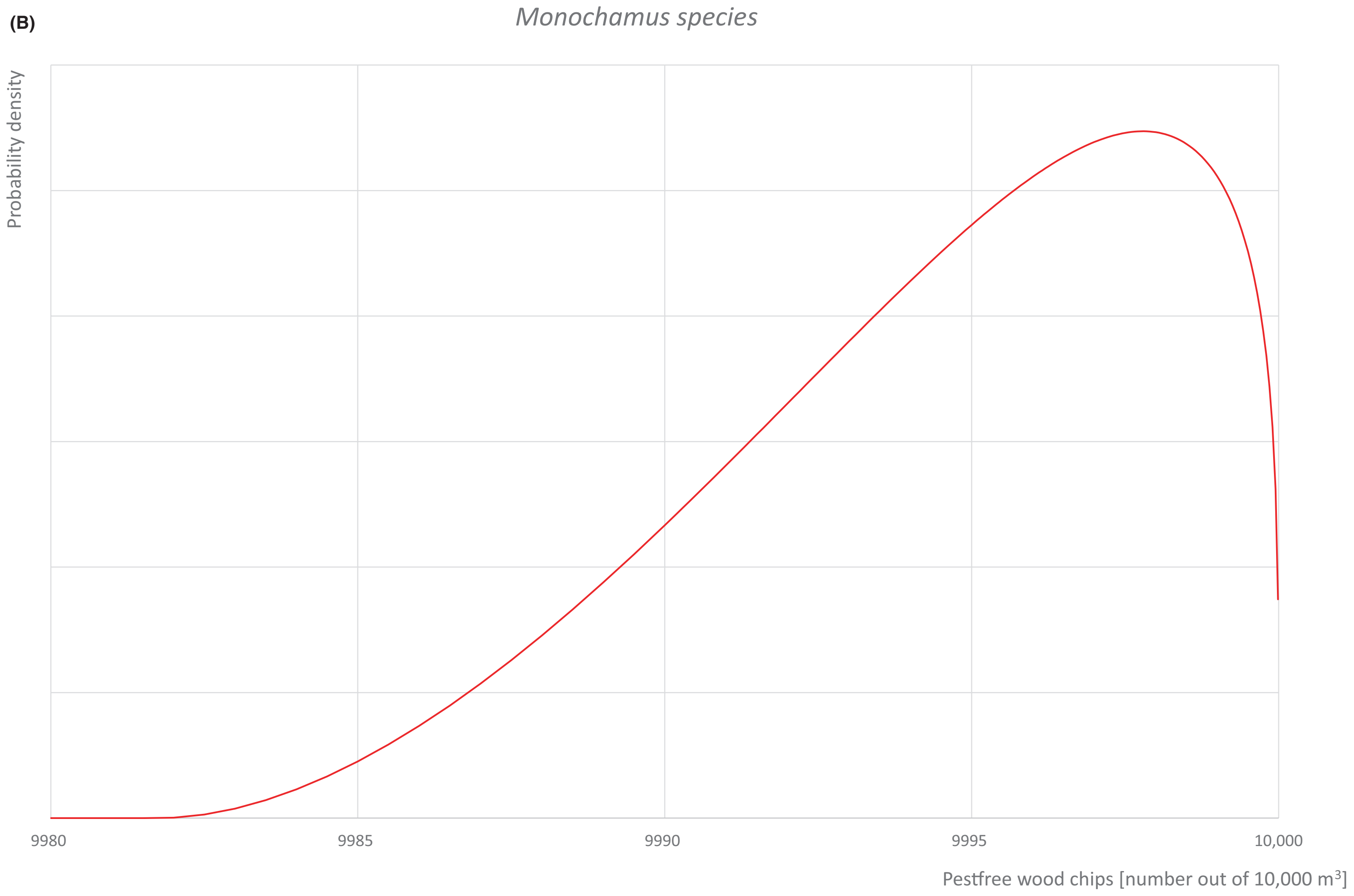


FIGURE E.2 (Continued)

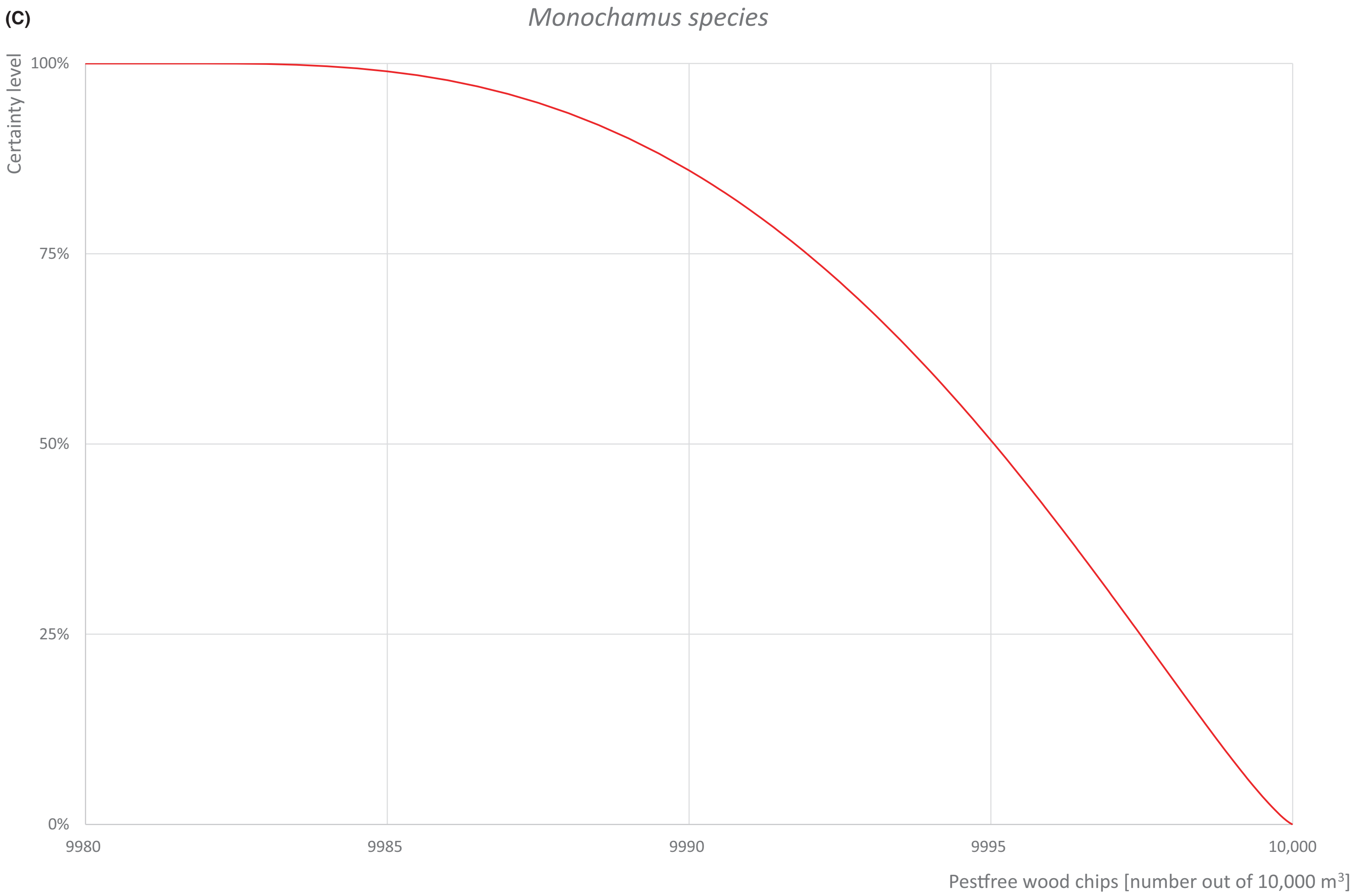


FIGURE E.2 (A) Elicited uncertainty of pest infestation per 10,000 m^3 wood chips (histogram in blue – vertical blue line indicates the elicited percentile in the following order: 1%, 25%, 50%, 75%, 99%) and distributional fit (red line); (B) uncertainty of the proportion of pest-free wood chips per 10,000 m^3 (i.e. =1 – pest infestation proportion expressed as percentage); (C) descending uncertainty distribution function of pest infestation per 10,000 m^3 wood chips.

E.3 | OVERALL LIKELIHOOD OF PEST FREEDOM OF *ATROPELLIS* SPECIES FOR CONIFER WOOD CHIPS

E.3.1 | Reasoning for a scenario which would lead to a reasonably low number of infested conifer wood chips

The scenario assumes a low prevalence (< 1% infected trees) of *Atropellis* spp. in forest stands where trees for wood chips production are harvested and a partial efficacy of the sulphuryl fluoride treatment. The scenario also assumes that symptoms will be visible and hence most of the trees will not enter the production process.

E.3.2 | Reasoning for a scenario which would lead to a reasonably high number of conifer wood chips

The scenario assumes a relatively high prevalence (10% infected trees) of *Atropellis* spp. in forest stands where trees for wood chips production are harvested and a low efficacy of the sulphuryl fluoride treatment. The scenario also assumes that symptoms will remain unnoticed during inspections so that most of the infected trees will enter the production process. The large majority of stained wood chips will go undetected before fumigation.

E.3.3 | Reasoning for a central scenario equally likely to over- or underestimate the number of infested conifer wood chips (Median)

The scenario assumes a moderate prevalence of *Atropellis* spp. in forest stands where trees for woodchips production are harvested, that most of the infected trees will not enter the production process because symptomatic. The scenario also assumes a partial efficacy of the sulfuryl fluoride treatment.

E.3.4 | Reasoning for the precision of the judgement describing the remaining uncertainties (1st and 3rd quartile/interquartile range)

Values of the 1st and 3rd quartile indicate high uncertainty as a result of the uncertainty on the efficacy of sulphuryl fluoride against *Atropellis* spp., on the prevalence of the pest and on whether the pest will be promptly detected because it will not always cause obvious symptoms.

E.3.5 | Elicitation outcomes of the assessment of the pest freedom for *Atropellis* species on conifer wood chips

The following Tables show the elicited and fitted values for pest infestation (Table E.5) and pest freedom (Table E.6).

TABLE E.5 Elicited and fitted values of the uncertainty distribution of pest infestation by *Atropellis* species per 10,000 m^3 wood chips.

Percentile	1%	2.5%	5%	10%	17%	25%	33%	50%	67%	75%	83%	90%	95%	97.5%	99%
Elicited values	25					80		130		230					350
EKE	25.0	27.3	31.6	41.0	55.0	73.9	94.3	140	193	223	258	290	319	337	350

Note: The EKE results is the BetaGeneral (0.54717, 1.5227) distribution fitted with @Risk version 7.6.

Based on the numbers of estimated infested wood chips the pest freedom was calculated (i.e. = 10,000 m^3 – number of infested wood chips per 10,000 m^3). The fitted values of the uncertainty distribution of the pest freedom are shown in Table E.6.

TABLE E.6 The uncertainty distribution of wood chips free of *Atropellis* species per 10,000 m^3 wood chips calculated by Table E.5.

Percentile	1%	2.5%	5%	10%	17%	25%	33%	50%	67%	75%	83%	90%	95%	97.5%	99%
Values	9650					9770		9870		9920					9975
EKE results	9650	9663	9681	9710	9742	9777	9807	9860	9906	9926	9945	9959	9968	9973	9975

Note: The EKE results are the fitted values.

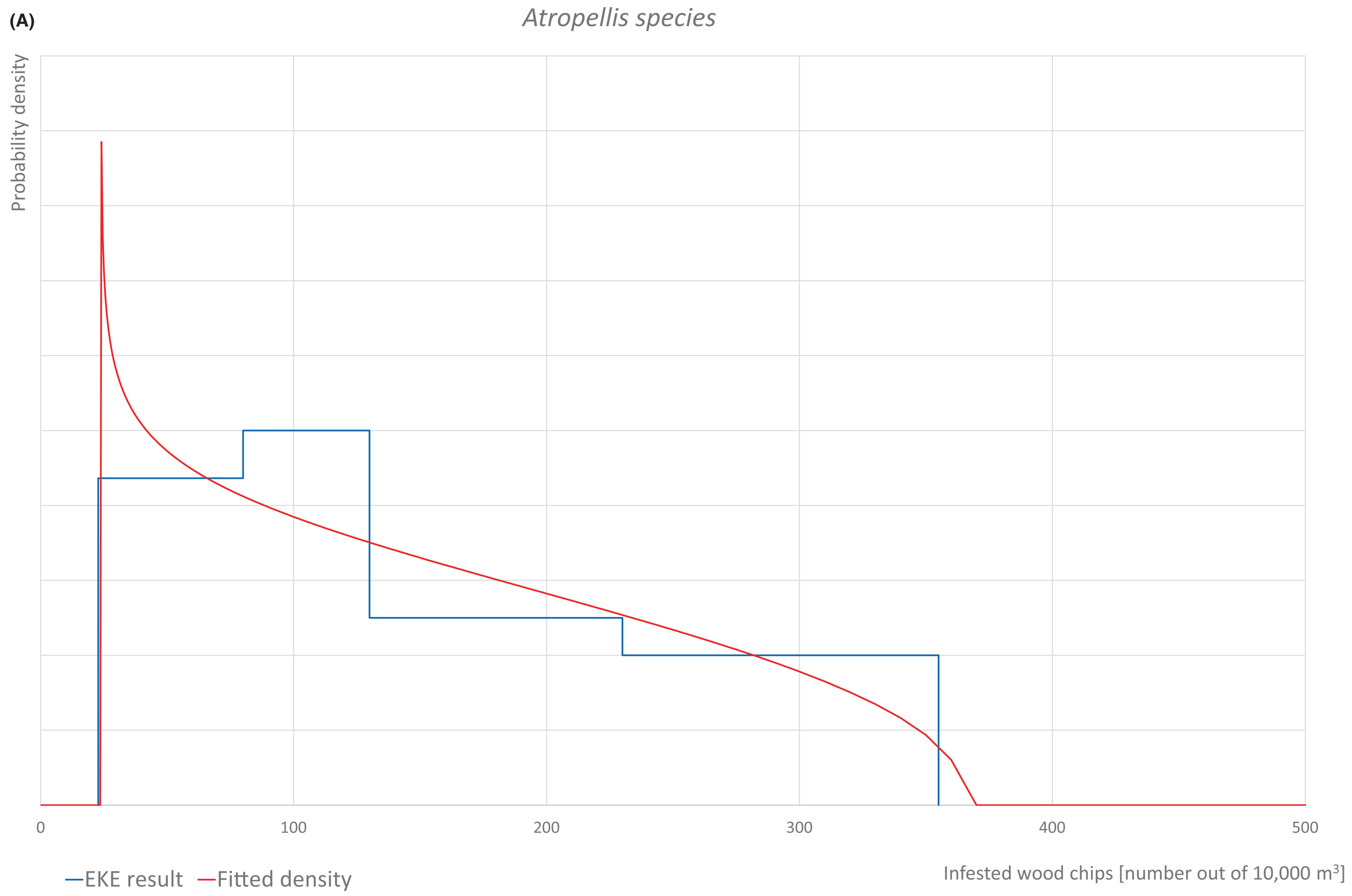


FIGURE E.3 (Continued)

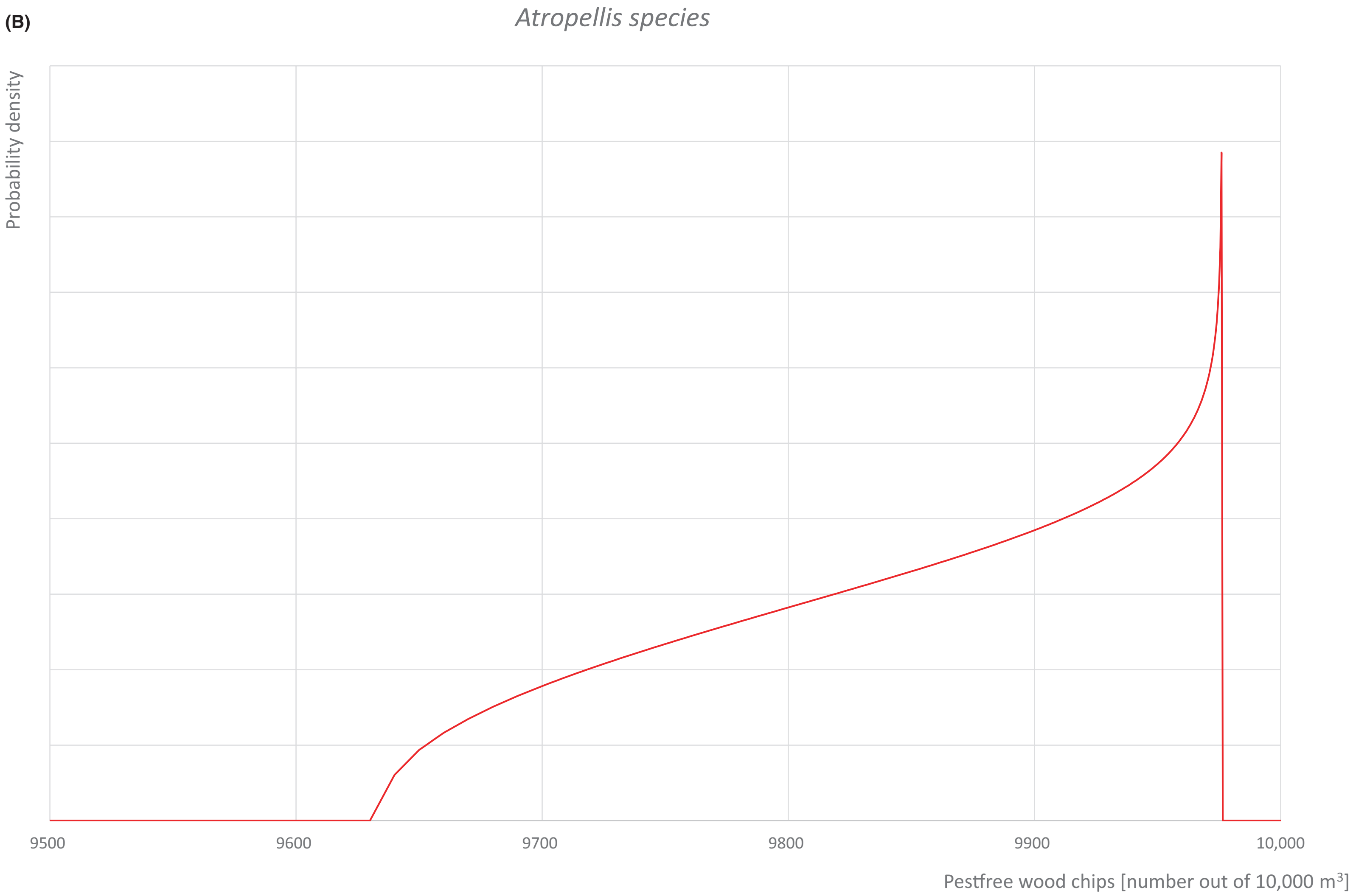


FIGURE E.3 (Continued)

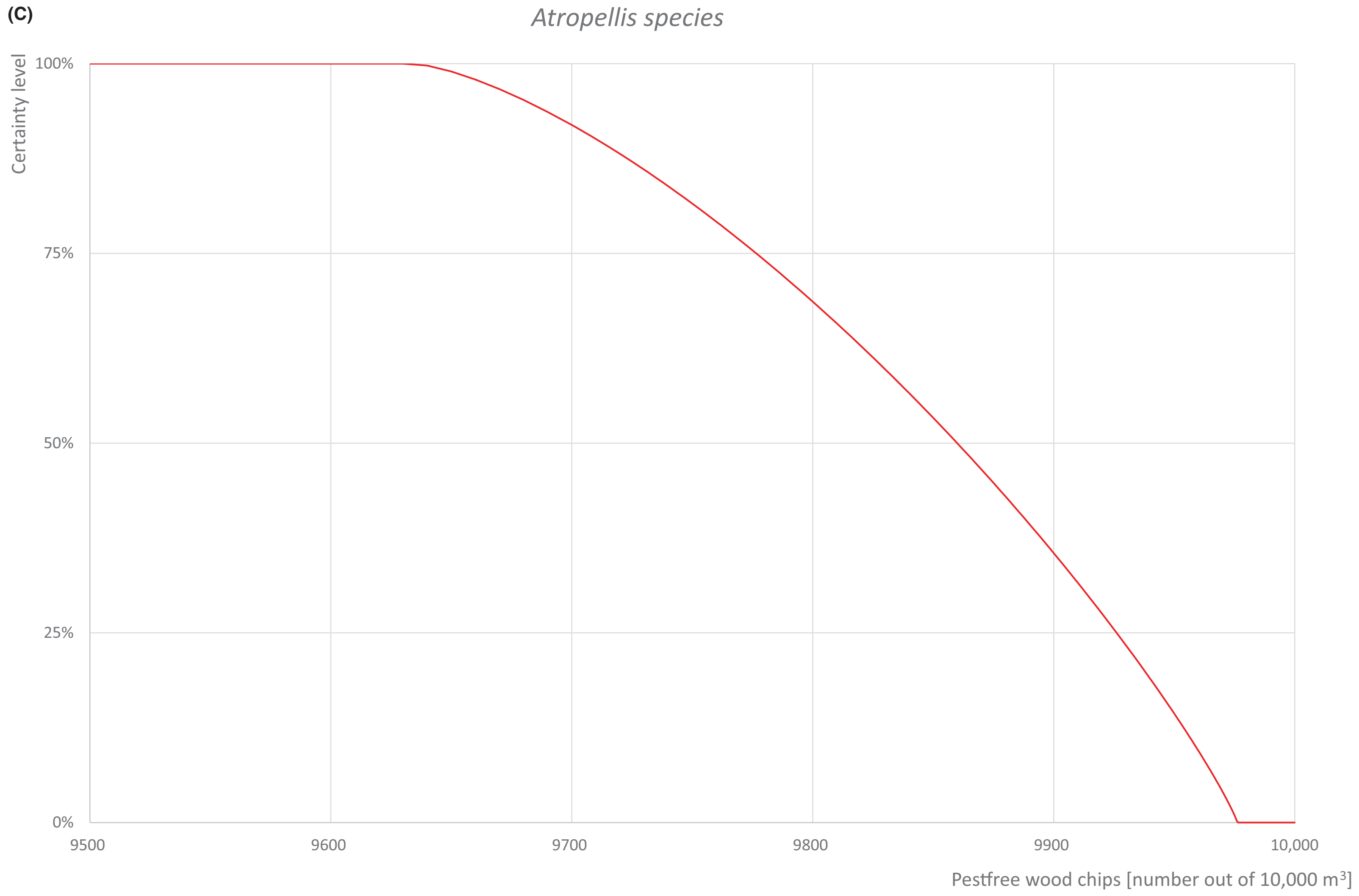


FIGURE E.3 (A) Elicited uncertainty of pest infestation per 10,000 m^3 wood chips (histogram in blue – vertical blue line indicates the elicited percentile in the following order: 1%, 25%, 50%, 75%, 99%) and distributional fit (red line); (B) uncertainty of the proportion of pest-free wood chips per 10,000 m^3 (i.e. = 1 – pest infestation proportion expressed as percentage); (C) descending uncertainty distribution function of pest infestation per 10,000 m^3 wood chips.

E.4 | OVERALL LIKELIHOOD OF PEST FREEDOM OF *CONIFERIPORIA* SPECIES FOR CONIFER WOOD CHIPS

E.4.1 | Reasoning for a scenario which would lead to a reasonably low number of infested conifer wood chips

The scenario assumes that the trees used for wood chip production are harvested in a pest free area.

E.4.2 | Reasoning for a scenario which would lead to a reasonably high number of conifer wood chips

The scenario assumes that the trees used for wood chip production are harvested in a highly infested area (10% infected trees). In some trees the pest may be present asymptomatically. The risk mitigation measures, including the SF fumigation are not very effective in reducing the pest in the wood chips. In addition, 2% rot is tolerated in wood chips.

E.4.3 | Reasoning for a central scenario equally likely to over- or underestimate the number of infested conifer wood chips (Median)

The scenario assumes that most trees used for wood chip production are grown in areas where the pest is absent or not widespread (e.g. Eastern and Southeastern US) and belong to species not reported as preferential hosts of the pests (*Pinus* spp.). Most wood chips will probably be produced from intensively managed forests reducing the likelihood of presence of the pathogen. The risk mitigation measures, including the SF fumigation are partially effective in reducing the pest from the wood chips.

E.4.4 | Reasoning for the precision of the judgement describing the remaining uncertainties (1st and 3rd quartile/interquartile range)

Limited information on the efficiency of the risk mitigation measures, especially the SF fumigation results in high uncertainty for infection rates below the median. Otherwise, the majority of trees used for wood chip production are expected to come from disease free areas giving less uncertainty for infection rates above the median.

E.4.5 | Elicitation outcomes of the assessment of the pest freedom for *Coniferiporia* species on conifer wood chips

The following Tables show the elicited and fitted values for pest infestation (Table E.7) and pest freedom (Table E.8).

TABLE E.7 Elicited and fitted values of the uncertainty distribution of pest infestation by *Coniferiporia* species per 10,000 m^3 wood chips.

Percentile	**1%**	**2.5%**	**5%**	**10%**	**17%**	**25%**	**33%**	**50%**	**67%**	**75%**	**83%**	**90%**	**95%**	**97.5%**	**99%**
Elicited values	0					12.5		25		55					150
EKE	0.380	0.973	1.99	4.14	7.22	11.4	16.0	27.2	42.4	52.8	67.0	84.1	106	126	151

Note: The EKE results is the BetaGeneral (0.98069, 9.3477, 0, 390) distribution fitted with @Risk version 7.6.

Based on the numbers of estimated infested wood chips the pest freedom was calculated (i.e. = 10,000 m^3 – number of infested wood chips per 10,000 m^3). The fitted values of the uncertainty distribution of the pest freedom are shown in Table E.8.

TABLE E.8 The uncertainty distribution of chips free of *Coniferiporia* species per 10,000 m^3 wood chips calculated by Table E.7.

Percentile	**1%**	**2.5%**	**5%**	**10%**	**17%**	**25%**	**33%**	**50%**	**67%**	**75%**	**83%**	**90%**	**95%**	**97.5%**	**99%**
Values	9850					9945		9975		9987.5					10,000
EKE results	9849	9874	9894	9916	9933	9947	9958	9973	9984	9989	9993	9996	9998	9999	10,000

Note: The EKE results are the fitted values.

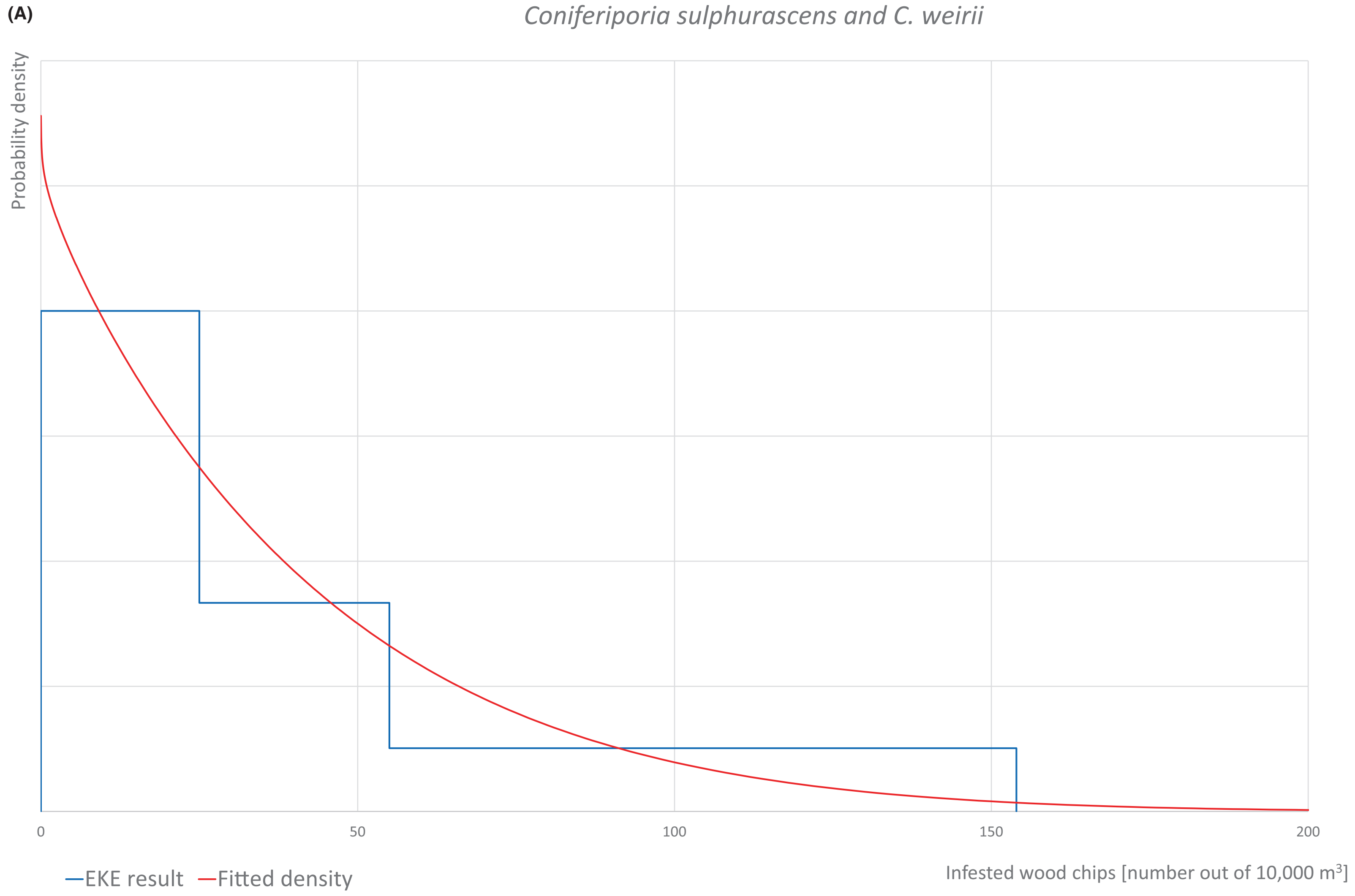


FIGURE E.4 (Continued)

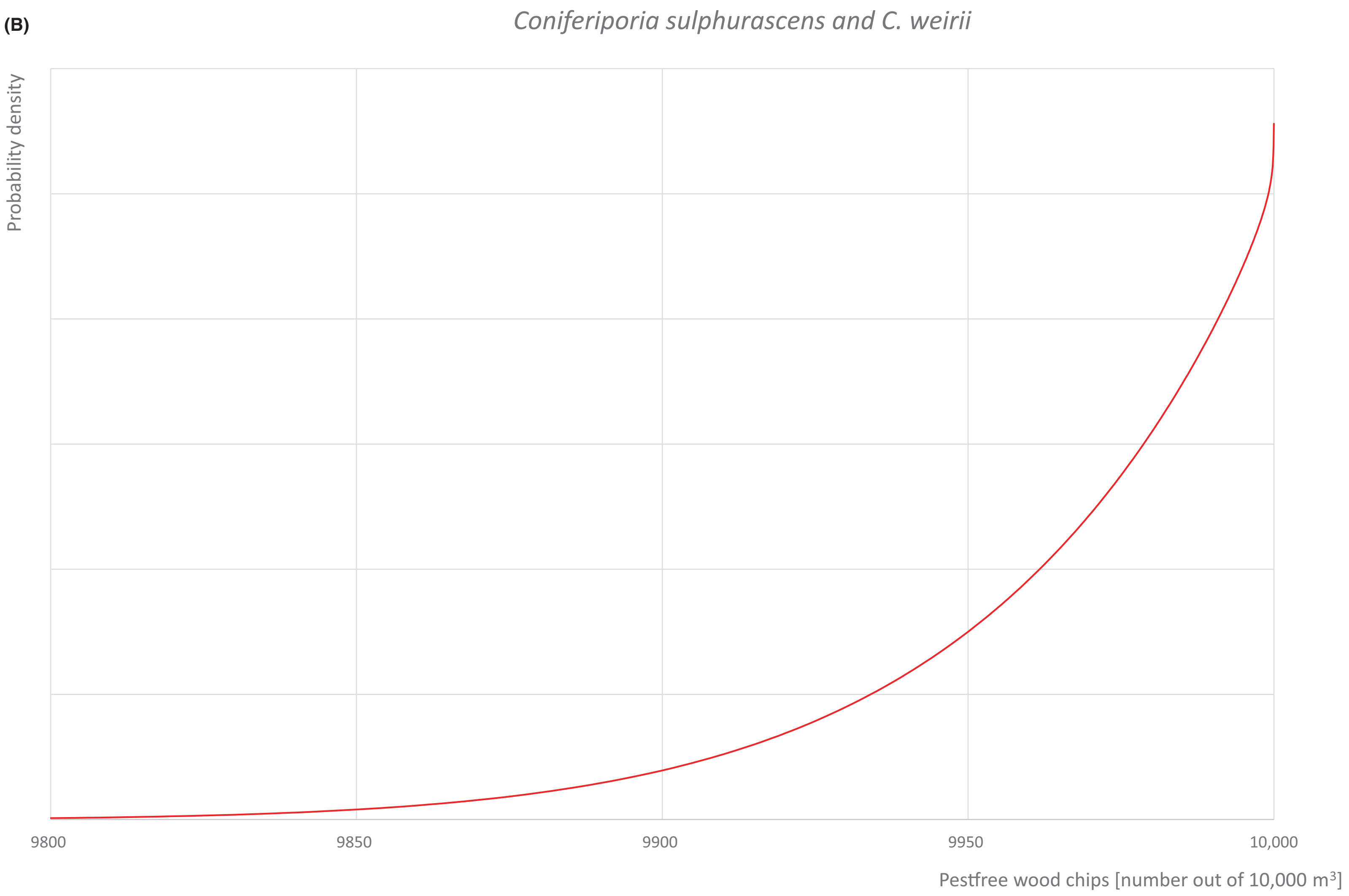


FIGURE E.4 (Continued)

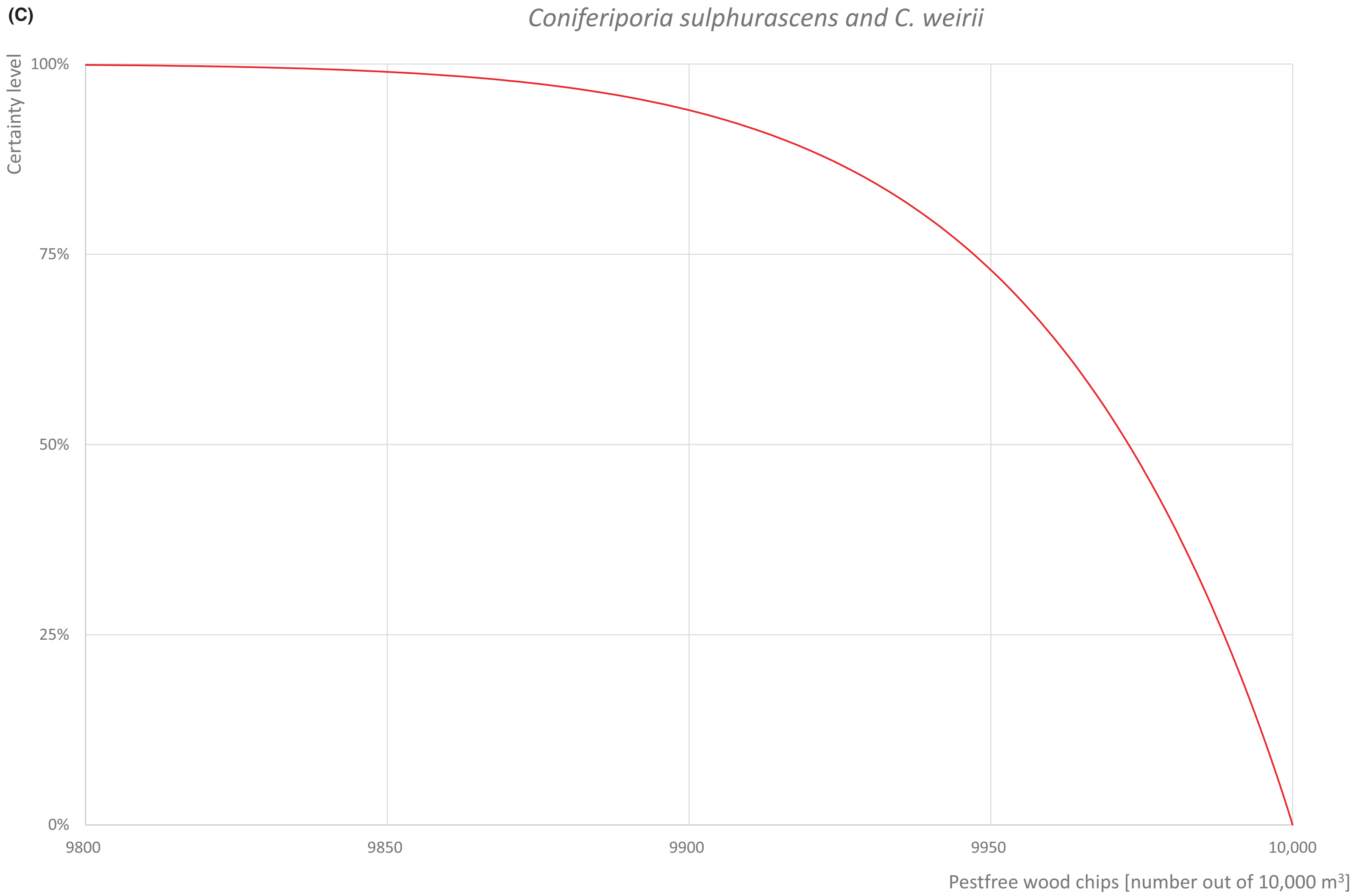


FIGURE E.4 (A) Elicited uncertainty of pest infestation per 10,000 m^3 wood chips (histogram in blue – vertical blue line indicates the elicited percentile in the following order: 1%, 25%, 50%, 75%, 99%) and distributional fit (red line); (B) uncertainty of the proportion of pest-free wood chips per 10,000 m^3 (i.e. = 1 – pest infestation proportion expressed as percentage); (C) descending uncertainty distribution function of pest infestation per 10,000 m^3 wood chips.

E.5 | OVERALL LIKELIHOOD OF PEST FREEDOM OF *CRONARTIUM* SPECIES FOR CONIFER WOOD CHIPS

E.5.1 | Reasoning for a scenario which would lead to a reasonably low number of infested conifer wood chips

The scenario assumes a low prevalence of the pest in the areas where the trees used for wood chip production are harvested. The risk mitigation measures, including the SF fumigation are not fully effective in eliminating the pest in the wood chips.

E.5.2 | Reasoning for a scenario which would lead to a reasonably high number of conifer wood chips

The scenario assumes a high prevalence of the pest in the area where the trees used for wood chip production are harvested and that the pest can also be present asymptomatically. The trees used for wood chips production are *Pinus* spp., which are the aecial hosts of the pest. The risk mitigation measures, including the SF fumigation are not very effective in reducing the pest in the wood chips.

E.5.3 | Reasoning for a central scenario equally likely to over- or underestimate the number of infested conifer wood chips (Median)

The scenario assumes that most trees used for wood chip production are *Pinus* spp. that are grown in areas where the pest is present. The risk mitigation measures, including the SF fumigation are partially effective in reducing the pest from the wood chips.

E.5.4 | Reasoning for the precision of the judgement describing the remaining uncertainties (1st and 3rd quartile/interquartile range)

The limited information on the prevalence of the pest and the efficiency of the risk mitigation measures, especially the SF fumigation results in high level of uncertainties for infection rates below the median. Otherwise, the pest pressure is expected to be moderate giving less uncertainties for rates above the median.

E.5.5 | Elicitation outcomes of the assessment of the pest freedom for *Cronartium* species on conifer wood chips

The following Tables show the elicited and fitted values for pest infestation (Table E.9) and pest freedom (Table E.10).

TABLE E.9 Elicited and fitted values of the uncertainty distribution of pest infestation by *Cronartium* species per 10,000 m^3 wood chips.

Percentile	1%	2.5%	5%	10%	17%	25%	33%	50%	67%	75%	83%	90%	95%	97.5%	99%
Elicited values	20					45		70		145					250
EKE	19.9	20.4	21.6	25.0	30.9	40.2	51.3	79.2	116	139	166	193	219	236	251

Note: The EKE results is the BetaGeneral (0.68743, 1.5894, 19.7269) distribution fitted with @Risk version 7.6.

Based on the numbers of estimated infested wood chips the pest freedom was calculated (i.e. = 10,000 m^3 – number of infested wood chips per 10,000 m^3). The fitted values of the uncertainty distribution of the pest freedom are shown in Table E.10.

TABLE E.10 The uncertainty distribution of wood chips free of *Cronartium* species per 10,000 m^3 wood chips calculated by Table E.9.

Percentile	1%	2.5%	5%	10%	17%	25%	33%	50%	67%	75%	83%	90%	95%	97.5%	99%
Values	9750					9855		9930		9955					9980
EKE results	9749	9764	9781	9807	9834	9861	9884	9921	9949	9960	9969	9975	9978	9979.6	9980.1

Note: The EKE results are the fitted values.

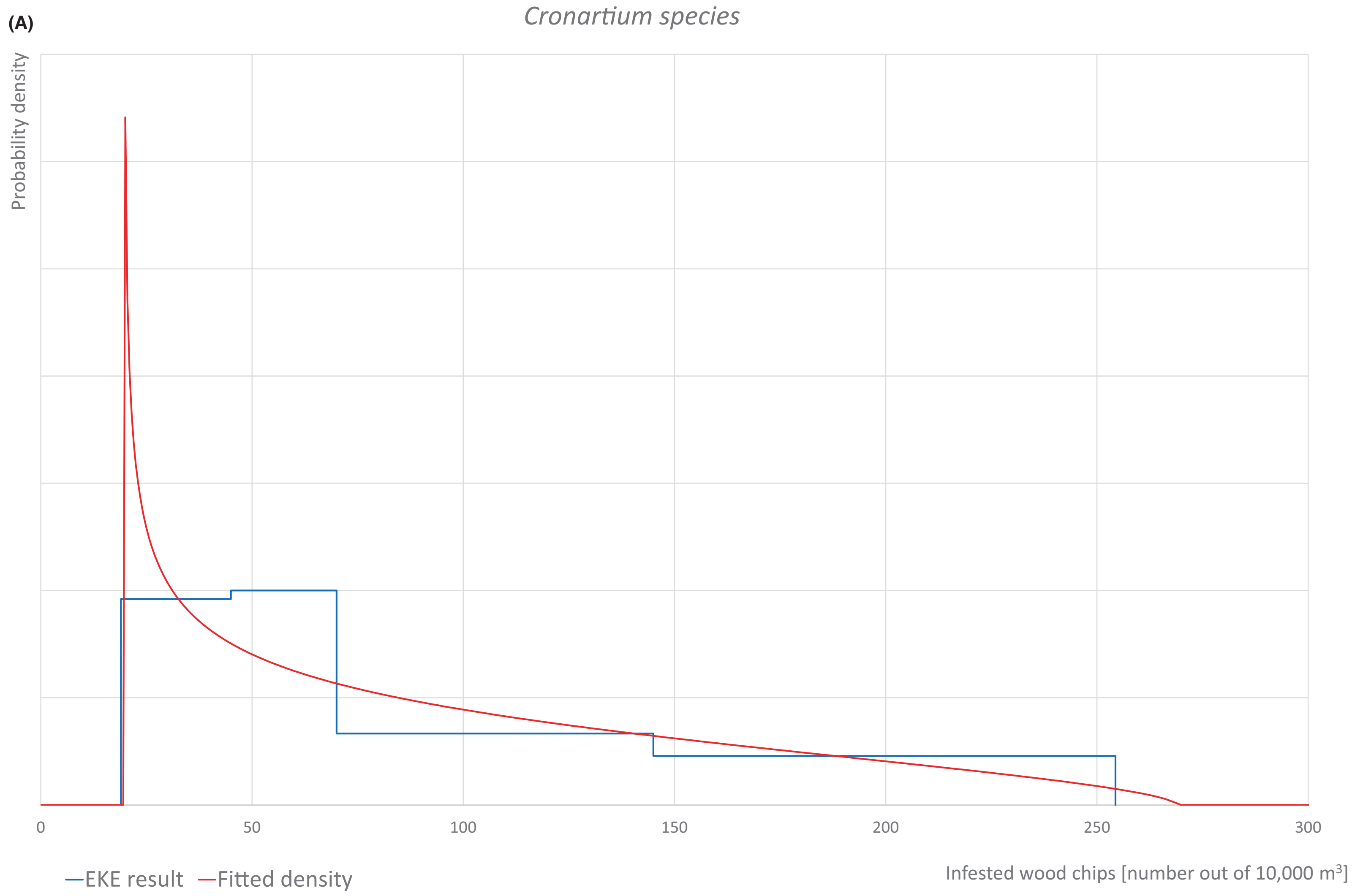


FIGURE E.5 (Continued)

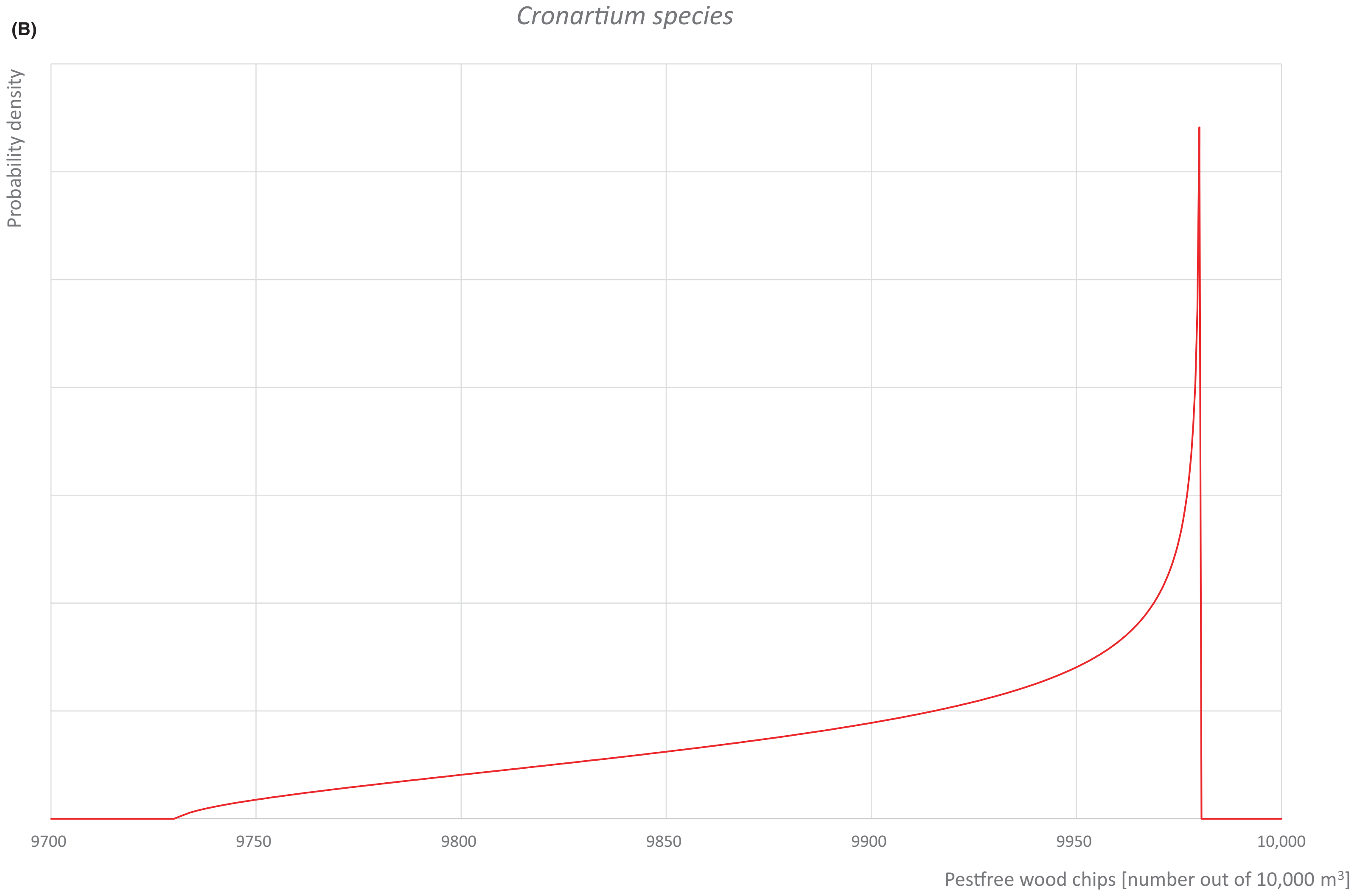


FIGURE E.5 (Continued)

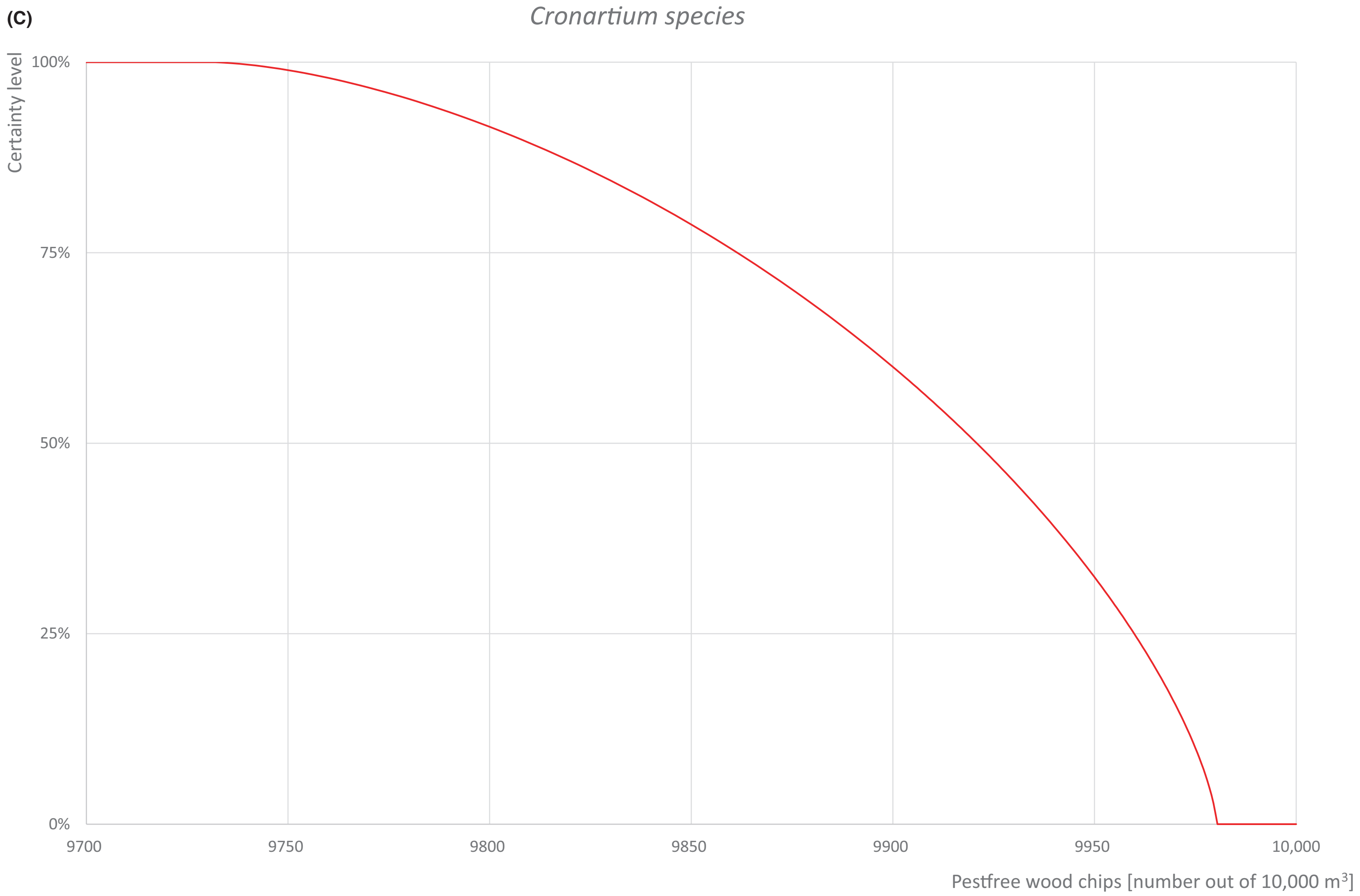


FIGURE E.5 (A) Elicited uncertainty of pest infestation per 10,000 m^3 wood chips (histogram in blue – vertical blue line indicates the elicited percentile in the following order: 1%, 25%, 50%, 75%, 99%) and distributional fit (red line); (B) uncertainty of the proportion of pest-free wood chips per 10,000 m^3 (i.e. = 1 – pest infestation proportion expressed as percentage); (C) descending uncertainty distribution function of pest infestation per 10,000 m^3 wood chips.

E.6 | OVERALL LIKELIHOOD OF PEST FREEDOM OF *FUSARIUM CIRCINATUM* FOR CONIFER WOOD CHIPS

E.6.1 | Reasoning for a scenario which would lead to a reasonably low number of infested conifer wood chips

The scenario assumes that the trees used for wood chip production are harvested in a pest free area.

E.6.2 | Reasoning for a scenario which would lead to a reasonably high number of conifer wood chips

The scenario assumes a high prevalence of the pest in the area where the trees used for wood chip production are harvested and that the pest can also be present asymptomatically. The trees used for wood chips production are Pinus spp., which are main hosts of the pest. The risk mitigation measures, including the SF fumigation are not very effective in reducing the pest in the wood chips.

E.6.3 | Reasoning for a central scenario equally likely to over- or underestimate the number of infested conifer wood chips (Median)

The scenario assumes that most trees used for wood chip production are Pinus spp. that are grown in areas where the pest is present. The risk mitigation measures, including the SF fumigation are partially effective in reducing the pest from the wood chips.

E.6.4 | Reasoning for the precision of the judgement describing the remaining uncertainties (1st and 3rd quartile/interquartile range)

The majority of trees used for chip production are expected to come from areas where the disease is present giving less uncertainties for infection rates below the median. Limited information on the prevalence of the pest and the efficiency of the risk mitigation measures, especially the SF fumigation results in high uncertainty for infection rates above the median.

E.6.5 | Elicitation outcomes of the assessment of the pest freedom for *Fusarium circinatum* on conifer wood chips

The following Tables show the elicited and fitted values for pest infestation (Table E.11) and pest freedom (Table E.12).

TABLE E.11 Elicited and fitted values of the uncertainty distribution of pest infestation by *Fusarium circinatum* per 10,000 m^3 wood chips.

Percentile	1%	2.5%	5%	10%	17%	25%	33%	50%	67%	75%	83%	90%	95%	97.5%	99%
Elicited values	0					80		130		240					350
EKE	2.73	6.80	13.6	27.3	45.9	69.5	93.7	145	201	232	265	296	323	339	351

Note: The EKE results is the BetaGeneral (1.0051, 1.3659, 0, 363) distribution fitted with @Risk version 7.6.

Based on the numbers of estimated infested wood chips the pest freedom was calculated (i.e. = 10,000 m^3 – number of infested wood chips per 10,000 m^3). The fitted values of the uncertainty distribution of the pest freedom are shown in Table E.12.

TABLE E.12 The uncertainty distribution of wood chips free of *Fusarium circinatum* per 10,000 m^3 wood chips calculated by Table E.11.

Percentile	1%	2.5%	5%	10%	17%	25%	33%	50%	67%	75%	83%	90%	95%	97.5%	99%
Values	9650					9760		9870		9920					10,000
EKE results	9649	9661	9677	9704	9735	9768	9799	9855	9906	9931	9954	9973	9986	9993	9997

Note: The EKE results are the fitted values.

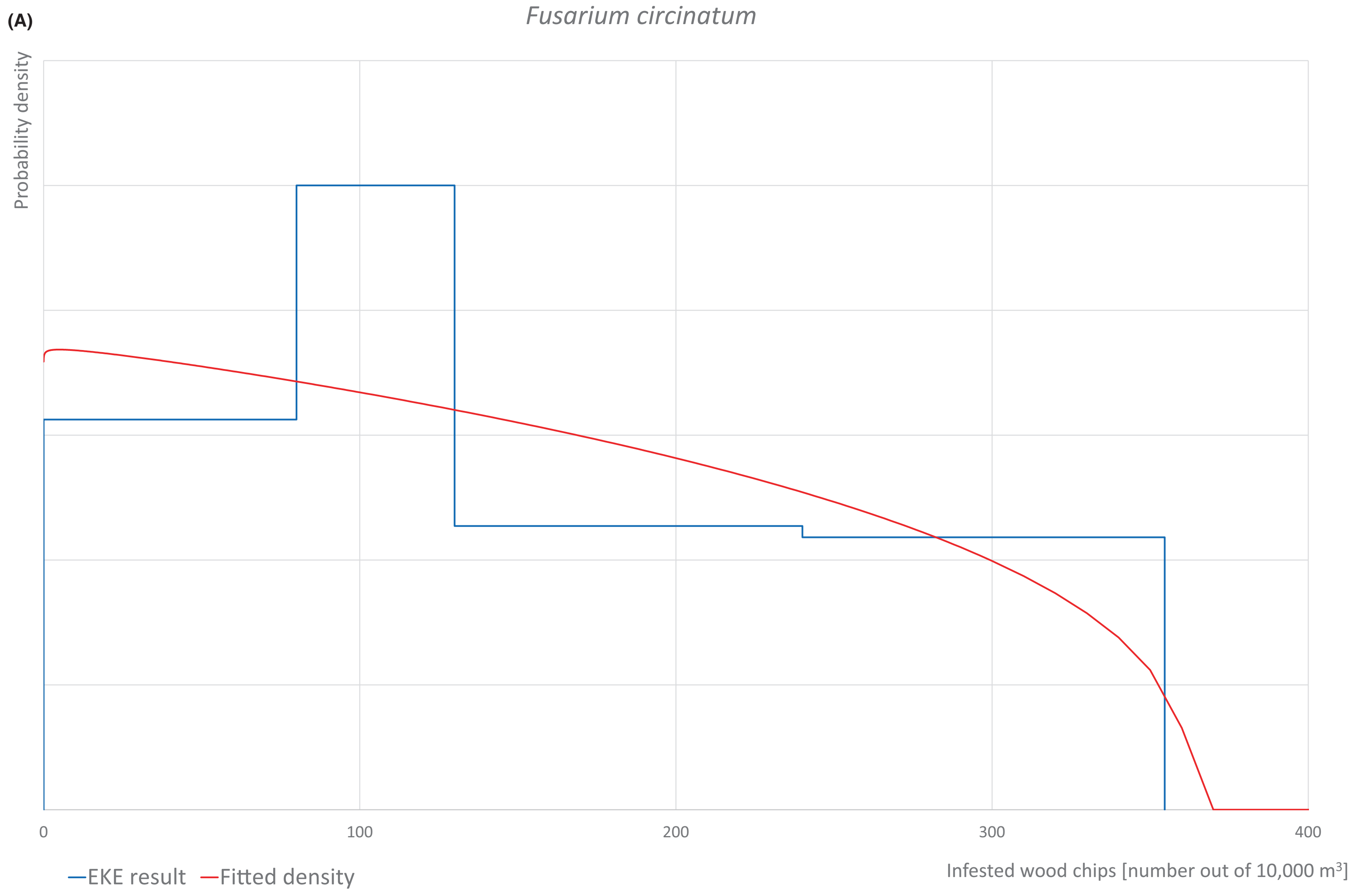
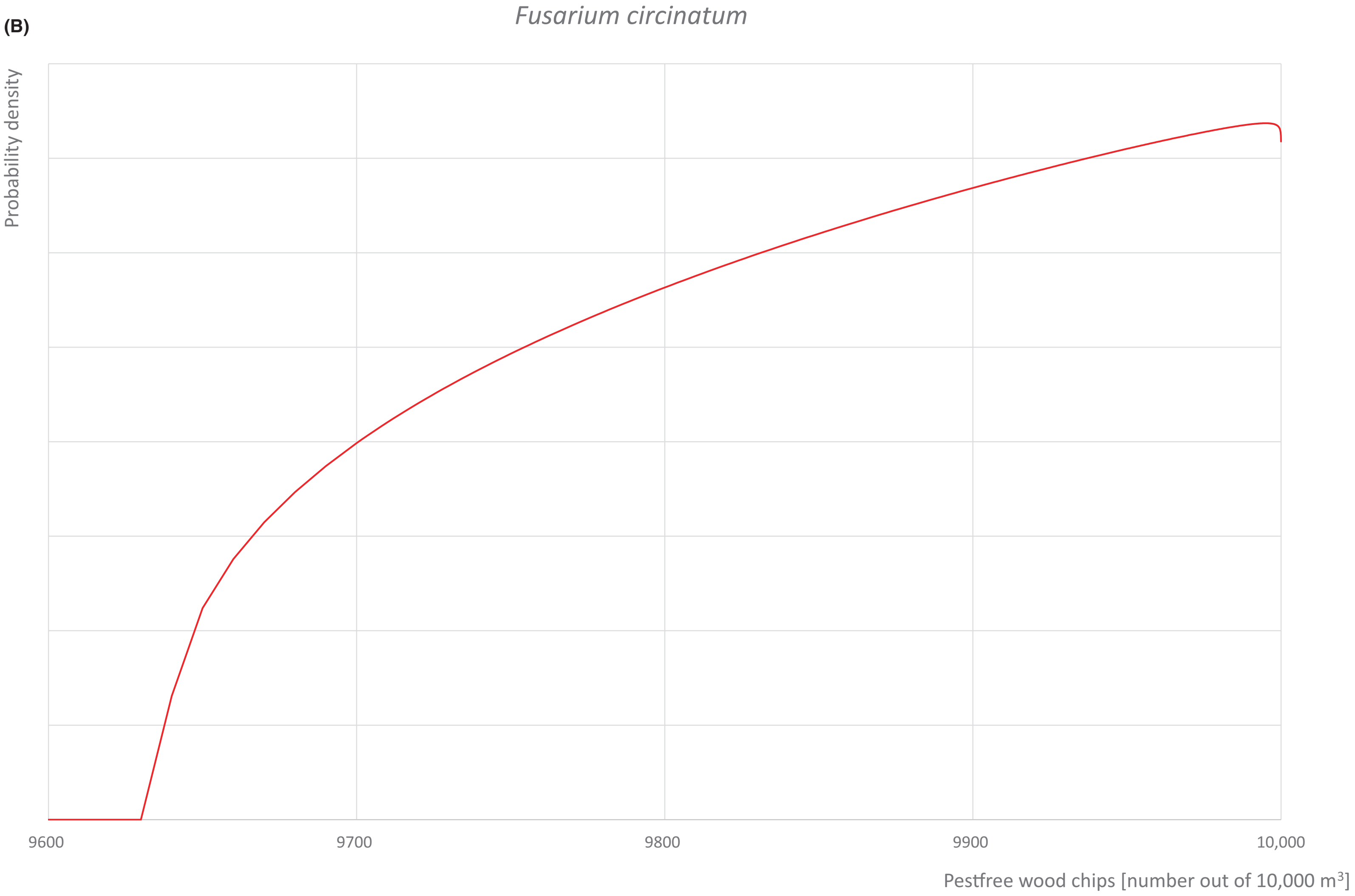


FIGURE E.6 (Continued)



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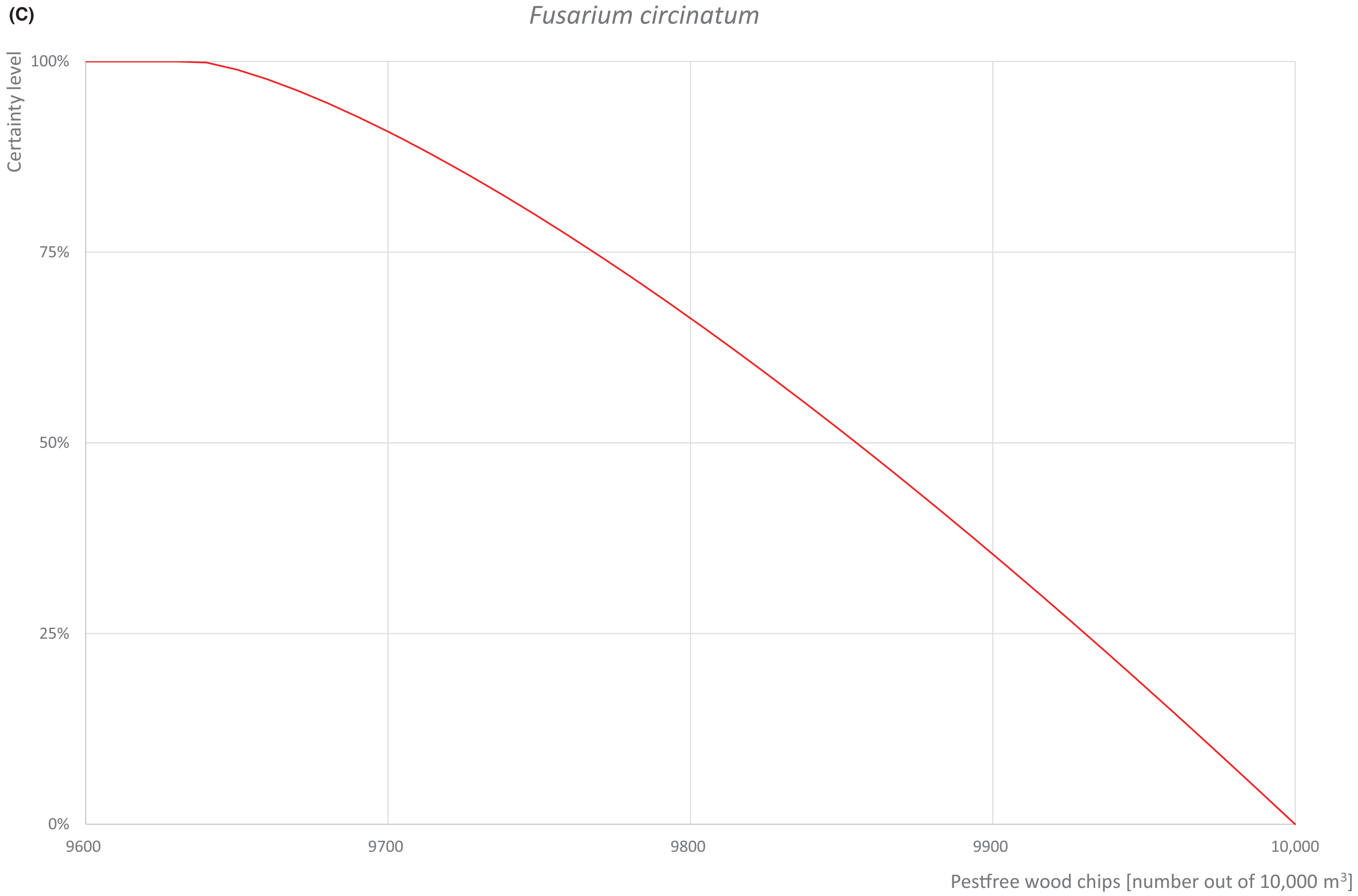

FIGURE E.6 (A) Elicited uncertainty of pest infestation per 10,000 m^3 wood chips (histogram in blue – vertical blue line indicates the elicited percentile in the following order: 1%, 25%, 50%, 75%, 99%) and distributional fit (red line); (B) uncertainty of the proportion of pest-free wood chips per 10,000 m^3 (i.e. = 1 – pest infestation proportion expressed as percentage); (C) descending uncertainty distribution function of pest infestation per 10,000 m^3 wood chips.

E.7 | OVERALL LIKELIHOOD OF PEST FREEDOM OF *GREMMENIELLA ABIETINA* FOR CONIFER WOOD CHIPS

E.7.1 | Reasoning for a scenario which would lead to a reasonably low number of infested conifer wood chips

The scenario assumes that the trees used for wood chip production are harvested in a pest free area.

E.7.2 | Reasoning for a scenario which would lead to a reasonably high number of conifer wood chips

The scenario assumes a high prevalence of the pest in the area where the trees used for wood chip production are harvested and that the pest can also be present asymptomatically. The risk mitigation measures, including the SF fumigation are not very effective in reducing the pest in the wood chips.

E.7.3 | Reasoning for a central scenario equally likely to over- or underestimate the number of infested conifer wood chips (Median)

The scenario assumes that most trees used for wood chip production are grown in areas where the pest is not widespread. The risk mitigation measures, including the SF fumigation are partially effective in reducing the pest from the wood chips.

E.7.4 | Reasoning for the precision of the judgement describing the remaining uncertainties (1st and 3rd quartile/interquartile range)

Limited information on the efficiency of the risk mitigation measures, especially the SF fumigation results in high uncertainty for infection rates below the median. Otherwise, the majority of trees used for wood chip production are expected to come from disease free areas giving less uncertainty for infection rates above the median.

E.7.5 | Elicitation outcomes of the assessment of the pest freedom for *Gremmeniella abietina* on conifer wood chips

The following Tables show the elicited and fitted values for pest infestation (Table E.13) and pest freedom (Table E.14).

TABLE E.13 Elicited and fitted values of the uncertainty distribution of pest infestation by *Gremmeniella abietina* per 10,000 m^3 wood chips.

Percentile	1%	2.5%	5%	10%	17%	25%	33%	50%	67%	75%	83%	90%	95%	97.5%	99%
Elicited values	0					20		40		80					350
EKE	1.07	2.34	4.29	7.97	12.8	19.1	25.9	41.7	63.3	78.2	98.8	125	159	193	238

Note: The EKE results is the BetaGeneral (1.1844, 208.54, 0, 10,000) distribution fitted with @Risk version 7.6.

Based on the numbers of estimated infested wood chips the pest freedom was calculated (i.e. = 10,000 m^3 – number of infested wood chips per 10,000 m^3). The fitted values of the uncertainty distribution of the pest freedom are shown in Table E.14.

TABLE E.14 The uncertainty distribution of wood chips free of *Gremmeniella abietina* per 10,000 m^3 wood chips calculated by Table E.13.

Percentile	1%	2.5%	5%	10%	17%	25%	33%	50%	67%	75%	83%	90%	95%	97.5%	99%
Values	9650					9920		9960		9980					10,000
EKE results	9762	9807	9841	9875	9901	9922	9937	9958	9974	9981	9987	9992	9996	9998	9999

Note: The EKE results are the fitted values.

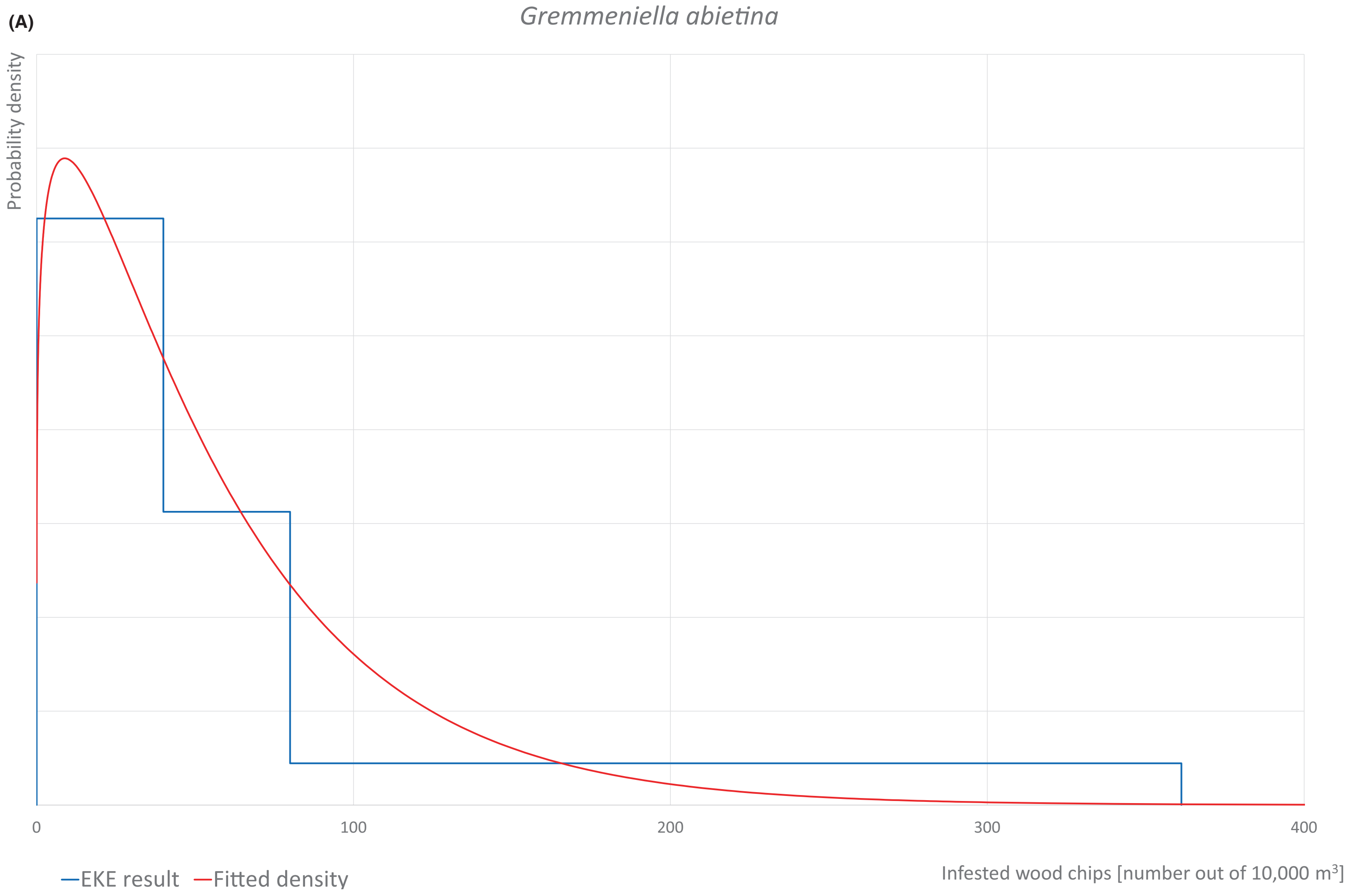

FIGURE E.7 (Continued)

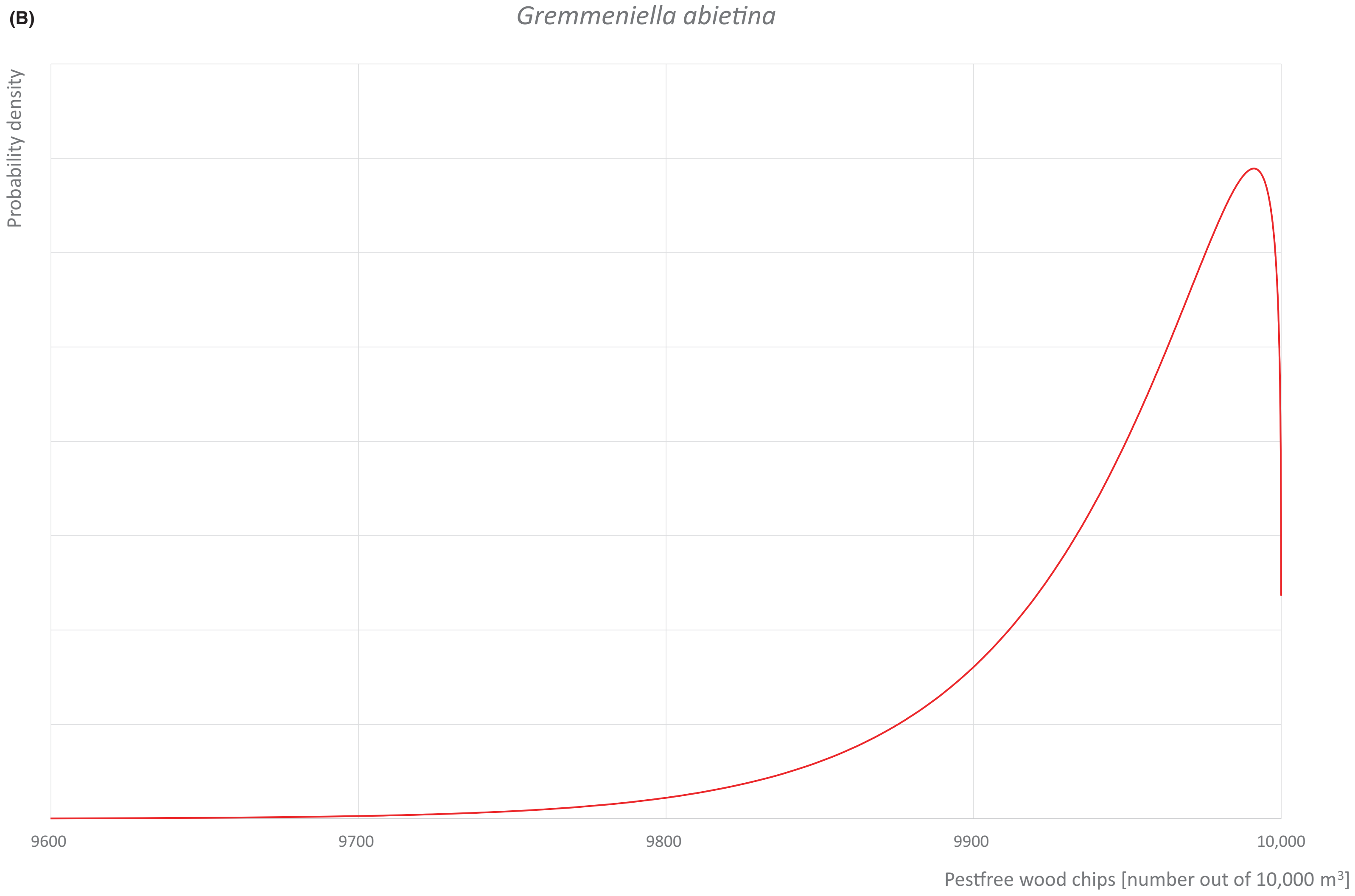

FIGURE E.7 (Continued)

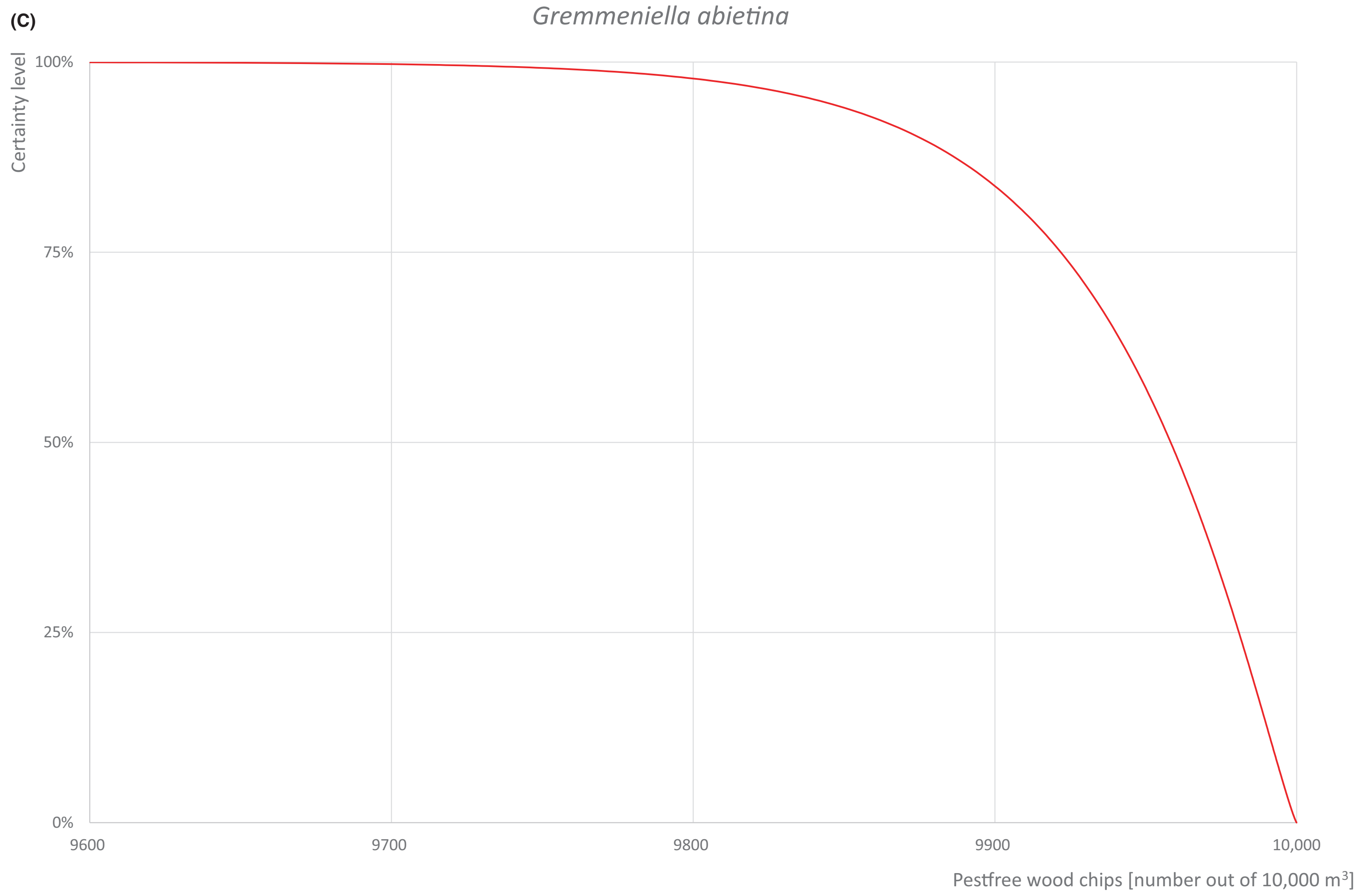

FIGURE E.7 (A) Elicited uncertainty of pest infestation per 10,000 m^3 wood chips (histogram in blue – vertical blue line indicates the elicited percentile in the following order: 1%, 25%, 50%, 75%, 99%) and distributional fit (red line); (B) uncertainty of the proportion of pest-free wood chips per 10,000 m^3 (i.e. = 1 – pest infestation proportion expressed as percentage); (C) descending uncertainty distribution function of pest infestation per 10,000 m^3 wood chips.

E.8 | Overall likelihood of pest freedom of *Gymnosporangium* species for conifer wood chips

E.8.1 | Reasoning for a scenario which would lead to a reasonably low number of infested conifer wood chips

No *Gymnosporangium* spp. hosts are used for wood chips production.

E.8.2 | Reasoning for a scenario which would lead to a reasonably high number of conifer wood chips.

Some *Juniperus* and other coniferous host species are used for wood chip production, and alternate hosts are present within a suitable distance. Remnants of the sporulating tissues are present on the 2% of remaining bark. The risk mitigation measures, including the SF fumigation are not very effective in reducing the pest in the wood chips.

E.8.3 | Reasoning for a central scenario equally likely to over- or underestimate the number of infested conifer wood chips (Median)

The scenario assumes that most trees used for wood chip production are not hosts of the pests. The risk mitigation measures, including the SF fumigation are partially effective in reducing the pest from the wood chips.

E.8.4 | Reasoning for the precision of the judgement describing the remaining uncertainties (1st and 3rd quartile/interquartile range)

Limited information on the efficiency of the risk mitigation measures, especially the SF fumigation results in high uncertainty for infection rates below the median. Otherwise, the majority of trees used for wood chip production are expected to be non-hosts of the pests giving less uncertainty for infection rates above the median.

E.8.5 | Elicitation outcomes of the assessment of the pest freedom for *Gymnosporangium* species on conifer wood chips

The following Tables show the elicited and fitted values for pest infestation (Table E.15) and pest freedom (Table E.16).

TABLE E.15 Elicited and fitted values of the uncertainty distribution of pest infestation by *Gymnosporangium* species per 10,000 m_3 wood chips.

Percentile	1%	2.5%	5%	10%	17%	25%	33%	50%	67%	75%	83%	90%	95%	97.5%	99%
Elicited values	0					5		10		20					60
EKE	0.270	0.591	1.08	2.00	3.22	4.78	6.46	10.4	15.8	19.5	24.7	31.2	39.8	48.4	59.6

Note: The EKE results is the BetaGeneral (1.1893, 840.68, 0, 10,000) distribution fitted with @Risk version 7.6.

Based on the numbers of estimated infested wood chips the pest freedom was calculated (i.e. = 10,000 m^3 – number of infested wood chips per 10,000 m^3). The fitted values of the uncertainty distribution of the pest freedom are shown in Table E.16.

TABLE E.16 The uncertainty distribution of chips free of *Gymnosporangium* species per 10,000 m^3 wood chips calculated by Table E.15.

Percentile	1%	2.5%	5%	10%	17%	25%	33%	50%	67%	75%	83%	90%	95%	97.5%	99%
Values	9940					9980		9990		9995					10,000
EKE results	9940	9952	9960	9969	9975	9980	9984	9990	9994	9995	9997	9998.0	9998.9	9999.4	9999.7

Note: The EKE results are the fitted values.

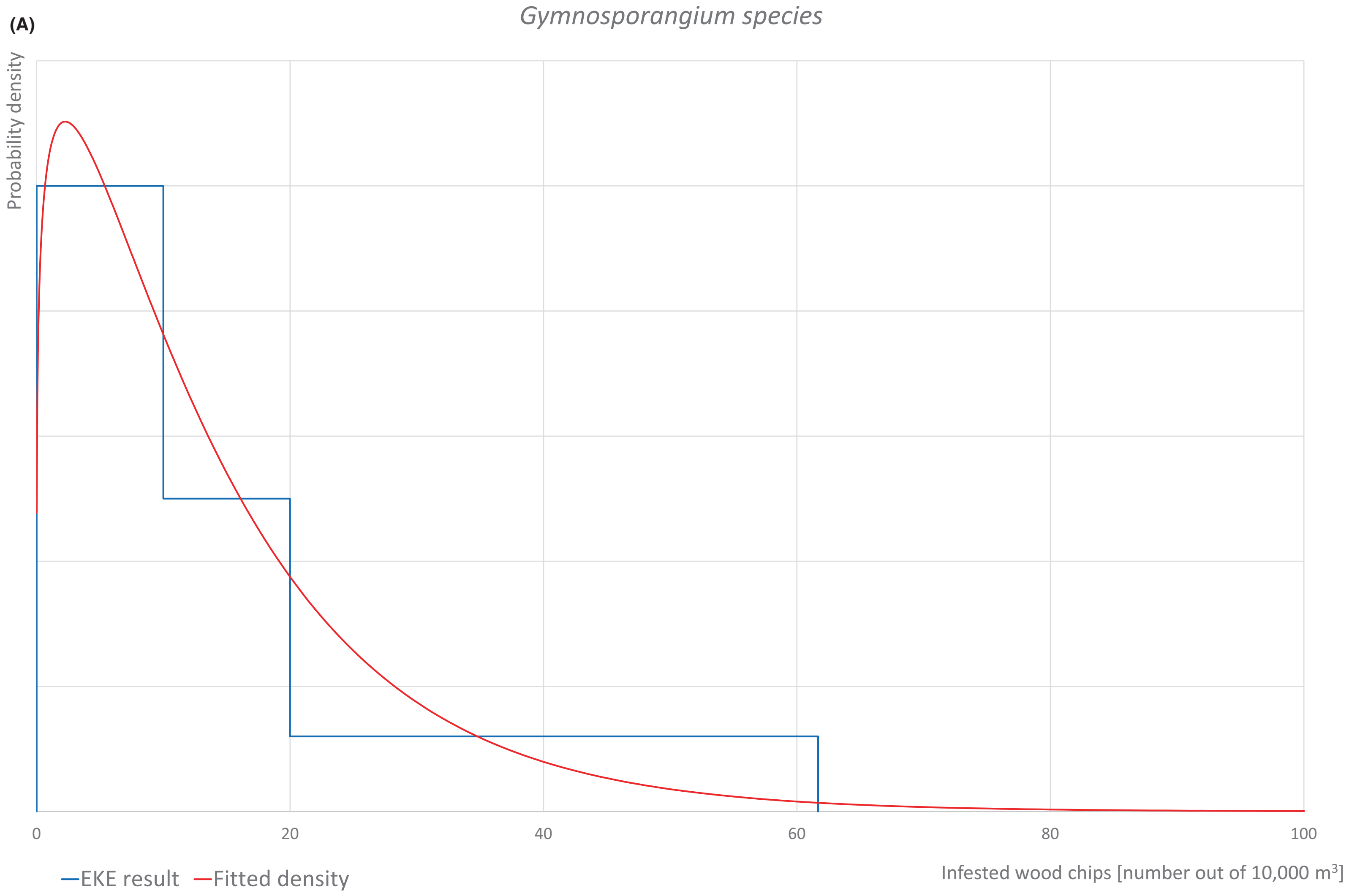

FIGURE E.8 (Continued)

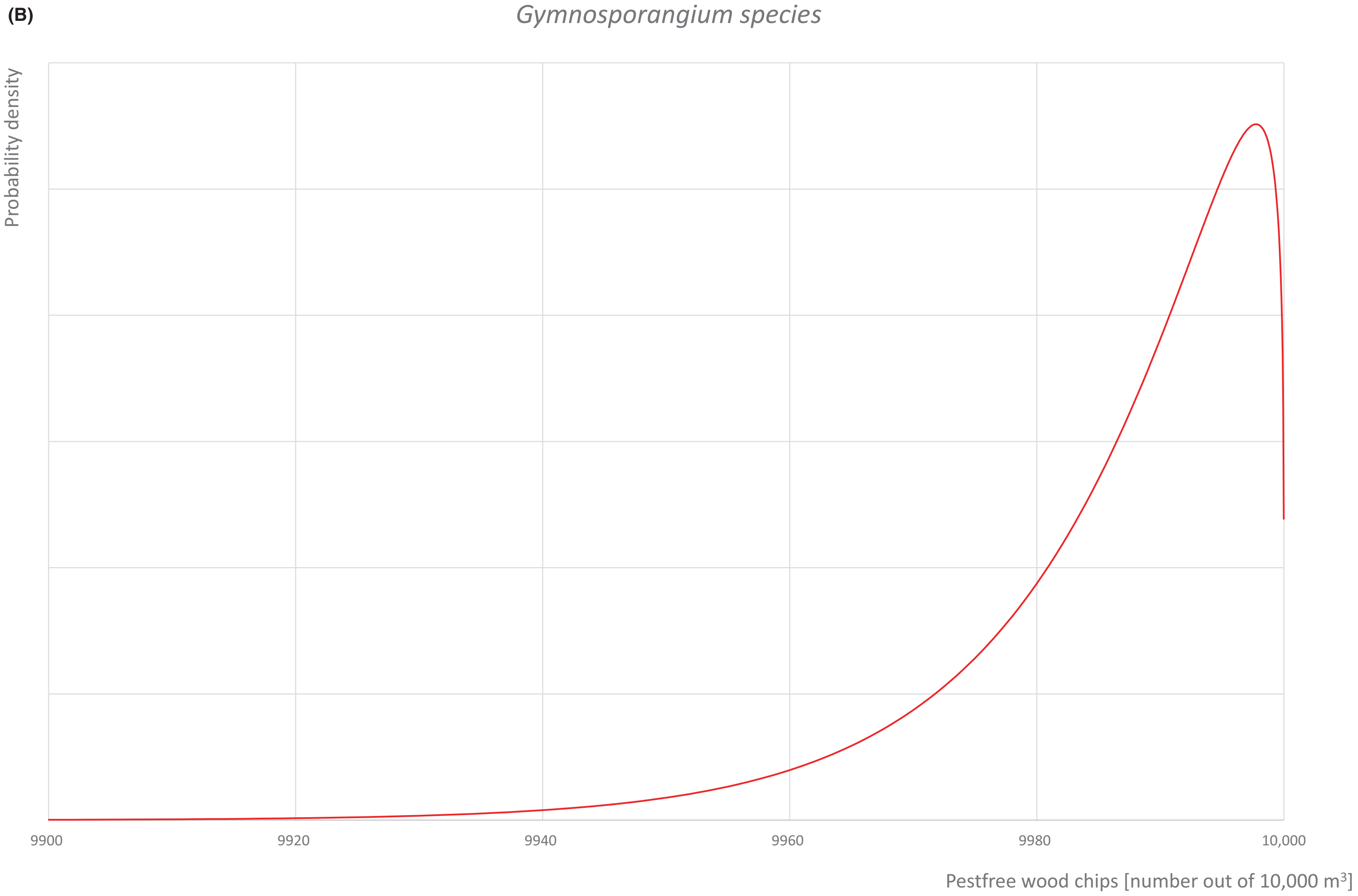

FIGURE E.8 (Continued)

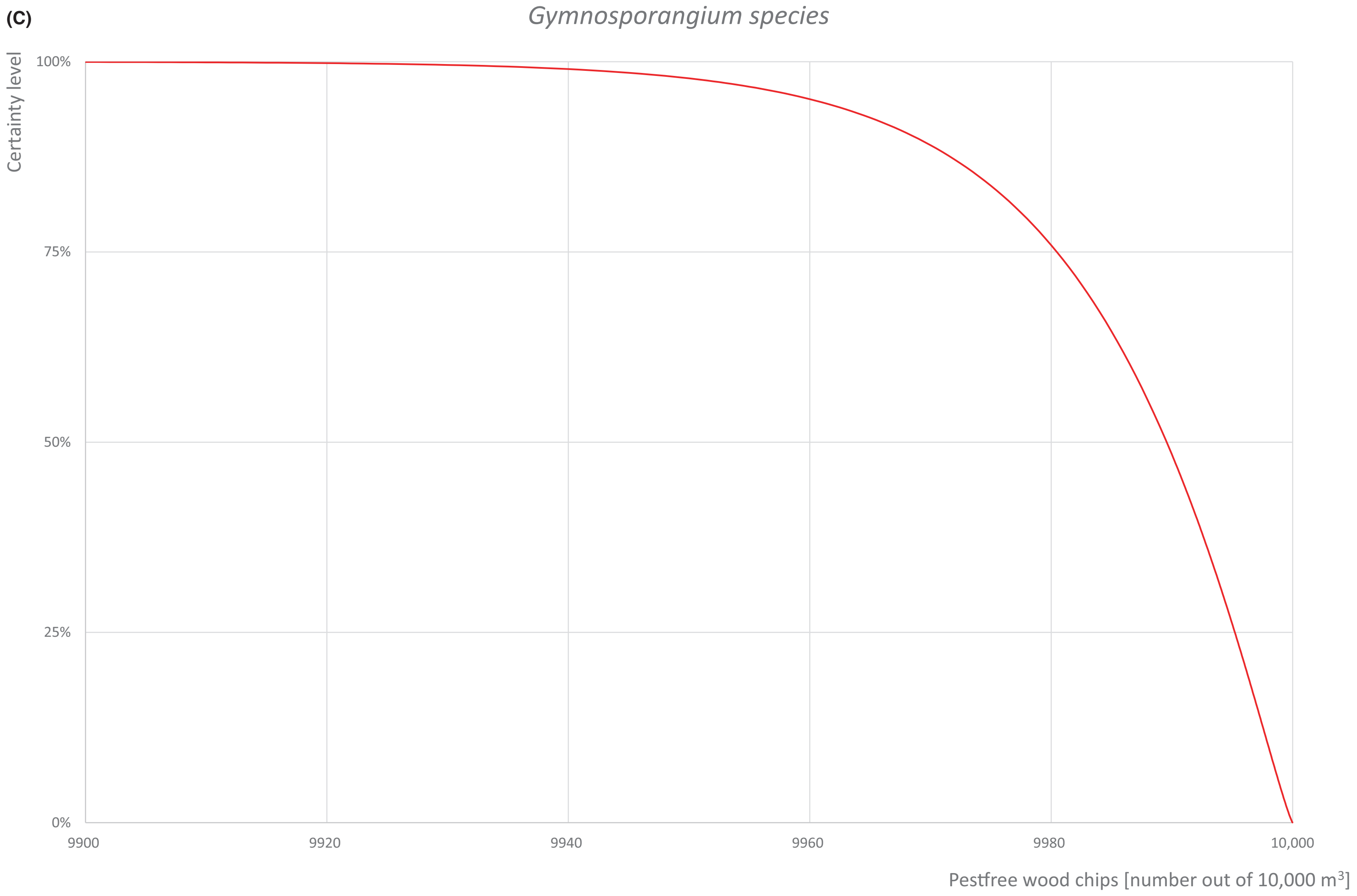

FIGURE E.8 (A) Elicited uncertainty of pest infestation per 10,000 m^3 wood chips (histogram in blue – vertical blue line indicates the elicited percentile in the following order: 1%, 25%, 50%, 75%, 99%) and distributional fit (red line); (B) uncertainty of the proportion of pest-free wood chips per 10,000 m^3 (i.e. =1 – pest infestation proportion expressed as percentage); (C) descending uncertainty distribution function of pest infestation per 10,000 m^3 wood chips.

E.9 | OVERALL LIKELIHOOD OF PEST FREEDOM OF *PHYTOPHTHORA RAMORUM* (NON-EU ISOLATES) FOR CONIFER WOOD CHIPS

E.9.1 | Reasoning for a scenario which would lead to a reasonably low number of infested conifer wood chips

The scenario assumes that the trees used for wood chip production are harvested in a pest free area.

E.9.2 | Reasoning for a scenario which would lead to a reasonably high number of conifer wood chips

The scenario assumes that host trees of the pest are used for wood chip production, and that these are grown in areas where the pest is present. The risk mitigation measures, including the SF fumigation are not very effective in reducing the pest in the wood chips.

E.9.3 | Reasoning for a central scenario equally likely to over- or underestimate the number of infested conifer wood chips (Median)

The scenario assumes that most trees species used for wood chip production are poor hosts of the pest and are grown in areas where the pest is not widespread. The risk mitigation measures, including the SF fumigation are partially effective in reducing the pest from the wood chips.

E.9.4 | Reasoning for the precision of the judgement describing the remaining uncertainties (1st and 3rd quartile/interquartile range)

The limited information on the prevalence of the pest and the efficiency of the risk mitigation measures, especially the SF fumigation results in high level of uncertainties for infection rates below the median. Otherwise, the pest pressure and tree susceptibility are expected to be low and giving less uncertainties for rates above the median.

E.9.5 | Elicitation outcomes of the assessment of the pest freedom for *Phytophthora ramorum* (non-EU isolates) on conifer wood chips

The following Tables show the elicited and fitted values for pest infestation (Table E.17) and pest freedom (Table E.18).

TABLE E.17 Elicited and fitted values of the uncertainty distribution of pest infestation by *Phytophthora ramorum* (non-EU isolates) per 10,000 m^3 wood chips.

Percentile	1%	2.5%	5%	10%	17%	25%	33%	50%	67%	75%	83%	90%	95%	97.5%	99%
Elicited values	0					5		10		20					50
EKE	0.209	0.494	0.952	1.86	3.10	4.72	6.46	10.5	15.9	19.5	24.2	29.8	36.6	42.8	50.0

Note: The EKE results is the BetaGeneral (1.0764, 6.8505, 0, 100) distribution fitted with @Risk version 7.6.

Based on the numbers of estimated infested wood chips the pest freedom was calculated (i.e. = 10,000 m^3 – number of infested wood chips per 10,000 m^3). The fitted values of the uncertainty distribution of the pest freedom are shown in Table E.18.

TABLE E.18 The uncertainty distribution of wood chips free of *Phytophthora ramorum* (non-EU isolates) per 10,000 m^3 wood chips calculated by Table E.17.

Percentile	1%	2.5%	5%	10%	17%	25%	33%	50%	67%	75%	83%	90%	95%	97.5%	99%
Values	9950					9980		9990		9995					10,000
EKE results	9950	9957	9963	9970	9976	9981	9984	9989	9994	9995	9997	9998	9999.0	9999.5	9999.8

Note: The EKE results are the fitted values.

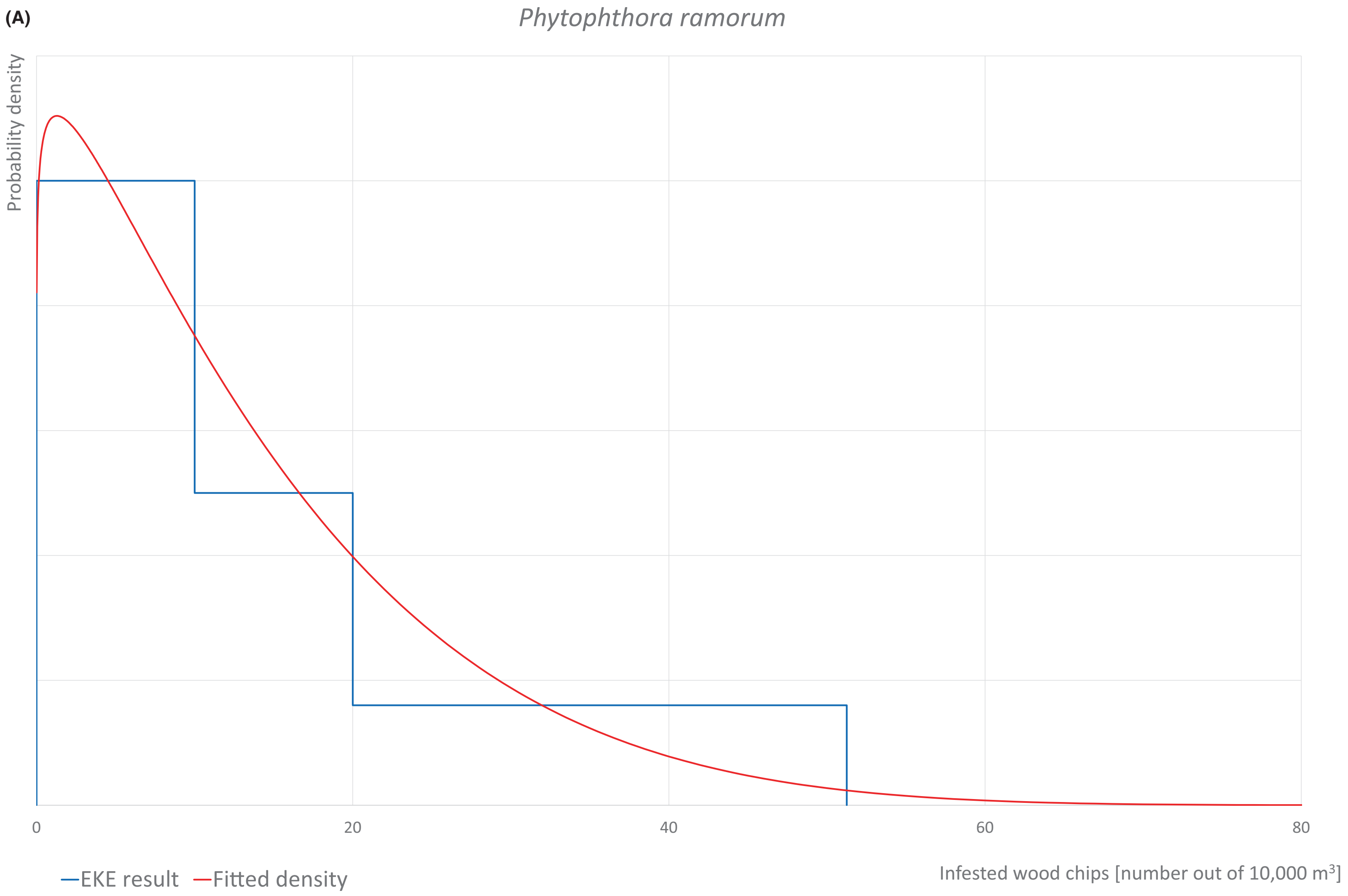

FIGURE E.9 (Continued)

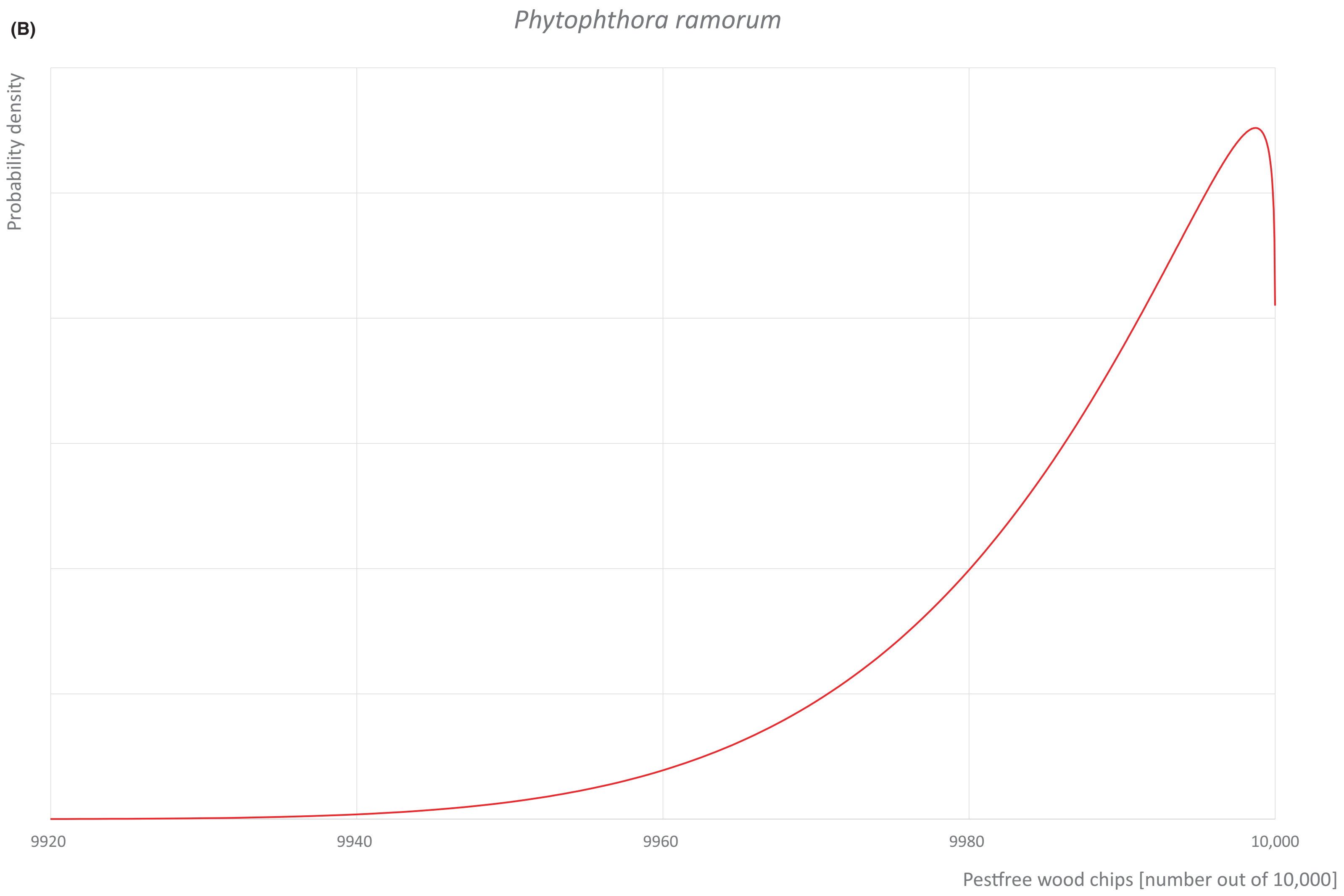

FIGURE E.9 (Continued)

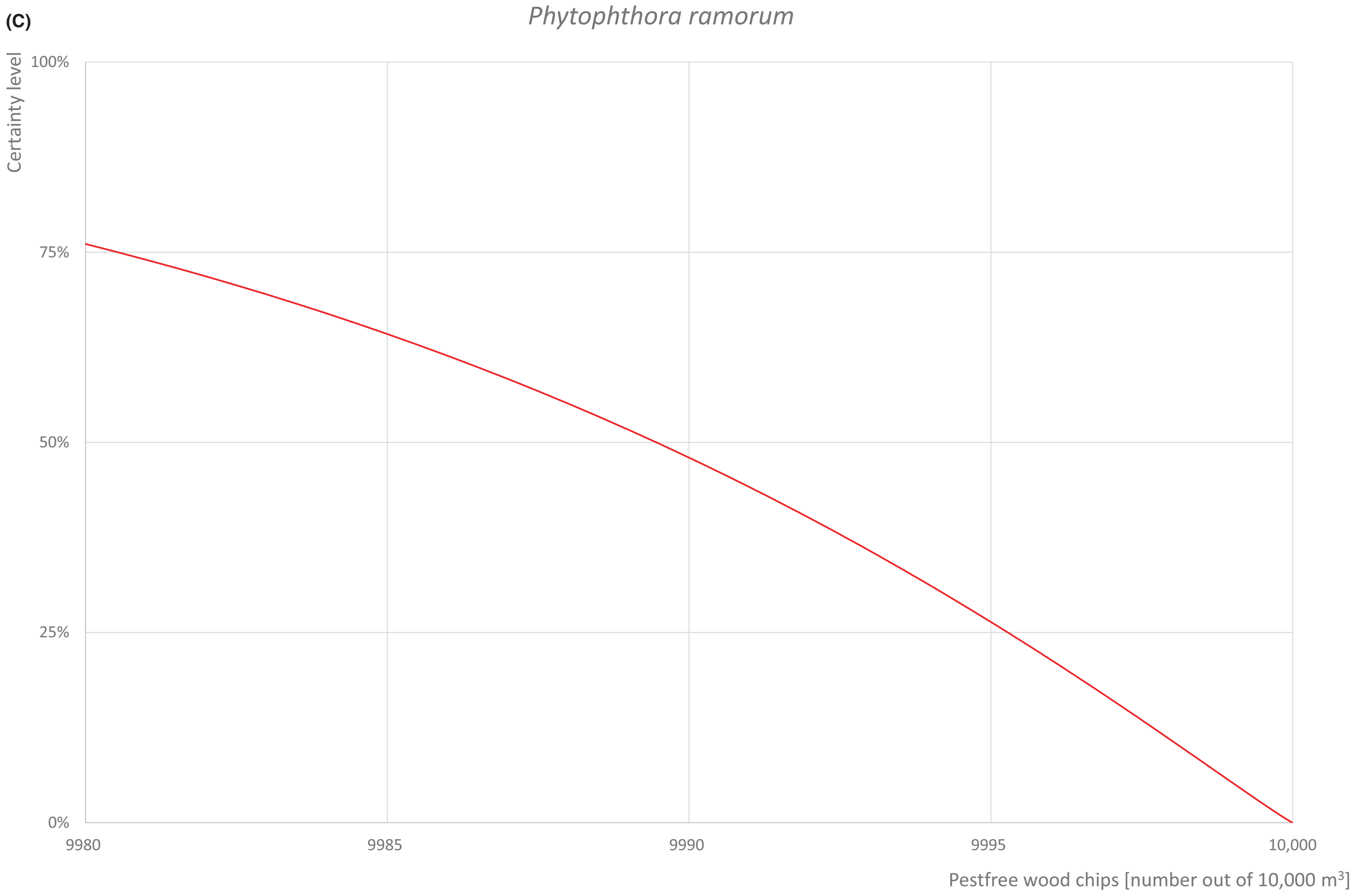

FIGURE E.9 (A) Elicited uncertainty of pest infestation per 10,000 m^3 wood chips (histogram in blue – vertical blue line indicates the elicited percentile in the following order: 1%, 25%, 50%, 75%, 99%) and distributional fit (red line); (B) uncertainty of the proportion of pest-free wood chips per 10,000 m^3 (i.e. = 1 – pest infestation proportion expressed as percentage); (C) descending uncertainty distribution function of pest infestation per 10,000 m^3 wood chips.

E.10 | OVERALL LIKELIHOOD OF PEST FREEDOM OF AMBROSIA BEETLES FOR CONIFER WOOD CHIPS

E.10.1 | Reasoning for a scenario which would lead to a reasonably low number of infested conifer wood chips

The scenario assumes that the risk mitigation measures, including the SF fumigation, are correctly performed and then fully effective in eliminating the pest in the wood chips.

E.10.2 | Reasoning for a scenario which would lead to a reasonably high number of conifer wood chips

The scenario assumes a high prevalence of the pest in the area where the trees used for wood chip production. The scenario also considers that debarking is not effective against this pest and that it could survive inside galleries within wood chips due to its small size and ecology. Finally, the scenario assumes that the risk mitigation measures, including the SF fumigation are not fully effective in eliminating the pest in the wood chips (SF fumigation treatment could be not fully standardised, and the gas may not reach all the chips).

E.10.3 | Reasoning for a central scenario equally likely to over- or underestimate the number of infested conifer wood chips (Median)

The scenario assumes a moderate prevalence of the pest in the area where trees used for wood chip production are located. The scenario also considers that some of the pest could survive all treatments prior to spraying with SF. Finally, the scenario assumes that the SF treatment is effective and that only if the gas cannot reach all wood chips could the commodity be infested.

E.10.4 | Reasoning for the precision of the judgement describing the remaining uncertainties (1st and 3rd quartile/interquartile range)

The pest presence in the wood chips is expected to be moderate, and the SF treatment is expected to be effective, this results in a high level of uncertainties for infestation rates below the median and less uncertainties for rates above the median.

E.10.5 | Elicitation outcomes of the assessment of the pest freedom for ambrosia beetles on conifer wood chips

The following Tables show the elicited and fitted values for pest infestation (Table E.19) and pest freedom (Table E.20).

TABLE E.19 Elicited and fitted values of the uncertainty distribution of pest infestation by ambrosia beetles per 10,000 m^3 wood chips.

Percentile	1%	2.5%	5%	10%	17%	25%	33%	50%	67%	75%	83%	90%	95%	97.5%	99%
Elicited values	0					15		30		48					90
EKE	1.05	2.19	3.85	6.85	10.6	15.2	19.8	29.7	41.3	48.3	56.8	65.7	75.4	82.8	90.1

Note: The EKE results is the BetaGeneral (1.2554, 2.847, 0, 109) distribution fitted with @Risk version 7.6.

Based on the numbers of estimated infested wood chips the pest freedom was calculated (i.e. = 10,000 m^3 – number of infested wood chips per 10,000 m^3). The fitted values of the uncertainty distribution of the pest freedom are shown in Table E.20.

TABLE E.20 The uncertainty distribution of wood chips free of ambrosia beetles per 10,000 m^3 wood chips calculated by Table E.19.

Percentile	1%	2.5%	5%	10%	17%	25%	33%	50%	67%	75%	83%	90%	95%	97.5%	99%
Values	9910					9952		9970		9985					10,000
EKE results	9910	9917	9925	9934	9943	9952	9959	9970	9980	9985	9989	9993	9996	9998	9999

Note: The EKE results are the fitted values.

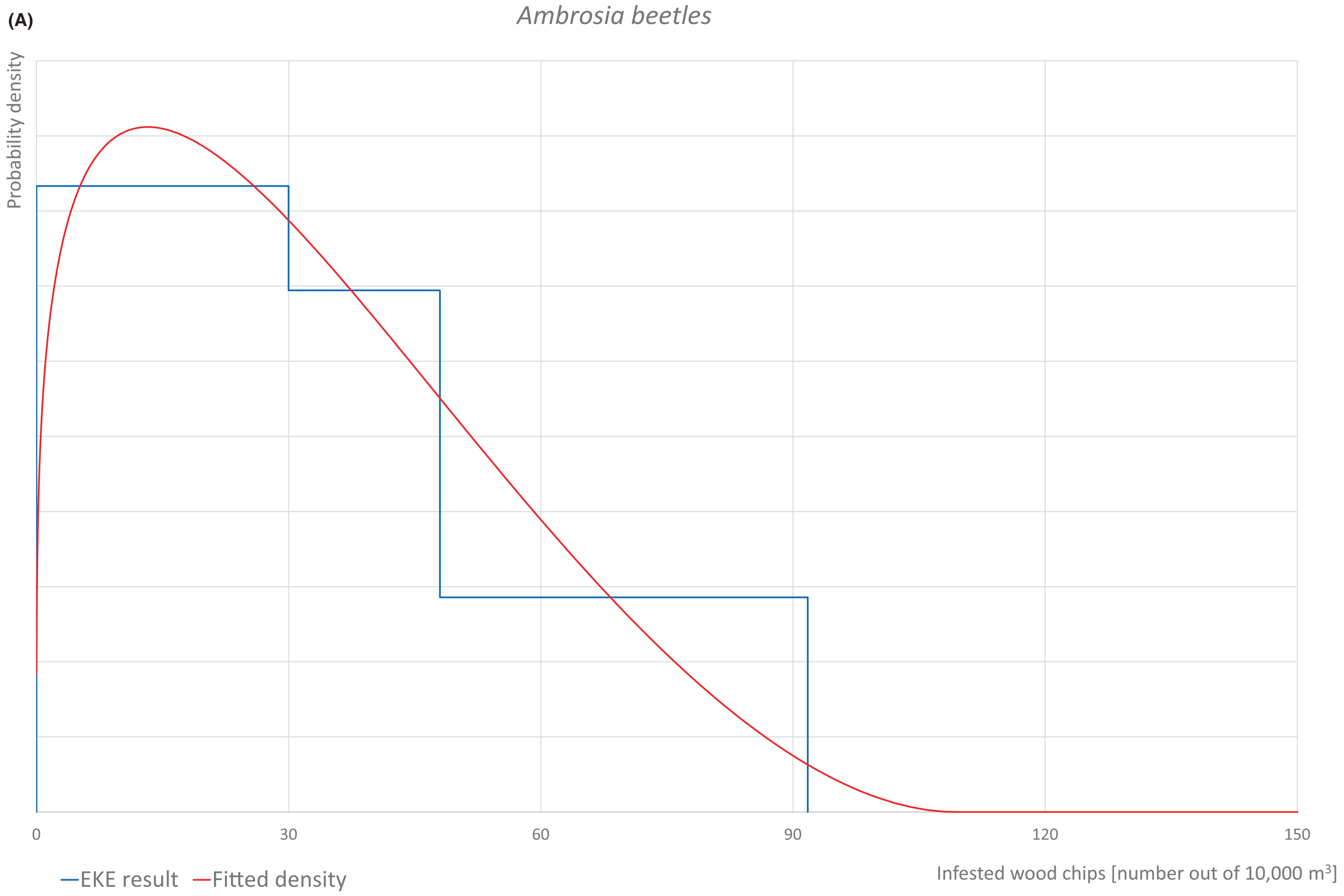

FIGURE E.10 (Continued)

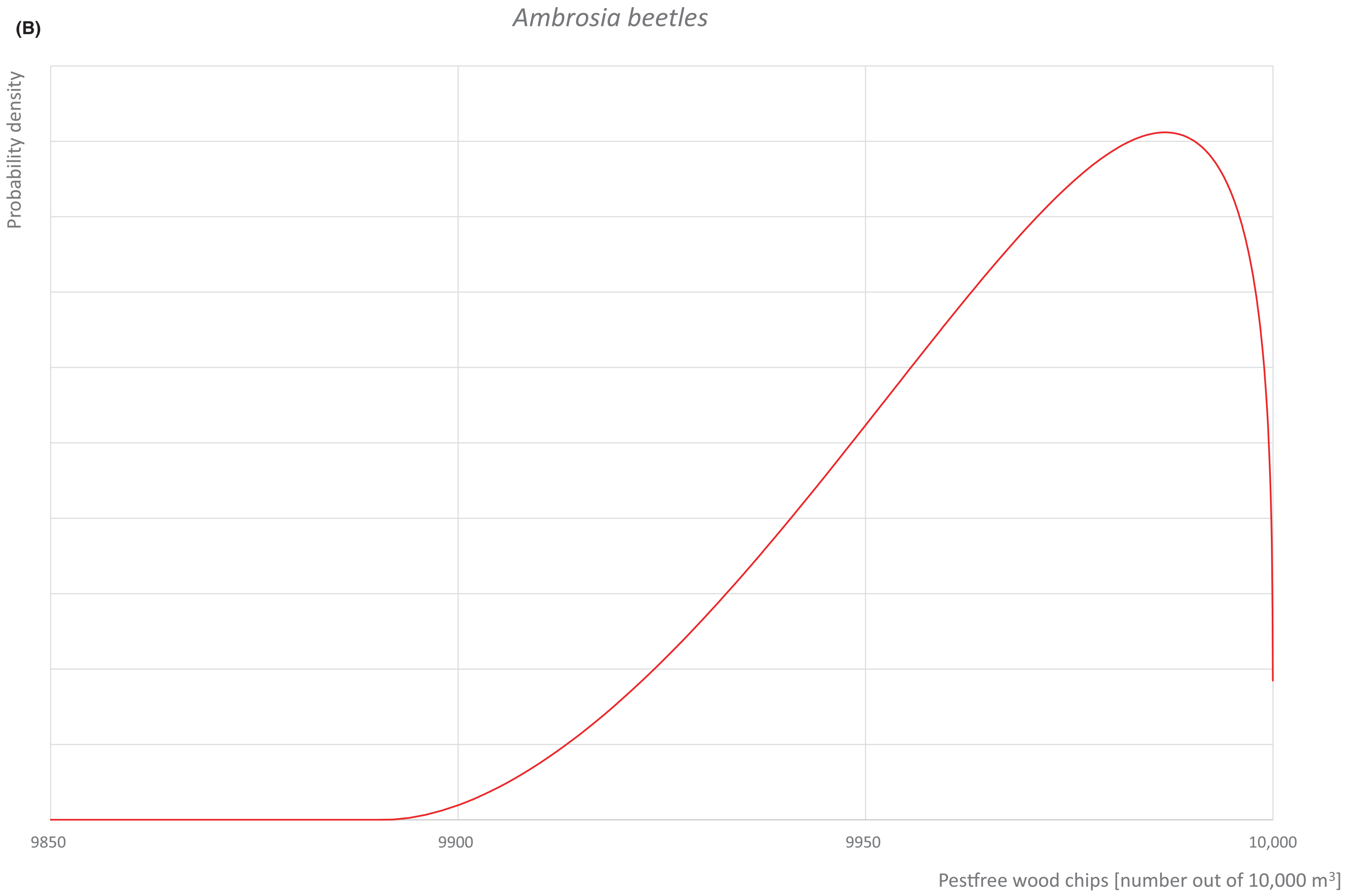

FIGURE E.10 (Continued)

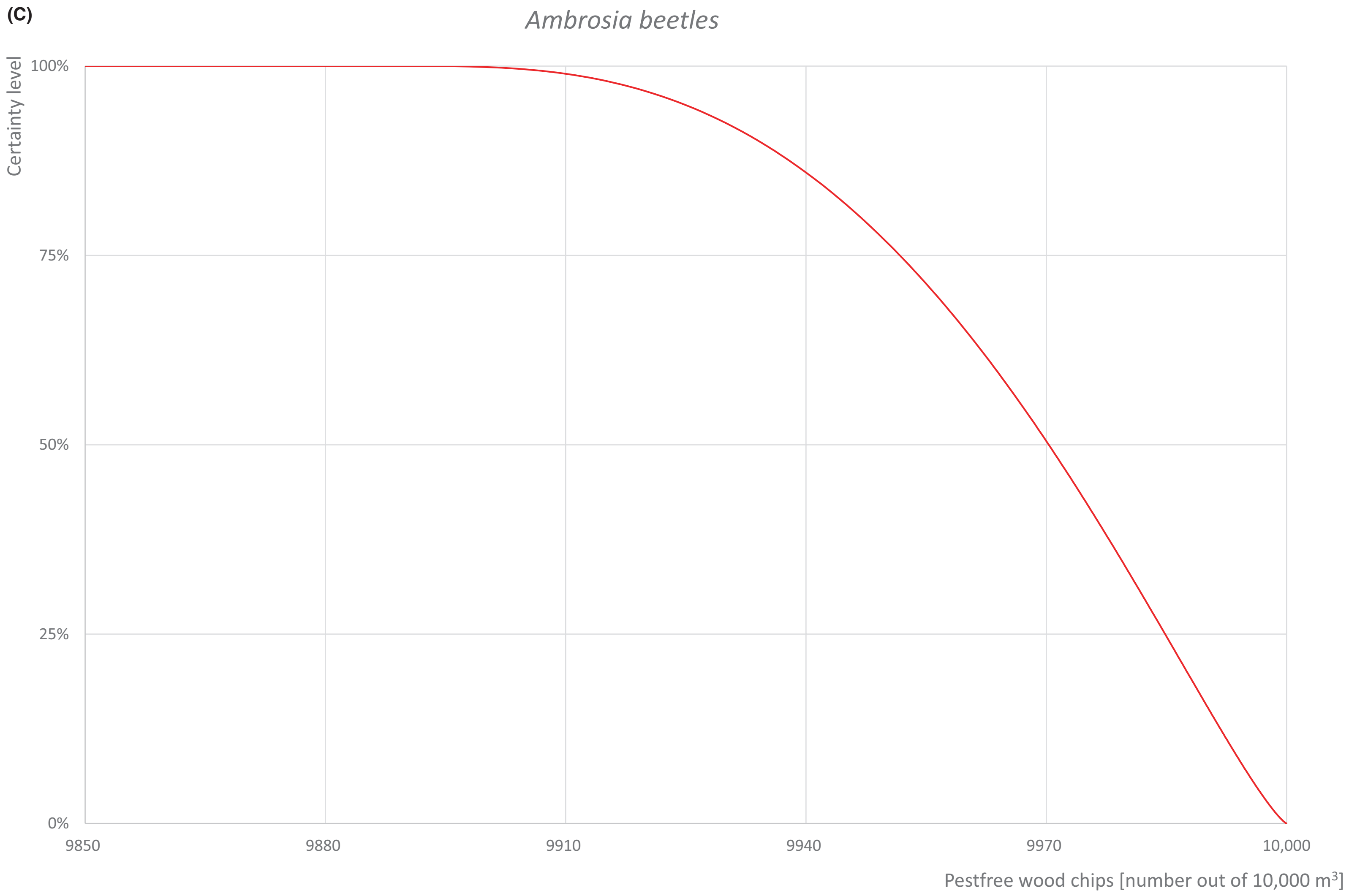

FIGURE E.10 (A) Elicited uncertainty of pest infestation per 10,000 m^3 wood chips (histogram in blue – vertical blue line indicates the elicited percentile in the following order: 1%, 25%, 50%, 75%, 99%) and distributional fit (red line); (B) uncertainty of the proportion of pest-free wood chips per 10,000 m^3 (i.e. = 1 – pest infestation proportion expressed as percentage); (C) descending uncertainty distribution function of pest infestation per 10,000 m^3 wood chips.

E.11 | OVERALL LIKELIHOOD OF PEST FREEDOM OF *CHORISTONEURA* SPECIES FOR CONIFER WOOD CHIPS

E.11.1 | Reasoning for a scenario which would lead to a reasonably low number of infested conifer wood chips

The scenario assumes that the presence of the pest in the wood chips is very low, and the risk mitigation measures, including the SF fumigation, are correctly performed and then fully effective in eliminating the pest in the wood chips.

E.11.2 | Reasoning for a scenario which would lead to a reasonably high number of conifer wood chips

The scenario assumes that the SF fumigation is not fully standardised, and the gas may not reach all the chips. This results in a not fully effective treatment in eliminating the pest in the wood chips. However, the pest presence in the wood chips is expected to be very low, what results in a very low number even for the worst scenario.

E.11.3 | Reasoning for a central scenario equally likely to over- or underestimate the number of infested conifer wood chips (Median)

The scenario assumes that the pest is only associated with the bark and during the overwintering phase. Therefore, it is highly unlikely that the pest will survive all treatments. Only if the pest is present in the remaining bark after debarking and if SF cannot reach all chips could the commodity become infested.

E.11.4 | Reasoning for the precision of the judgement describing the remaining uncertainties (1st and 3rd quartile/interquartile range)

The pest presence in the wood chips is expected to be very low, and the SF treatment is expected to be effective, this results in a high level of uncertainties for infestation rates below the median and less uncertainties for rates above the median.

E.11.5 | Elicitation outcomes of the assessment of the pest freedom for *Choristoneura* species on conifer wood chips

The following Tables show the elicited and fitted values for pest infestation (Table E.21) and pest freedom (Table E.22).

TABLE E.21 Elicited and fitted values of the uncertainty distribution of pest infestation by *Choristoneura* species per 10,000 m^3 wood chips.

Percentile	1%	2.5%	5%	10%	17%	25%	33%	50%	67%	75%	83%	90%	95%	97.5%	99%
Elicited values	0					0.75		1.25		2.5					5
EKE	0.0348	0.0786	0.146	0.276	0.447	0.662	0.887	1.39	2.01	2.40	2.88	3.42	4.02	4.50	5.01

Note: The EKE results is the BetaGeneral (1.1354, 3.4543, 0, 6.65) distribution fitted with @Risk version 7.6.

Based on the numbers of estimated infested wood chips the pest freedom was calculated (i.e. = 10,000 m^3 – number of infested wood chips per 10,000 m^3). The fitted values of the uncertainty distribution of the pest freedom are shown in Table E.22.

TABLE E.22 The uncertainty distribution of wood chips free of *Choristoneura* species per 10,000 m^3 wood chips calculated by Table E.21.

Percentile	1%	2.5%	5%	10%	17%	25%	33%	50%	67%	75%	83%	90%	95%	97.5%	99%
Values	9995					9997.5		9998.75		9999.25					10,000
EKE results	9995.0	9995.5	9996.0	9996.6	9997.1	9997.6	9998.0	9998.6	9999.1	9999.3	9999.6	9999.7	9999.85	9999.92	9999.97

Note: The EKE results are the fitted values.

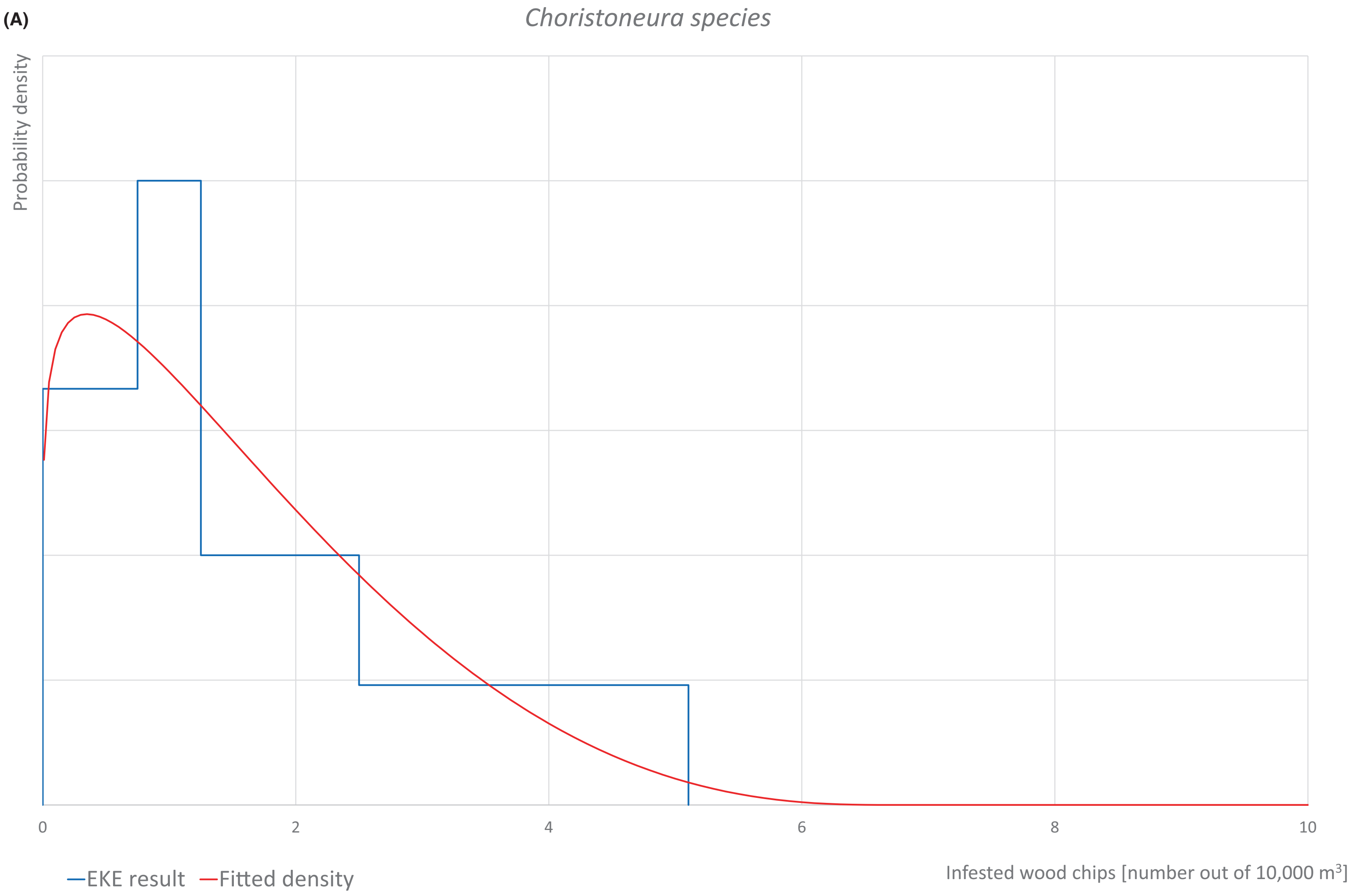

FIGURE E.11 (Continued)

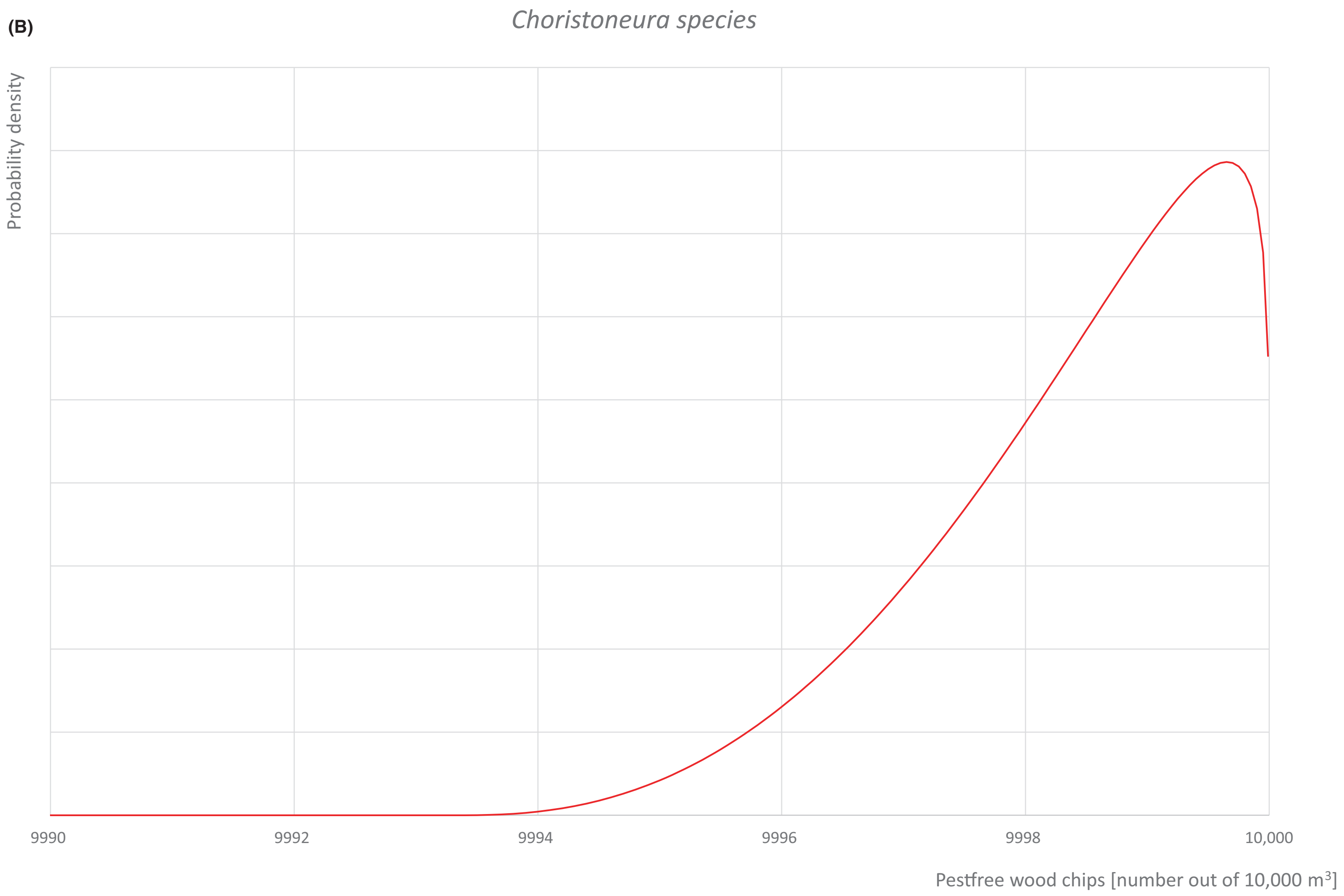

FIGURE E.11 (Continued)

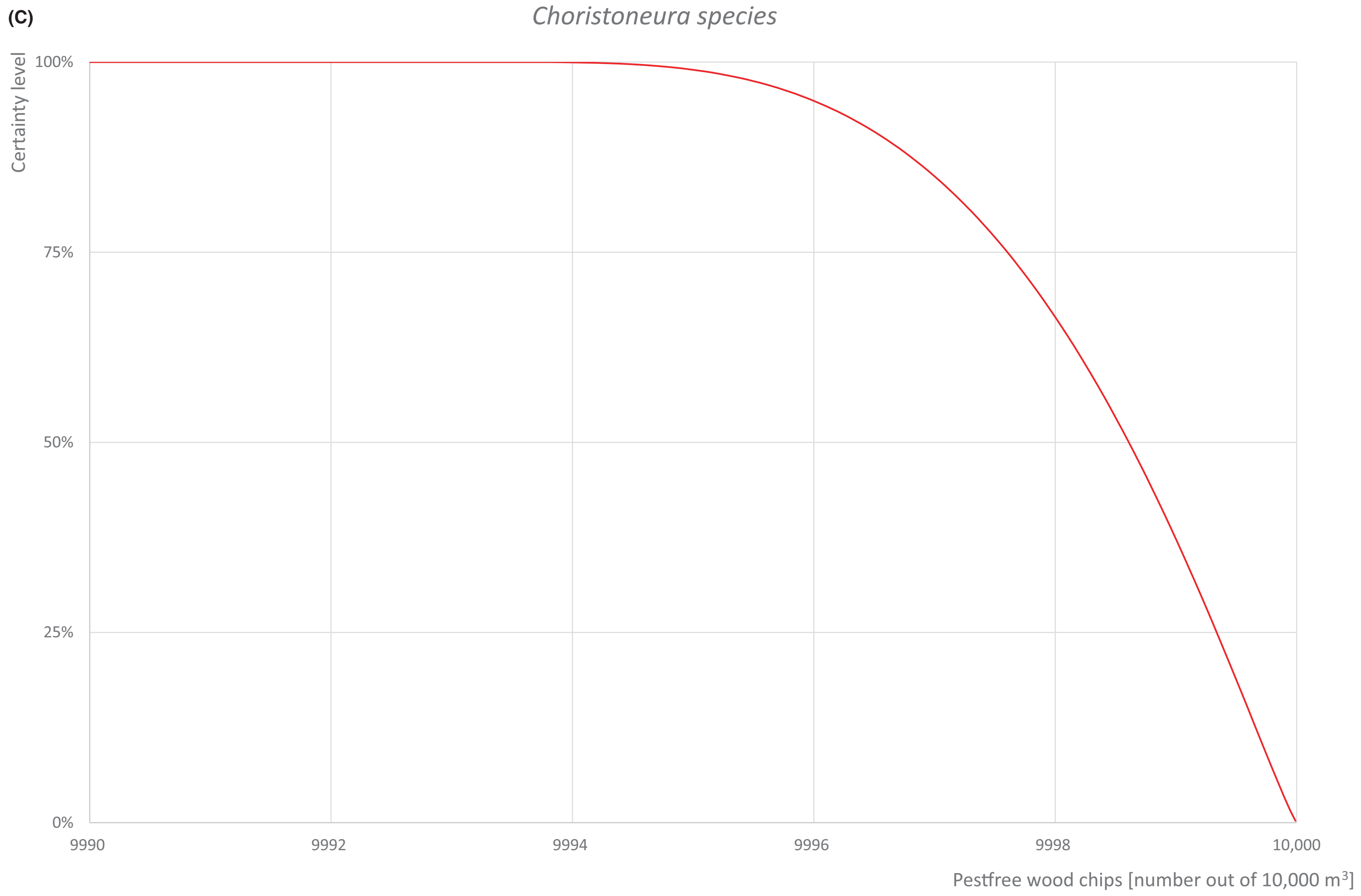

FIGURE E.11 (A) Elicited uncertainty of pest infestation per 10,000 m^3 wood chips (histogram in blue – vertical blue line indicates the elicited percentile in the following order: 1%, 25%, 50%, 75%, 99%) and distributional fit (red line); (B) uncertainty of the proportion of pest-free wood chips per 10,000 m^3 (i.e. = 1 – pest infestation proportion expressed as percentage); (C) descending uncertainty distribution function of pest infestation per 10,000 m^3 wood chips.

E.12 | OVERALL LIKELIHOOD OF PEST FREEDOM OF *LYCORMA DELICATULA* FOR CONIFER WOOD CHIPS

E.12.1 | Reasoning for a scenario which would lead to a reasonably low number of infested conifer wood chips

The scenario assumes that the risk mitigation measures, including the SF fumigation, are correctly performed and then fully effective in eliminating the pest in the wood chips.

E.12.2 | Reasoning for a scenario which would lead to a reasonably high number of conifer wood chips

The scenario assumes that the SF fumigation is not fully standardised, and the gas may not reach all the chips. This results in a not fully effective treatment in eliminating the pest in the wood chips. The scenario also considers the low susceptibility of conifers to the pest and the presence of eggs on the surface of the wood and not inside it, what results in low numbers even for the worst-case scenario.

E.12.3 | Reasoning for a central scenario equally likely to over- or underestimate the number of infested conifer wood chips (Median)

The scenario assumes that the pest is very unlikely to survive all treatments. Only if the SF cannot reach all the chips the commodity could be infested. The scenario also assumes that overall prevalence of the pest is not expected to be high on the trees used for woodchip production as it is expected a low susceptibility of conifers to the pest.

E.12.4 | Reasoning for the precision of the judgement describing the remaining uncertainties (1st and 3rd quartile/interquartile range)

There is a lack of experimental evidence of the efficacy of SF treatment on this specific pest. However, many scientific studies show its efficacy on other similar pests, so the treatment is expected to be effective. Conifers are not expected to be a good host for the pest. This results in a high level of uncertainties for infestation rates below the median, and less uncertainties for rates above the median.

E.12.5 | Elicitation outcomes of the assessment of the pest freedom for *Lycorma delicatula* on conifer wood chips

The following Tables show the elicited and fitted values for pest infestation (Table E.23) and pest freedom (Table E.24).

TABLE E.23 Elicited and fitted values of the uncertainty distribution of pest infestation by *Lycorma delicatula* per 10,000 m^3 wood chips.

Percentile	1%	2.5%	5%	10%	17%	25%	33%	50%	67%	75%	83%	90%	95%	97.5%	99%
Elicited values	0					1.5		2.5		5					10
EKE	0.0705	0.159	0.295	0.554	0.895	1.32	1.77	2.78	4.02	4.79	5.77	6.84	8.05	9.03	10.1

Note: The EKE results is the BetaGeneral (1.1406, 3.5355, 0, 13.5) distribution fitted with @Risk version 7.6.

Based on the numbers of estimated infested wood chips the pest freedom was calculated (i.e. = 10,000 m^3 – number of infested wood chips per 10,000 m^3). The fitted values of the uncertainty distribution of the pest freedom are shown in Table E.24.

TABLE E.24 The uncertainty distribution of wood chips free of *Lycorma delicatula* per 10,000 m^3 wood chips calculated by Table E.23.

Percentile	1%	2.5%	5%	10%	17%	25%	33%	50%	67%	75%	83%	90%	95%	97.5%	99%
Values	9990					9995		9998		9999					10,000
EKE results	9990	9991	9992	9993	9994	9995	9996	9997	9998.2	9998.7	9999.1	9999.4	9999.7	9999.8	9999.9

Note: The EKE results are the fitted values.

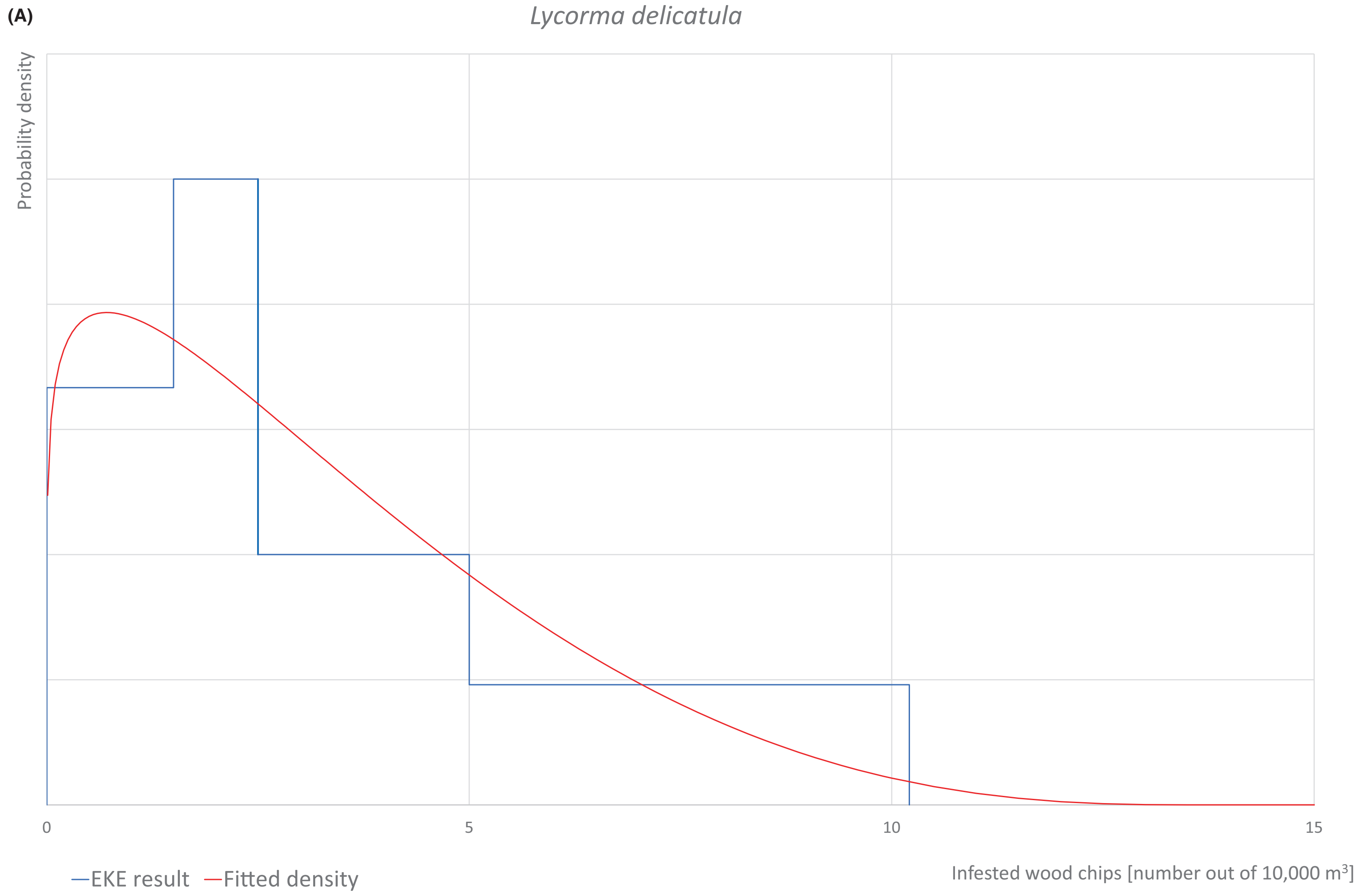

FIGURE E.12 (Continued)

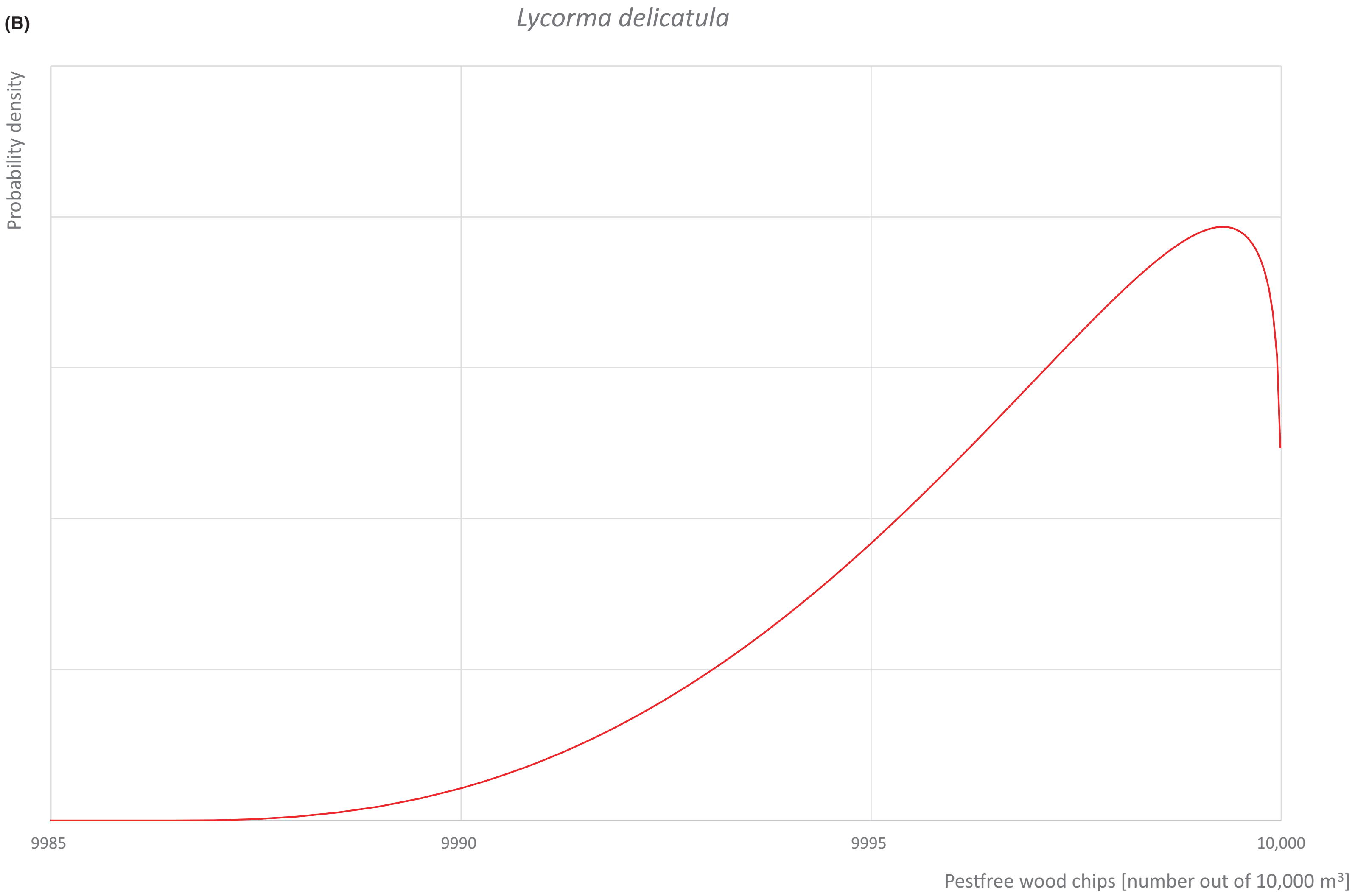

FIGURE E.12 (Continued)

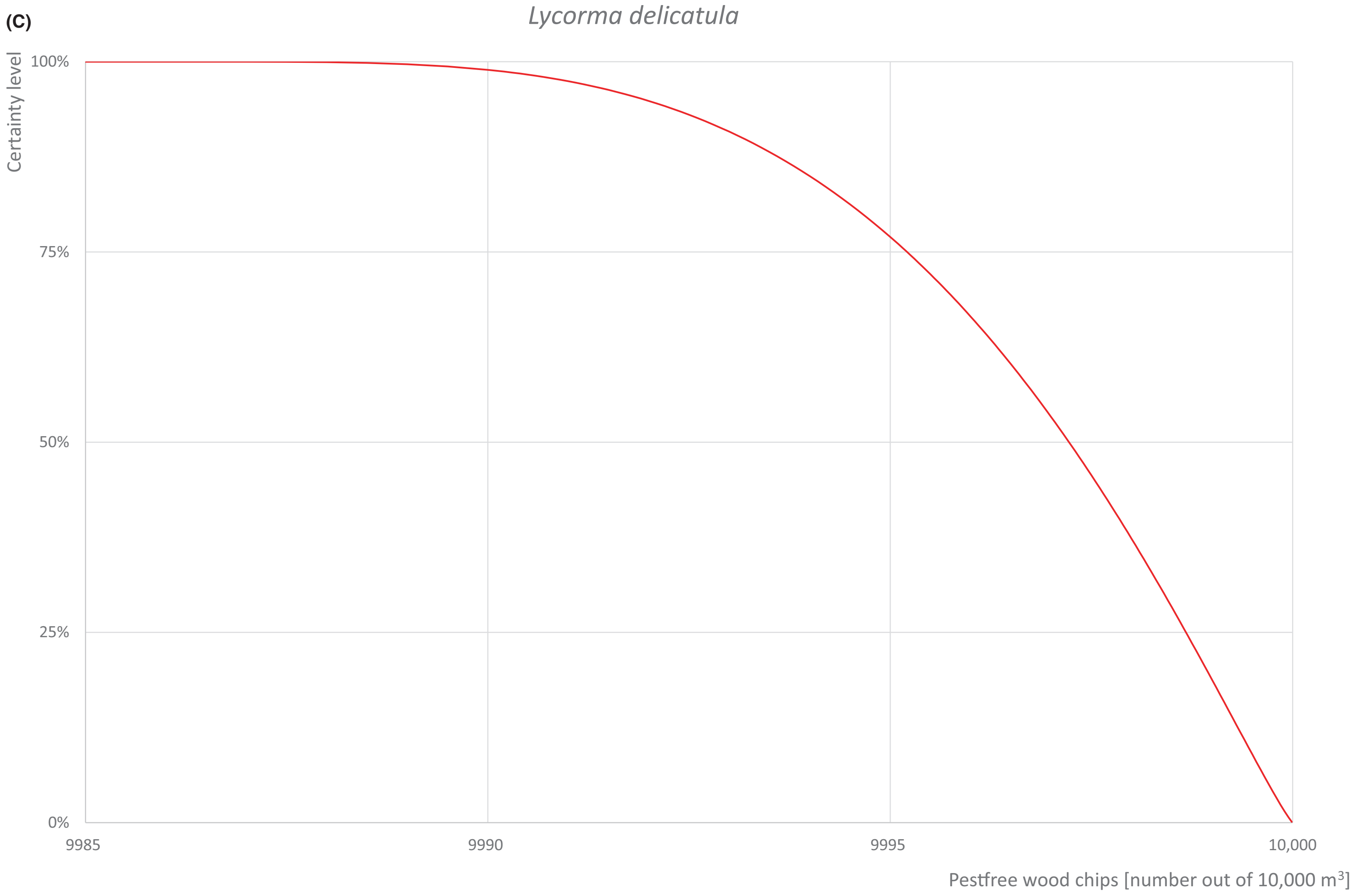

FIGURE E.12 (A) Elicited uncertainty of pest infestation per 10,000 m^3 wood chips (histogram in blue – vertical blue line indicates the elicited percentile in the following order: 1%, 25%, 50%, 75%, 99%) and distributional fit (red line); (B) uncertainty of the proportion of pest-free wood chips per 10,000 m^3 (i.e. = 1 – pest infestation proportion expressed as percentage); (C) descending uncertainty distribution function of pest infestation per 10,000 m^3 wood chips.

E.13 | OVERALL LIKELIHOOD OF PEST FREEDOM OF *PISSODES* AND BARK BEETLES FOR CONIFER WOOD CHIPS

E.13.1 | Reasoning for a scenario which would lead to a reasonably low number of infested conifer wood chips

The scenario assumes that the risk mitigation measures, including the SF fumigation, are correctly performed and then fully effective in eliminating the pest in the wood chips.

E.13.2 | Reasoning for a scenario which would lead to a reasonably high number of conifer wood chips

The scenario assumes a reasonably high prevalence of the pest in the area where the trees used for wood chip production. The scenario also assumes that the pest could be present in the commodity if it survives in the remaining 2% of the bark after chipping. Finally, the scenario assumes that the risk mitigation measures, including the SF fumigation are not fully effective in eliminating the pest in the wood chips (SF fumigation treatment could be not fully standardised, and the gas may not reach all the chips).

E.13.3 | Reasoning for a central scenario equally likely to over- or underestimate the number of infested conifer wood chips (Median)

The scenario assumes that the pest is very unlikely to survive all treatments. Only if the pest is present in the remaining bark after debarking and if SF cannot reach all chips could the commodity become infested.

E.13.4 | Reasoning for the precision of the judgement describing the remaining uncertainties (1st and 3rd quartile/interquartile range)

The pest presence in the wood chips is expected to be low (just in the remaining bark after debarking), and the SF treatment is expected to be effective, this results in a high level of uncertainties for infestation rates below the median and less uncertainties for rates above the median.

E.13.5 | Elicitation outcomes of the assessment of the pest freedom for *Pissodes* and bark beetles on conifer wood chips

The following Tables show the elicited and fitted values for pest infestation (Table E.25) and pest freedom (Table E.26).

TABLE E.25 Elicited and fitted values of the uncertainty distribution of pest infestation by *Pissodes* and bark beetles per 10,000 m^3 wood chips.

Percentile	1%	2.5%	5%	10%	17%	25%	33%	50%	67%	75%	83%	90%	95%	97.5%	99%
Elicited values	0					2.5		5		8					15
EKE	0.175	0.365	0.643	1.14	1.77	2.53	3.30	4.95	6.88	8.05	9.46	11.0	12.6	13.8	15.0

Note: The EKE results is the BetaGeneral (1.2563, 2.8559, 0, 18.2) distribution fitted with @Risk version 7.6.

Based on the numbers of estimated infested wood chips the pest freedom was calculated (i.e. = 10,000 m^3 – number of infested wood chips per 10,000 m^3). The fitted values of the uncertainty distribution of the pest freedom are shown in Table E.26.

TABLE E.26 The uncertainty distribution of wood chips free of *Pissodes* and bark beetles per 10,000 m^3 wood chips calculated by Table E.25.

Percentile	1%	2.5%	5%	10%	17%	25%	33%	50%	67%	75%	83%	90%	95%	97.5%	99%
Values	9985					9992		9995		9998					10,000
EKE results	9985	9986	9987	9989	9991	9992	9993	9995	9997	9997	9998.2	9998.9	9999.4	9999.6	9999.8

Note: The EKE results are the fitted values.

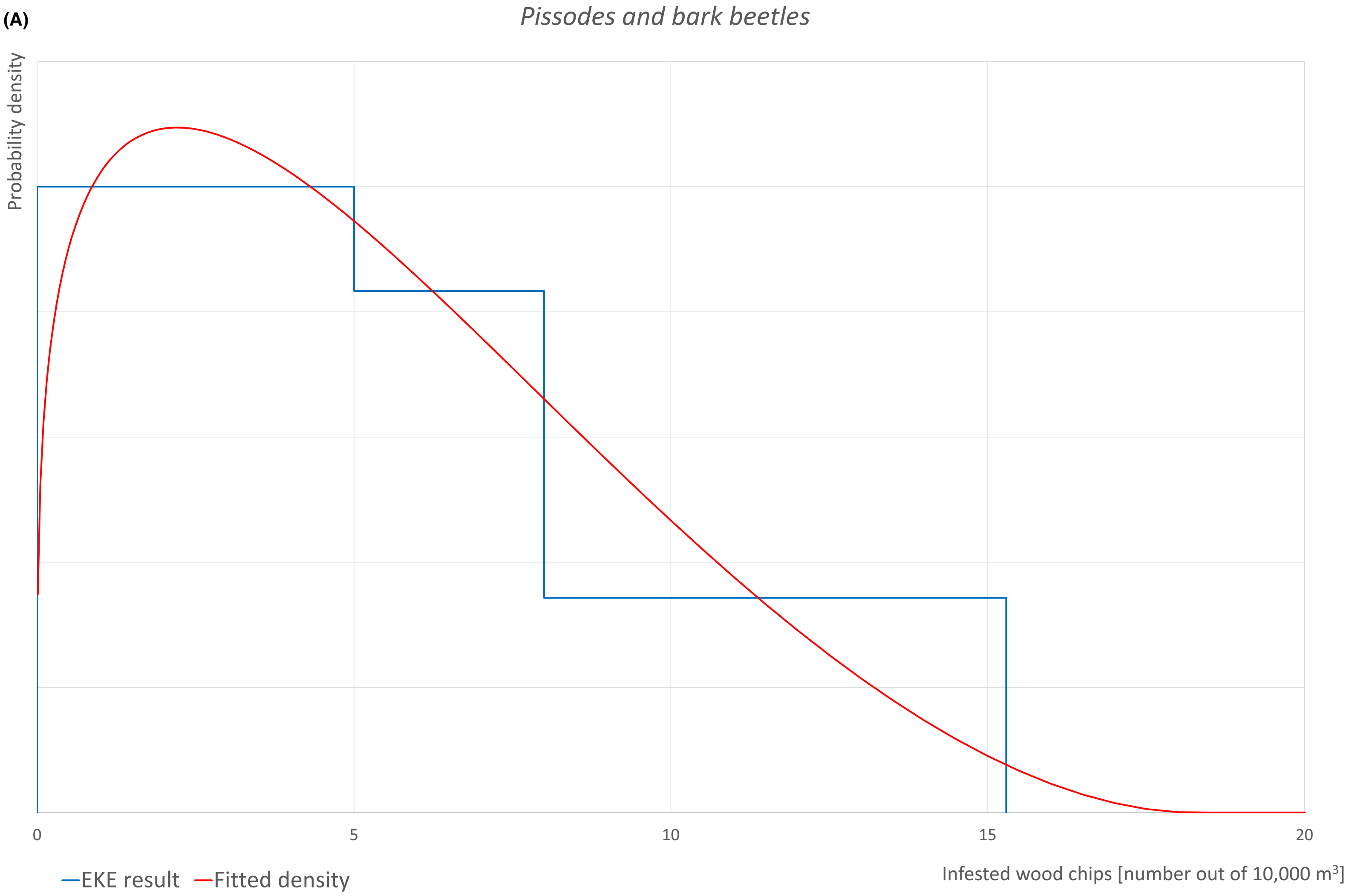

FIGURE E.13 (Continued)

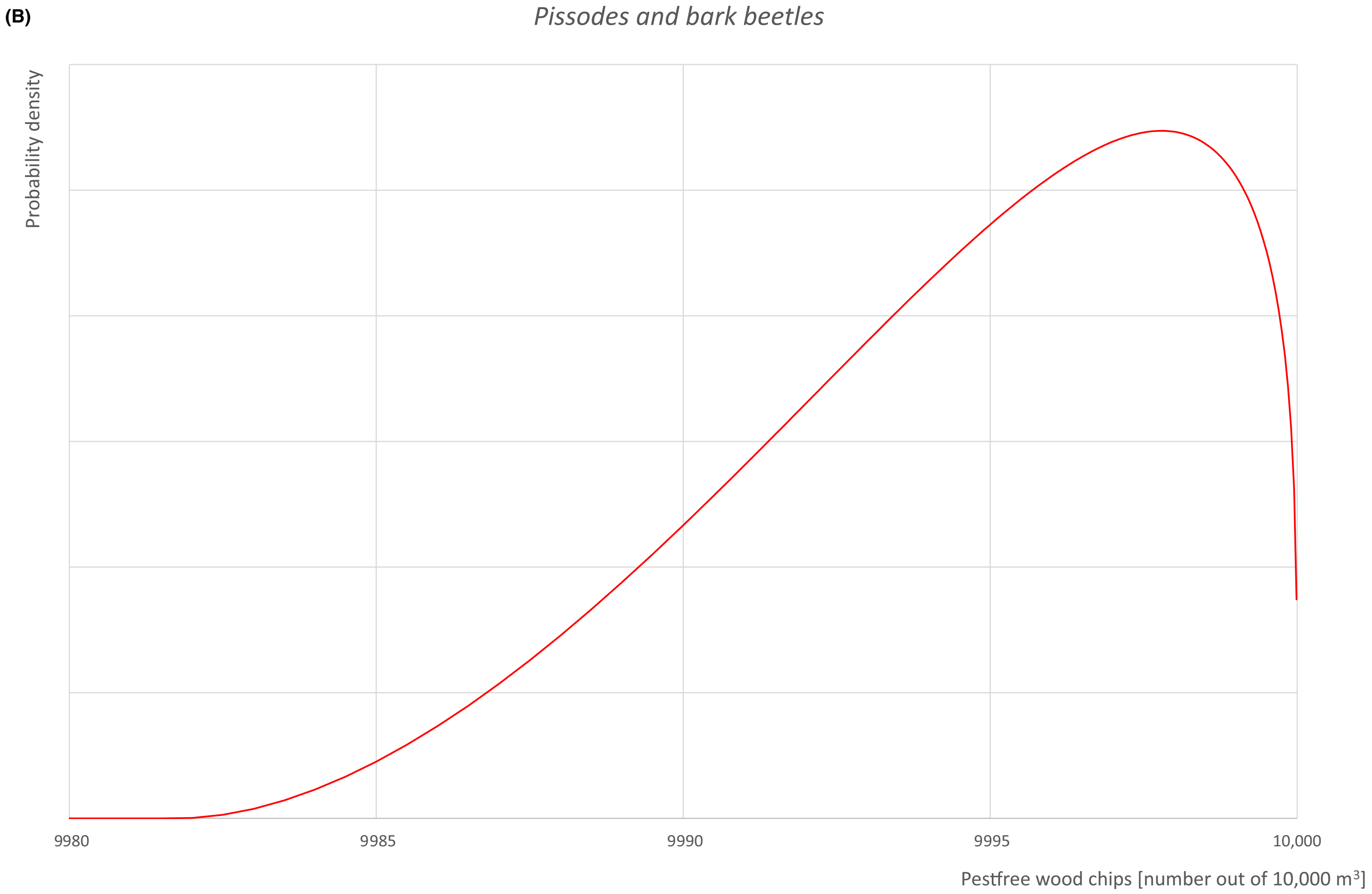

FIGURE E.13 (Continued)

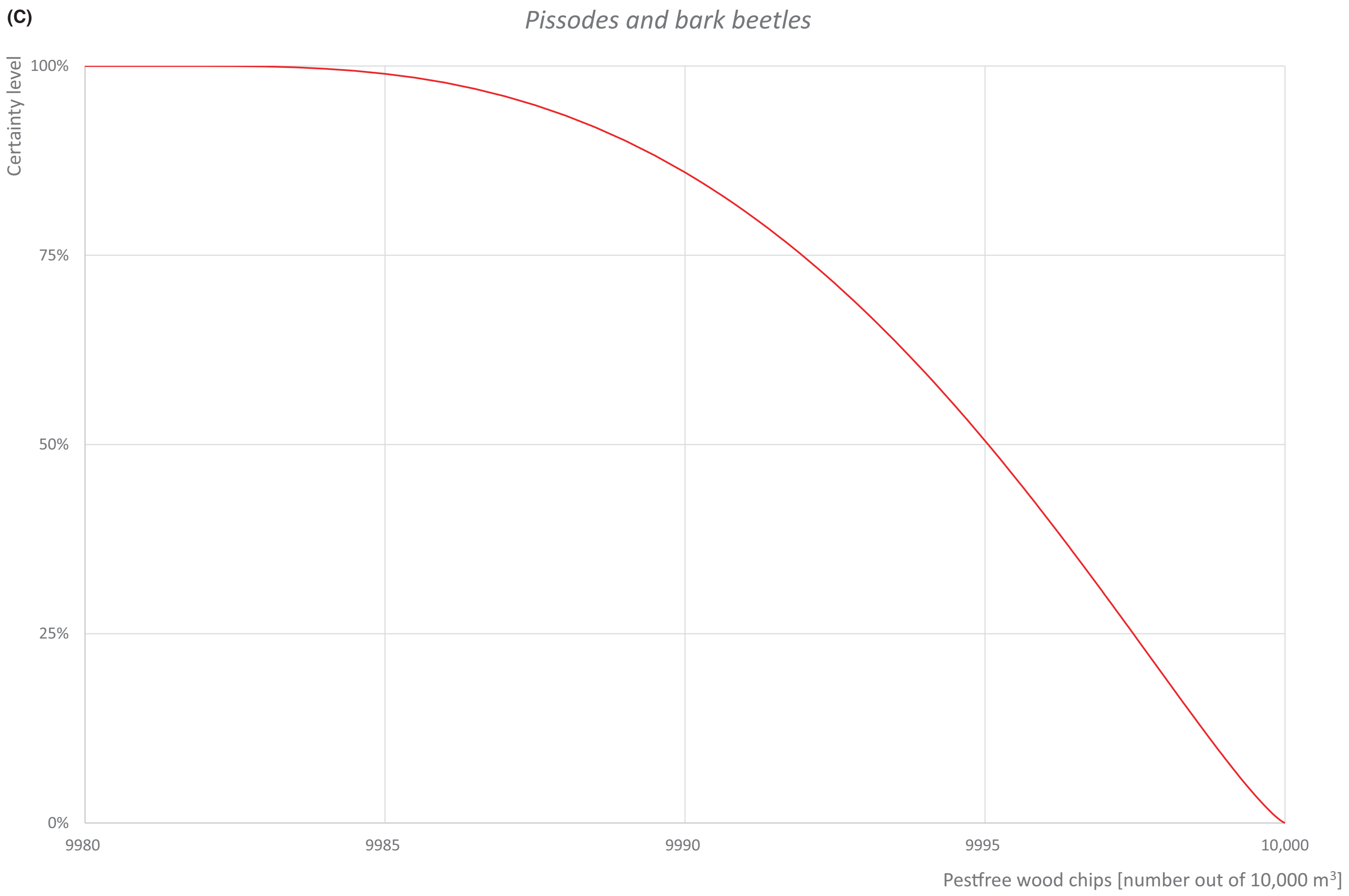

FIGURE E.13 (A) Elicited uncertainty of pest infestation per 10,000 m^3 wood chips (histogram in blue – vertical blue line indicates the elicited percentile in the following order: 1%, 25%, 50%, 75%, 99%) and distributional fit (red line); (B) uncertainty of the proportion of pest-free wood chips per 10,000 m^3 (i.e. =1 – pest infestation proportion expressed as percentage); (C) descending uncertainty distribution function of pest infestation per 10,000 m^3 wood chips.

APPENDIX F

Excel file with the EU quarantine pest list of conifer species

Appendix F is available under the Supporting Information section on the online version of the scientific output.