SCIENTIFIC OPINION

EFSA Journal

ADOPTED: 24 May 2017

doi: 10.2903/j.efsa.2017.4877

Pest risk assessment of *Atropellis* spp. for the EU territory

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Abstract

Following a request from the European Commission, the EFSA Plant Health (PLH) Panel performed a risk assessment for *Atropellis* spp. in the EU focusing on the risk of entry, the host range and the potential impacts. *Atropellis* is a fungal pathogen of several *Pinus* spp. in North America. The pathogen has not been reported from Europe and is a quarantine pest regulated in Annex IIAI of Council Directive 2000/29/EC on plants (other than fruit and seeds), isolated bark and wood of *Pinus*. The main pathways of entry considered were *Pinus* plants, wood and isolated bark. Given the ban of importing *Pinus* plants from outside Europe into the EU and the lack of information on EU imports of isolated *Pinus* bark, only the wood pathway was assessed quantitatively. The conclusion of the assessment of entry for scenario A0 (current regulatory situation) is that the risk of entry of *Atropellis* spp. is close to zero. This conclusion is expected to apply also in the case of removing the specific *Atropellis* regulations, because of the remaining generic *Pinus* requirements, as well as in a scenario with additional risk reduction options. The uncertainty associated with this assessment is relatively limited, given that all the quartiles of the estimated distribution of the number of potential founder populations are close to zero. For the North American *Pinus* spp. known to be susceptible and widely planted in the EU (mainly *P. contorta* and *P. strobus*), the damage observed in North America (loss of wood quality, stem deformations, mortality in young stands, environmental consequences) is expected in the EU to a similar (or higher) degree, should the pathogen be introduced. Similar impacts are expected on the European *Pinus* spp. known to be host of *Atropellis* spp. These include widespread and locally abundant species such as *P. nigra, P. sylvestris* and *P. pinaster*. There are, however, large uncertainties associated with this impact assessment due to the unknown susceptibility of several other *Pinus* spp. present in Europe. There is a need for research on the susceptibility to *Atropellis* spp. of those European *Pinus* spp.

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Keywords: Canada, forest pathology, *Pinus* spp., quarantine pests, risk reduction options, USA, wood trade

Requestor: European Commission

Question number: EFSA-Q-2016-00490

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Acknowledgements: The Panel wishes to thank EFSA staff member: Olaf Mosbach-Schulz for the support provided to this scientific output.

Suggested citation: EFSA Panel on Plant Health (PLH), Jeger M, Caffier D, Candresse T, Chatzivassiliou E, Dehnen-Schmutz K, Gilioli G, Grégoire J-C, Jaques Miret JA, MacLeod A, Navajas Navarro M, Niere B, Parnell S, Potting R, Rafoss T, Urek G, Van Bruggen A, Van Der Werf W, West J, Winter S, Boberg J, Porta Puglia A, Vettraino AM, Pautasso M and Rossi V, 2017. Scientific Opinion on the pest risk assessment of *Atropellis* spp. for the EU territory. EFSA Journal 2017;15(7): 4877, 46 pp.https://doi.org/10.2903/j.efsa.2017.4877

ISSN: 1831-4732

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The EFSA Journal is a publication of the European Food Safety Authority, an agency of the European Union.

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1. Introduction

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

The European Food Safety Authority (EFSA) was requested, pursuant to Article 22(5.b) and Article 29(1) of Regulation (EC) No 178/20002, to provide a scientific opinion in the field of plant health. Specifically, as a follow up to the request of 29 March 2014 (Ares(2014)970361) and the pest categorisations (step 1) delivered in the meantime for 38 regulated pests, EFSA is requested to complete the pest risk assessment (PRA), to identify risk reduction options and to provide an assessment of the effectiveness of current EU phytosanitary requirements (step 2) for *Atropellis* spp.

During the preparation of this opinion, EFSA was requested to take into account the outcome of the European Commission Working Group on the future regulatory status of *Atropellis* spp. (annexed to the letter and presented below in Section 1.1.1), prepared on the basis of the EFSA pest categorisations and discussed with Member States in the relevant Standing Committee. In order to gain time and resources, the recommendations[1] highlight, where possible, some elements which require further work during the completion of the PRA process.

1.1.1. Outcome of the European Commission Working Group on the Annexes of the Council Directive 2000/29/EC – Section II – Listing of Harmful Organisms as regards the future listing of *Atropellis* spp.

Current regulatory status. *Atropellis* spp. is currently listed in Annex IIAI (c.3) of Council Directive 2000/29/EC[2] on plants of *Pinus* L., other than fruit and seeds, isolated bark and wood of *Pinus* L.

Special requirements are laid down under Annex IVAI as regards the introduction and movement of plants, plant products and other objects into and within all Member States.

Atropellis spp. host plants are regulated also in Annex IIIA as regards import prohibitions for the entire European Union (EU) for specific commodities and in Annex VAI, Annex VAII, Annex VBI and Annex VBII as commodities subject to plant health inspections and phytosanitary certificate or plant passport.

Host plants of *Atropellis* spp., regulated in Annex IIAII, are explicitly mentioned also in the Council Directive 1999/105/EC on the marketing of forest reproductive material and Council Directive 98/56/EC on the marketing of propagating material of ornamental plants.

Identity of the pest. *Atropellis* spp. consists of four native North American species: *Atropellis apiculata, Atropellis pinicola, Atropellis piniphila* and *Atropellis tingens*. All four species are clearly defined organisms and differentiation between species is based on their morphological and cultural characteristics. Detection is based on visual symptoms.

Infection can be asymptomatic for quite a long time. It is necessary that apothecia are present, which may require several years to appear.

Atropellis cankers may be similar to those caused by certain rust fungi (stalactiform rust on *Pinus contorta* and white pine blister rust on *Pinus monticola*), but *Atropellis* cankers are easily distinguishable by the presence of 'blue-stained' wood beneath the affected bark.

Distribution of the pest. *A. pinicola* is present only in western North America while *A. piniphila* has a wider geographical distribution in North America. *A. apiculata* is known only from the states of North Carolina and Virginia in the eastern USA. *A. tingens* is found throughout eastern North America (Nova Scotia to Florida) as well as in Colorado and British Columbia.

Atropellis spp. are not known to occur in the EU so far. No information was retrieved in the literature concerning the presence of *Atropellis* spp. in the risk assessment area.

Potential for establishment and spread in the PRA area. All species belonging to the genus *Pinus* are hosts for *Atropellis* spp. The susceptibility to infection with the four pathogenic *Atropellis* species varies among *Pinus* species native to Europe and Eurasia.

As hosts of *Atropellis* spp. are present in most parts of the risk assessment area and considering also the biology of the pathogen and the similarities between the European climate and the climate in

[1] Recommendation of the Working Group on the Annexes of the Council Directive 2000/29/EC – Section II – Listing of Harmful Organisms as regards the future listing of *Atropellis* spp. Scientific basis for the recommendation: EFSA PLH Panel (EFSA Panel on Plant Health), 2014. Scientific Opinion on the pest categorisation of *Atropellis* spp. EFSA Journal 2014;12(12):3926, 33 pp. https://doi.org/10.2903/j.efsa.2014.3926. http://www.efsa.europa.eu/en/efsajournal/doc/3926.pdf

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

Canada and the USA where the pathogen is known to be present, that there are no obvious eco-climatic factors limiting the potential establishment and spread of the pathogen in the risk assessment area.

Atropellis spp. may spread over long distances by means of movement of infected host plants for planting, cut branches, wood or isolated bark. Inoculum capable of establishing new infections consists of ascospores which are wind dispersed (less than 100 m) in summer or early autumn. Rain may also play a secondary role in dispersal. They germinate under appropriate conditions of moisture and temperature, and the mycelium penetrates undamaged bark or leaf scars. The spread by natural means is expected to be relatively low.

Potential for consequences in the PRA area. Infection can be asymptomatic for quite a long time cause cancers in their early stage show no external sign of the underlying infection. It could take 2–5 years until infection could be seen on small branches and stems of small, suppressed trees. In the case of large, vigorous trees, it can often take 20 or more years for stem infections to manifest. Inoculum production, once it has begun, continues each year until the death of the host. Inoculum formation on cankers left after clear-cutting usually ceases within a year.

Atropellis spp. do not grow quickly and are generally not aggressive pathogens. However, *A. piniphila* has been recorded to cause up to 31% mortality in severely infected stands of *P. contorta* (lodgepole pine). Single cankers may occasionally kill small trees but mortality is uncommon in vigorous trees, and usually occurs only when multiple cankers encircle the stem.

The cankers may cause malformation of the trees resulting in lower wood quality or tree marketability due to 'blue-stained' wood beneath the affected bark. In cankered parts of the host, copious amounts of resin are produced, and the bark is tightly attached to the underlying wood, thus affecting the debarking and chipping characteristics of the wood.

The impacts of *Atropellis* spp. in North American forests are minor. Damage caused by the pathogens tends to be sporadic and of limited extent. In Christmas tree farms, particularly in eastern North America. In both forests and in Christmas tree farms, damage from *Atropellis* spp. is minimal and can be controlled by appropriate cultural practices and sanitation measures.

No recent information is available in the literature on the consequences of *Atropellis* spp. in the infested areas of North America. No information is available on possible environmental effect of the disease.

Recommendation. The Working Group had concerns regarding the pathways for spreading of the pest and its apparent economic impact and proposes maintaining *Atropellis* spp. as a **Union Quarantine status**. *Atropellis* spp. also do not occur in the EU.

The Pest Risk Assessment has to continue. In particular, EFSA is asked to provide, on the basis of the main pathways of distribution, further information on probability of entry into the European Union, clarify the host range affected by *Atropellis* spp., and develop proper risk reduction options on which further regulatory measures may be taken. There is no need to provide specific details on the probability of establishment in the EU, as it is already known. Economic and environmental consequences should be, however, further studied.

1.2. Interpretation of the Terms of Reference

1.2.1. Pest categorisation

The EFSA Plant Health Panel already provided a pest categorisation on *Atropellis* spp. in the past (EFSA PLH Panel, 2014) that remains valid and is therefore not repeated here.

1.2.2. Interpretation of ToR and recommendations

The Panel interpreted the Terms of Reference (ToR) as a request to prepare a risk assessment (RA) on *Atropellis* spp., for the EU (i.e. the RA area) and thus to provide information on the probability of entry of these fungi, based on the previously published pest categorisation, taking into consideration only the following main pathways: (1) plants (plants for planting, Christmas trees, ornamental cut branches and bonsais); (2) wood (any kinds, with or without bark); and (3) isolated bark.

The different aspects of these pathways that are relevant for this RA are described in Section 1.2.2.1. All three pathways of entry are subjected to current regulation, which is summarised in Section 1.2.2.2. Based on Sections 1.2.2.1 and 1.2.2.2, the Panel defined the scenarios listed in Section 1.2.2.3 and assessed in detail in Appendix A.

In agreement with the ToR and because there are no sufficient data to consider the different *Atropellis* spp. and their hosts separately, the assessment was done for *Atropellis* spp. and *Pinus* spp.

The recommendation to clarify the host range and to further study economic and environmental consequences was addressed by searching for additional information on the host status of *Pinus* spp. and by extrapolating to the EU a model developed in British Columbia on the impact of *Atropellis* spp. on lodgepole pine.

1.2.2.1. Description of the pathways of entry

Pathway 1: plants. Based on the definition of 'plants' in Article 2 of 2000/29/EC, this pathway includes plants for planting, Christmas trees and cut branches (for ornamental purposes). *Atropellis* spp. are not known to be transmitted by *Pinus* fruit or seeds.

Pathway 2: wood. *Pinus* wood becomes infected by *Atropellis* spp. trough ascospores. Ascospores germinate under appropriate conditions of moisture and temperature, and the mycelium penetrates undamaged bark or leaf scars (*A. tingens* penetrates the base of the needle) of susceptible hosts (Lightle and Thompson, 1973; Thomas and Pickel, 2010). Infection can remain asymptomatic for quite a long time. A period of 2–5 years usually elapses between infection and the onset of symptoms on small branches and stems of small, suppressed trees (Lockman, 2005; Sinclair and Lyon, 2005). In the case of large, vigorous trees, it can often take 20 or more years for stem infections to manifest. Incipient cankers show no external sign of the underlying infection. Dark-brown, necrotic spots, 5 mm in diameter, occur within the bark, possibly enclosed by a single layer of wound tissue. The first external symptom is a drop of resin on the bark surface. Copious amounts of fresh resin are found during the summer at the margin of cankers throughout their life (Lockman, 2005). Cankers normally expand each year, modifying the infected wood to become resin-soaked and stained blue-black. Blue-black streaks develop in the direction of the long axis of the wood fibres. The fungus penetrates sapwood rapidly, but penetrates heartwood more slowly. At canker tips a reddish-brown stain often develops in the sapwood between the bark and the nearest invaded (blue-black) sapwood. Furrowing develops longitudinally on the stem and is deepest on the most vigorous trees. Bark is often cracked at the margins of cankers. Ascospores are formed in ascomata that are produced in stromata on the surface of the bark over the cankers, in the central sunken canker zone (Hopkins and Callan, 1991). Therefore, debarked wood, even though it is affected by *Atropellis*, cannot transfer the pest by ascospores. In case infected wood (even if without bark) comes into contact with another piece of wood, mycelium could colonise new units of wood. This has been demonstrated under artificial conditions (Hopkins, 1963), but there is no evidence that this could happen during transport.

Since the presence of bark is essential for the production of ascospores and ultimately for the transfer of the pathogen to suitable hosts, the wood pathway was split into the following subpathways:

2.1) wood with bark, in which cankers and ascospores may be produced;
2.2) debarked wood, in which no ascospores can be produced, unless portions of affected bark remain after debarking;
2.3) chips, particles, sawdust, shavings, wood waste and scrap, that can be considered similar to debarked wood for the possibility of transferring the pathogen to a suitable host.
2.4) wood packaging material, which, in the presence of bark pieces, can be considered similar to debarked wood for the possibility of transferring the pathogen to a suitable host.

Pathway 3: isolated bark. As for wood with bark, isolated bark pieces with cankers and ascomata may produce ascospores under suitable conditions, and be responsible for transfer of the pathogen to a suitable host.

1.2.2.2. Current regulations

1.2.2.2.1. Pest specific measures

Atropellis spp. are listed in Annex II, part A, section 1 of Directive 2000/29/CE. This implies that *Atropellis* spp. (i) are not known to occur in the EU and are important for the entire Community and (ii) should be absent from plants of *Pinus* L., other than fruit and seeds, isolated bark and wood of *Pinus* L., imported into the EU from third countries or spread within the EU.

The inclusion of *Atropellis* spp. into that Annex also means that measures shall be taken in the EU if an outbreak occurs (eradication and containment measures) and that inspections should be done prior to issuing plant passports (when appropriate) for movement of plant and plant material within the EU. This also implies that release of that pest in the environment is forbidden and that scientific

research or breeding activities with that pest are governed by Directive 2008/61/CE, which sets up protective measures to avoid accidental release.

1.2.2.2.2. Measures for specific pathways not specifically related to *Atropellis* spp.

1.2.2.2.2.1. Measures for *Pinus* plants

Plants of *Pinus* spp., among which some are host plants for *Atropellis* spp., are listed in Annex III, part A of Directive 2000/29/CE. This implies that the introduction into the EU (and circulation within) of plants of *Pinus*, originating in non-European countries, is forbidden. This covers plant for planting and other plants, including parts of plants as branches for Christmas trees for instance, but excluding fruit and seed in this particular case. 'Non-European countries' shall here be understood as countries outside of Europe (Europe being made of EU and non-EU European countries).

According to Annex V, part A of Directive 2000/29/CE, plants of *Pinus* spp. originating in the EU and intended for planting shall be submitted to plant health inspection by the Member State of origin before being moved within the EU. As *Atropellis* spp. are listed in Annex II, those inspections shall certify the absence of the fungus.

According to Annex V, part B of Directive 2000/29/CE, plants of *Pinus* spp. originating in non-EU European countries and intended for planting shall be submitted to plant health inspection by the Plant health service of the country of origin before being exported to the EU. As *Atropellis* spp. are listed in Annex II, those inspections shall certify the absence of the fungus.

Additionally, emergency measures may restrict the import from third countries, or the circulation from certain EU areas, of plants of *Pinus* spp. (Commission implementing decision 2012/535/EU of 26 September 2012 on emergency measures to prevent the spread within the Union of *Bursaphelenchus xylophilus* (the pine wood nematode), Commission decision 2007/433/EC of 18 June 2007 on provisional emergency measures to prevent the introduction into and the spread within the European Community of *Gibberella circinata*).

1.2.2.2.2.2. Measures for fruit and seeds of *Pinus* spp.

No phytosanitary measures are in place for import into the EU and circulation within the EU of fruit of seeds of *Pinus* spp. according to Annex III, part A of Directive 2000/29/CE. *Atropellis* spp. are not known to be transmitted by fruit or seeds.

1.2.2.2.2.3. Special measures for wood packaging material

Annex IV of Directive 2000/29/CE states that wood packaging material shall be subjected to one of the approved treatments as specified in Annex I to FAO International Standard for Phytosanitary Measures No 15 on Regulation of wood packaging material in international trade (i.e. debarking plus either heat treatment or fumigation).

1.2.2.2.2.4. Special measures for isolated bark

Annex IV states that isolated bark originating in non-European countries shall:

(a) be subjected to an appropriate fumigation with an approved fumigant;

or

(b) undergo an appropriate heat treatment to achieve a minimum temperature of 56°C for a minimum duration of 30 continuous minutes throughout the entire profile of the bark.

According to Annex V, part B, isolated bark of conifers, originating in non-European countries shall be submitted to plant health inspection by the country of origin before entering the EU.

Isolated bark from *Pinus* spp. may be circulated within the EU, except when emergency measures are prescribed (Commission implementing decision 2012/535/EU of 26 September 2012 on emergency measures to prevent the spread within the Union of *Bursaphelenchus xylophilus* (the pine wood nematode).

1.2.2.2.2.5. Special measures for wood of *Pinus* spp.

- For wood originating in Canada, China, Japan, the Republic of Korea, Mexico, Taiwan and the USA (*Atropellis* spp. is known to be present only in the USA and Canada), Annex IV of directive 2000/29/CE prescribes that an official statement shall certify that it has undergone the following appropriate measures:

(a) heat treatment to achieve a minimum temperature of 56°C for a minimum duration of 30 continuous minutes throughout the entire profile of the wood (including at its core);

or

(b) fumigation to a specification approved in accordance with the procedure laid down in Article 18.2 of Directive 2000/29/EC;

or

(c) chemical pressure impregnation with an approved product.

- For wood originating in Russia, Kazakhstan and Turkey (*Atropellis* spp. are not known to be present in those countries), an official statement shall state that wood:

(a) originates in areas known to be free from: *Monochamus* spp. (non-European), *Pissodes* spp. (non-European), Scolytidae spp. (non-European);

or

(b) is bark-free and free from grub holes, caused by the genus *Monochamus* spp. (non-European);

or

(c) has undergone kiln-drying to below 20% moisture content, expressed as a percentage of dry matter, achieved through an appropriate time/temperature schedule;

or

(d) has undergone an appropriate heat treatment to achieve a minimum temperature of 56°C for a minimum duration of 30 continuous minutes throughout the entire profile of the wood (including at its core);

or

(e) has undergone an appropriate fumigation to a specification approved;

or

(f) has undergone an appropriate chemical pressure impregnation with an approved product.

- For wood originating in other countries, no measure applies and the consignment can enter the EU without special measures.
- Nevertheless, additional specific measures apply for wood of *Pinus* spp. originating in EU areas where *Bursaphelenchus xylophilus* (isolated bark from *Pinus* spp. may be circulated within the EU, except when emergency measures are prescribed or *Gibberella circinata* (syn. *Fusarium circinatum*) occurs (Commission implementing decision 2012/535/EU of 26 September 2012 on emergency measures to prevent the spread within the Union of *Bursaphelenchus xylophilus*, Commission decision 2007/433/EC of 18 June 2007 on provisional emergency measures to prevent the introduction into and the spread within the Community of *Gibberella circinata*). *Atropellis* spp. are nevertheless not known to occur in those areas.

1.2.2.2.2.6 Special measures for other kind of wood of *Pinus* spp.

Here, we consider chips, particles, sawdust, shavings, wood waste and scrap obtained in whole or part from *Pinus* spp.

- For such material originating in Canada, China, Japan, the Republic of Korea, Mexico, Taiwan and the USA, an official document shall state that it has undergone the following appropriate measures:

(a) heat treatment to achieve a minimum temperature of 56°C for a minimum duration of 30 continuous minutes throughout the entire profile of the wood.

or

(b) fumigation to an approved specification in accordance with the procedure laid down in Article 18.2 of Directive 2000/29/EC.

- For such material originating in Russia, Kazakhstan and Turkey, non-European countries other than Canada, China, Japan, the Republic of Korea, Mexico, Taiwan and the USA, an official document shall state that such material:

(a) has been produced from debarked round wood;

or

(c) has undergone kiln-drying to below 20% moisture content, expressed as a percentage of dry matter, achieved through an appropriate time/temperature schedule;

or

(d) has undergone an appropriate fumigation to a specification approved in accordance with the procedure laid down in Article 18.2 of Directive 2000/29/EC;

or

(e) has undergone an appropriate heat treatment to achieve a minimum temperature of 56°C for a minimum duration of 30 continuous minutes throughout the entire profile of the wood.

- For other kinds of wood originating in other countries, no measure applies and consignments may enter the EU without any phytosanitary requirements.
- Additional specific measures may apply for other kind of wood of *Pinus* spp. originating in EU areas where *Bursaphelenchus xylophilus* or *Gibberella circinata* occur.

1.2.2.3. Definition of the scenarios

1.2.2.3.1. Scenario A0

Scenario A0 is the current regulatory situation. Scenario A0 thus consists in the regulation and risk reduction options (RRO) regarding protection against *Atropellis* spp. (Directive 2000/29/EC, version in force in the EU when preparing this opinion) (see Appendix B).

Amendments of Directive 2000/29/EC that have been notified to WTO (Committee on Sanitary and Phytosanitary Measures) at the beginning of 2017 for Member Country consultation (https://members.wto.org/crnattachments/2017/SPS/EEC/17_0805_00_e.pdf) do not impact this scenario.

Scenario A0 consists of measures that specifically target *Atropellis* spp. and in measures that target particular pathways.

In this scenario, the Panel considers that:

- Pathway 1 (plants) is closed due to the ban of importing *Pinus* plants from outside Europe into the EU;
- Pathway 2 (wood) includes the wood types with bark (round wood, sawn wood with remaining bark, etc.) and wood without bark. Chips, particles, sawdust, shavings, wood waste scrap and wood packaging material are not specifically assessed because they can be considered similar to two subpathways previously mentioned for the purposes of this RA (see also Section 1.2.2.1);
- Pathway 3 (isolated bark) was not considered quantitatively, but as a source of uncertainty, as no information was retrieved on bark imports, and since various requirements are in place for the import of isolated bark of *Pinus* into the EU.

1.2.2.3.2. Alternative scenarios

An alternative scenario based on removal of the current *Atropellis* regulation would result in *Atropellis* spp. no longer being listed in Annex II of Directive 2000/29/CE. The removal of *Atropellis* spp. from Annex II would imply that: (i) phytosanitary certificates do not imply anymore that consignments are free from *Atropellis* spp.; (ii) plant or plant material with *Atropellis* spp. can thus no longer be intercepted at the EU external borders; (iii) plant passports for the internal market circulation do not anymore imply that consignments are free from the fungus; and (iv) eradication and containment measures as well as restriction of circulation of possibly contaminated material within the EU can no longer be made mandatory based on Directive 2000/29/CE.

Since all the other measures related to commodities and described in Section 1.2.2.2, which are sustained by various other phytosanitary reasons, would all be kept, the Panel considered that the scenario with the removal of the current *Atropellis* regulation would provide the same results as the scenario A0 regarding the probably of entry of *Atropellis* spp. into the EU. Therefore, it was not specifically addressed in this risk assessment.

The Panel considered that an alternative scenario based on the introduction of further regulations (as requested by the ToR) or the replacement of present RRO by others would not be informative because additional regulations are not needed when the current regulation is fully effective (see results

of the entry assessment, Section 3.1.1). Therefore, a scenario with further regulations was not specifically addressed in this risk assessment. Notwithstanding that consideration, the Panel identified potential gaps in the current regulation and proposed some possible improvement.

1.2.2.3.3 Potential gaps in the current regulation

The Panel identified potential gaps in the current regulation, which are listed below.

- As *Atropellis* spp. are included into Annex II (and not I) of Directive 2000/29/CE, their introduction into and spread within the EU shall be banned only when present on *Pinus* spp. and related products. This may imply that the introduction of the pest on other kind of material is governed neither by Directive 2000/29/CE, nor by Directive 2008/61/UE that deals with scientific and breeding activities. That gap is mostly theoretical as *Atropellis* spp. have only been found on *Pinus* material.
- To date, *Atropellis* spp. are known to occur only in North America but may establish everywhere host plants grow. Import of plants of *Pinus* spp. for planting or for other uses is authorised only from non-EU European countries. Phytosanitary rules were checked for most non-EU European countries as shown in Table 1. It appears that *Atropellis* spp. are not listed as regulated organisms in some of those countries and that *Pinus* spp. as plants for planting and other plants as well as wood and bark of *Pinus* spp. can be imported to at least some of those countries. Therefore, the risk theoretically exists that infected plant material (not necessarily showing symptoms) originating in infected North American areas is accidentally imported into non-EU European countries and then further exported to the EU, if inspections are not able to detect the presence of *Atropellis* spp.

Table 1: Analysis of the regulation of most non-EU European countries regarding *Atropellis* spp., plants for planting, other plants, wood and bark of *Pinus* spp.

Country	**Source**	**Is *Atropellis* spp. a quarantine pest?**	**Are there special requirements for the import from the USA and Canada of:**		
			***Pinus* plants**	***Pinus* wood**	***Pinus* bark**
Albania	EPPO, 1999a	No	No. The import of plants in general requires an import permit or certificate	No. The import of wood in general requires an import permit or certificate	Isolated bark prohibited in general
Belarus	EPPO, 1999b	No	No. The import of plants in general requires an import permit or certificate	No. The import of wood in general requires an import permit or certificate	Isolated bark in general not regulated
Iceland	EPPO, 2000a	Yes	Prohibited	Yes. Prohibited unless debarked	Prohibited
Moldova	EPPO, 2000b	No	No. The import of plants in general requires an import permit or certificate	No. The import of wood in general requires an import permit or certificate	No. The import of bark in general requires an import permit or certificate
Norway	EPPO, 2003	Yes	Yes. Import of *Pinus* plants requires freedom from *Atropellis* spp.	Yes. Import of *Pinus* wood requires freedom from *Atropellis* spp.	Yes. Import of *Pinus* bark requires freedom from *Atropellis* spp.
Russia	EPPO, 1999c	No	Prohibited	Prohibited	Prohibited
Serbia	EPPO, 2001	No	Prohibited	No. Debarking or Kiln-drying required for import of coniferous wood from non-European countries	No. A disinfection treatment is required for isolated bark of coniferous wood

Country	Source	Is *Atropellis* spp. a quarantine pest?	Are there special requirements for the import from the USA and Canada of:		
			***Pinus* plants**	***Pinus* wood**	***Pinus* bark**
Switzerland	OPV, 2017	Yes	Prohibited	Yes. Import of *Pinus* wood requires freedom from *Atropellis* spp.	Yes. Import of *Pinus* isolated bark requires freedom from *Atropellis* spp.
Ukraine	EPPO, 1999d	No	No. The import of plants in general requires an import permit or certificate	No. No mention of requirements for import of wood with or without bark	No. No mention of requirements for import of isolated bark

- Import of wood or wood products of *Pinus* spp. is permitted from all countries, but special requirements that may effectively mitigate risks associated with *Atropellis* spp. apply for some of them (Canada, China, Japan, the Republic of Korea, Mexico, Taiwan and the USA on the one hand, Russia, Kazakhstan and Turkey one the other one). For wood originating in Russia, Kazakhstan and Turkey, the possibility is offered by Directive 2000/29/CE Annex IV to choose among a list of treatments, some of them with no mitigation effect on *Atropellis* spp. [wood that 'originates in areas known to be free from *Monochamus* spp. (non-European), *Pissodes* spp. (non-European), Scolytidae spp. (non-European)']. Therefore, the risk theoretically exists that infected wood or wood material originating in infected North American areas is imported into a third country or into a non-EU European country and then further exported to the EU without any treatment effective against *Atropellis* spp.
- These gaps are mostly theoretical as countries exporting goods to the EU should be able to certify that they are free from *Atropellis* spp. (as the species is included in Annex II), which is not the case if re-exporting goods from North America.

Based on these potential gaps, the Panel considers the following as possible improvements of the current regulation.

- Expansion of prohibition of import of plant of *Pinus* spp. for planting to include all third countries. This possible improvement is not considered as a separate scenario in the quantitative RA because Pathway 1 (plants) is already not considered in this RA.
- Homogenisation of risk mitigation measures for wood of *Pinus* spp. would imply:

  for wood of *Pinus* spp. originating in third countries, an official statement shall state that wood:

  (a) is bark-free;

  and

  (b) has undergone kiln-drying to below 20% moisture content, expressed as a percentage of dry matter, achieved through an appropriate time/temperature schedule;

  or

  (c) has undergone an appropriate heat treatment to achieve a minimum temperature of 56°C for a minimum duration of 30 continuous minutes throughout the entire profile of the wood (including at its core);

  or

  (d) has undergone an appropriate fumigation to a specification approved;

  or

  (e) has undergone an appropriate chemical pressure impregnation with an approved product.

This possible improvement was not considered as a separate scenario in the quantitative RA because wood trade data from all the third countries may not be available and the expected result would be no introduction of *Atropellis* spp. because of the high efficacy against *Atropellis* spp. of debarking plus kiln-drying or heat treatment; concerning fumigation and chemical pressure

impregnation there are at the moment no specifications/products applicable to the type of wood approved under Article 18.2.

2. Data and methodologies

2.1. Pilot phase

EFSA recommends that efforts should be made to work towards more quantitative expression of both risk and uncertainty whenever possible (EFSA Scientific Committee, 2012), i.e. where possible, the expression of the probability of the negative effect and the consequences of the effect should be reported quantitatively.

The method used in this assessment seeks to address the call for increased quantitative reporting of risk. The first iteration of the method was applied to four case study pests (EFSA Panel on Plant Health, 2016a–d). Feedback from users has been taken into account to refine the method and the revised method is being used in a further series of tests on four more pilot case studies. This is one of these second phase pilot studies. Following feedback received from the second series of pilot case studies, it is anticipated that further refinements may be made to the method before it is published in 2018 as a new guidance document for the EFSA PLH Panel (Gilioli et al., 2017).

2.2. Data

EFSA performed an extensive literature search for the pest categorisation of *Atropellis* spp. (EFSA PLH Panel, 2014). Further references and information were obtained from experts and from citations within the references. The same strategy was followed to retrieve relevant papers that appeared since the publication of the pest categorisation (EFSA PLH Panel, 2014).

Data relevant to the RA of *Atropellis* spp. were searched in the scientific literature (using the search engines: Web of Science, Scopus, Google Scholar, keyword: "*Atropellis*", in January 2017), trade databases and by contacting experts.

Data on records of *Atropellis* spp. were requested from the US Plant Diagnostic Network (https://www.npdn.org/) and from the Sentinel Plant Network of Botanic Garden Conservation International (https://www.bgci.org/plant-conservation/ipsn/) in January 2017.

Data on import of coniferous wood from the USA and Canada into the EU were obtained from EUROSTAT and the United Nations ComTrade database in January 2017.

Data on interceptions (none so far) of *Atropellis* spp. in commodities imported by the EU were retrieved from EUROPHYT in January 2017.

Data on the regulations concerning *Atropellis* spp. and *Pinus* spp. for non-EU European countries were retrieved from EPPO summaries in January 2017, as detailed above in Table 1.

2.3. Methodologies

The Panel performed the RA for *Atropellis* spp. following the guiding principles presented in the EFSA Guidance on a harmonised framework for risk assessment (EFSA PLH Panel, 2010) and as defined in the International Standard for Phytosanitary Measures (ISPM) No. 11 (FAO, 2013).

A specific quantitative assessment model was used to perform the RA. The specification of the model is described in Section 2.4.

When conducting this RA, the Panel took also into consideration the following EFSA horizontal guidance documents:

- Guidance of the Scientific Committee on Transparency in the Scientific Aspects of risk assessments carried out by EFSA. Part 2: General Principles (EFSA, 2009);
- Guidance on the structure and content of EFSA's scientific opinions and statements (EFSA Scientific Committee, 2014);
- Guidance on Statistical Reporting (EFSA, 2014b);
- Guidance on uncertainty (EFSA Scientific Committee, 2016).

The assessment follows a quantitative approach, in which the step of entry is elaborated quantitatively under one scenario, identified as A0. Within the entry step, substeps are distinguished to quantitatively assess the underlying component processes. An overall summary description of the steps is provided in Appendix A which describes the overall risk assessment model without mathematical equations.

Uncertainty involved in estimating entry is represented using a probability distribution which expresses the best estimates of the variables provided by the experts considering both available data and judgement. The distribution is characterised by a median value and four additional percentiles of the distribution. The median is the value for which the probability of over- or underestimation of the actual true value is judged as equal. Calculations with the model are made by stochastic simulation, whereby values are drawn randomly from the distribution specified for each parameter. The stochastic simulations are repeated at least 20,000 times to generate a probability distribution of outcomes, i.e. the outcome of the entry process in a given time period in the future.

In the model calculation, the uncertainty of each component is passed through the model equation, so that its contribution to the uncertainty of the final result can be shown. The decomposition of uncertainty calculates the relative contribution of each individual input to the overall uncertainty of the result.

Section 3 of the assessment reports the outcomes of scenario calculations. The distributions given in this section characterise the possible range of outcomes at the time horizon of the opinion under scenario A0.

The distributions of the uncertain components (in this opinion: 'uncertainty distributions') are characterised by different values and ranges:

The median is a central value with equal probability of over- or underestimating the actual value. In the opinion, the median is also referred as 'best estimate'.

The quantiles divide the uncertainty distribution into classes, each containing a certain fraction of the total number of expected founder populations (for the entry assessment). Quartiles are quantiles subdividing the uncertainty distribution in four classes, while percentiles are quantiles subdividing it in 100 classes.

The interquartile range is an interval around the median, where it is as likely that the actual value is inside as it is likely that the actual value is outside that range. The interquartile range is bounded by the 1st and 3rd quartile (the 25th and 75th percentile) of the distribution. This range expresses the precision of the estimation of interest. The wider the interquartile range, the greater is the uncertainty on the estimate. In this opinion, we refer to the interquartile range by using the term '50%-uncertainty interval'.

For experimental designs, it is common to report the mean (m) and the standard error (s) for the precision of the estimate of a measured parameter. The interval: $m \pm s$ ($[m - s, m + s]$) is used to express an interval of likely values. This estimation concept is based on replicated measurements. In the context of uncertainty, it is not reasonable to assume replicated judgements. Therefore, the median and interquartile ranges are used instead of the mean and the interval $m \pm s$, but the interpretation of the precision of judgements is similar.

In addition to the median and interquartile range, a second range is reported: the credibility range. The credibility range is formally defined as the range between the 1st and 99th percentile of the distribution allowing the interpretation that it is extremely unlikely that the actual value is outside this range. In this opinion, we refer to the credibility range by using the term '98%-uncertainty interval'.

Further intervals with different levels of coverage could be calculated from the probability distribution, but these are not reported as standard in this opinion.

The methodology used for this risk assessment is quantitative and produces quantitative results (Gilioli et al., 2017). As in all quantitative science, the results are reported in a manner that appropriately reflects the degree of precision or approximation of the data used. Plant health risk assessment data are often limited and some input parameters have been assessed by expert judgement, which is necessarily approximate in nature. The risk assessment outputs are thus also approximate. Therefore, outputs have been rounded to an appropriate degree to reflect the degree of approximation that is present in the assessment.

Please note that the number of significant figures used to report the characteristics of the distribution does not imply the precision of the estimation. For example, the precision of a variable with a median of 13 could be reported using the associated interquartile range, perhaps 3–38, which means that the actual value is below a few tens. In the opinion, an effort was made to present all results both as a statement on the model outcome in numerical expressions and as an interpretation in verbal terms.

2.3.1. Specification of the scenarios

A0: baseline scenario (current regulatory situation).

2.3.2. Definitions for the scenarios

The scenario A0 is described in Table 2.

Table 2: Summary of the main features of scenario A0. Note: 'n.a.' = not assessed

Scenario A_0		Steps			
		Entry	**Establishment**	**Spread**	**Impact**
Pathways	Pathway 1 (plants)	Closed, thus n.a.	n.a.	n.a.	n.a.
	Pathway 2 (wood)	Assessed	n.a.	n.a.	n.a.
	Pathway 3 (isolated bark)	n.a.	n.a.	n.a.	n.a.
Units	Production unit in the country of origin	1 m^3 of wood	n.a.	n.a.	n.a.
	Production unit in the assessment area	1 m^3 of wood	n.a.	n.a.	n.a.
	Pathway 2 (wood) unit	1 m^3 (Eurostat unit of measure)	n.a.	n.a.	n.a.
Abundance	Production unit in the country of origin	1 m^3 of wood	n.a.	n.a.	n.a.
	Production unit in the assessment area	1 m^3 of wood	n.a.	n.a.	n.a.
	Pathway 2 (wood) unit	% infected m^3 of wood	n.a.	n.a.	n.a.
Risk Reduction Options (RRO)	Heat treatment of imported *Pinus* wood	Relevant	n.a.	n.a.	n.a.
	Debarking of imported *Pinus* wood	Relevant	n.a.	n.a.	n.a.
Ecological factors	–	Current situation	n.a.	n.a.	Current situation
Scales	Temporal resolution	1 year	n.a.	n.a.	As for the temporal horizon
	Temporal horizon	10 years	n.a.	n.a.	This assessment is constant over the period, i.e. a relationship linking prevalence and/or other independent variables to impact without considering a trend
	Spatial resolution	RA area	n.a.	n.a.	Production or service providing unit
	Spatial extent	RA area	n.a.	n.a.	n.a.

2.4. Model for entry

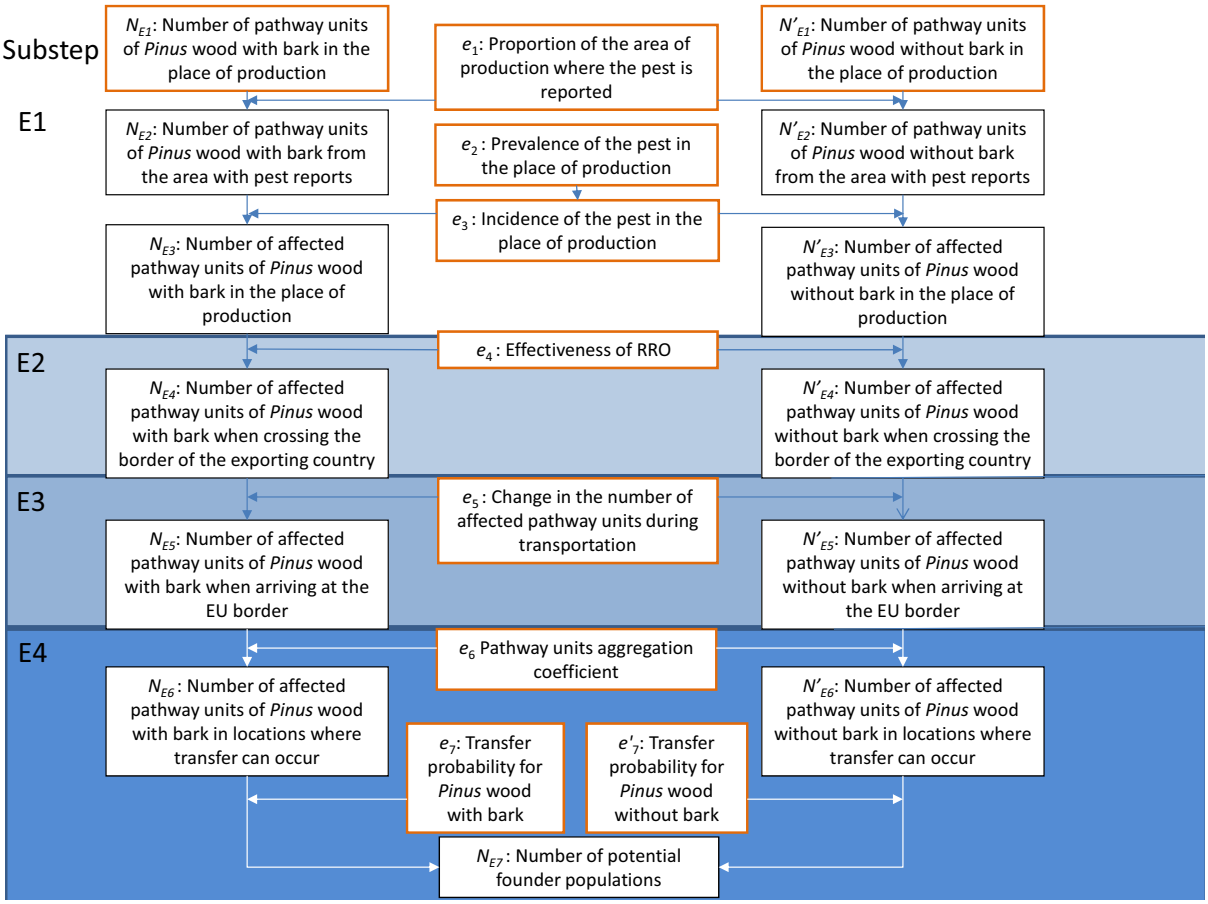
2.4.1. Conceptual model for entry

For *Atropellis* spp., a conditional RA was considered in which only the entry step was assessed. The model for entry describes the change in the number of pathway units from the place of production to the locations where transfer to a suitable host can occur in the RA area (Gilioli et al., 2017). The probability of transfer is then taken into account for the calculation of the number of potential founder populations.

As described in the guidance for good modelling practice of the EFSA Panel on Plant Protection Products and their Residues (EFSA PPR Panel, 2014), 'the basis of good modelling practice [is] the

knowledge of relevant processes and the availability of data of sufficient quality'. The conceptual model (summarising the knowledge of the Panel on the relevant processes and clarifying the data needs for the assessment) used for assessing the number of potential founder populations of *Atropellis* spp. in the RA area for scenario A0 is described in Figure 1. A series of substeps for entry were considered for which the variables shown in Figure 1 are defined for the two subpathways (wood with and without bark).

The model here presented is a simplified version of the model considered in the assessment. For the sake of simplicity, only the deterministic version is given. The extension considering the random variables estimated by the experts or calculated is reported in the *Atropellis* spp. @Risk file (Annex A).



Boxes in an orange frame refer to estimated distributions, whereas boxes in black frames refer to calculated distributions. The substeps of the conceptual model are described in detail in Appendix A (substep E1: from harvested wood to the number of affected pathway units of *Pinus* wood in the place of production; substep E2: from having left the place of production to the border of the exporting country; substep E3: from having left the border of the exporting country to the EU point of entry; and substep E4: from having left the EU port of entry to the transfer to a suitable host).

Figure 1: Conceptual model for the assessment of the risk of entry into the EU of *Atropellis* spp. (pathway wood, with and without bark)

2.4.2. Formal model for entry

Substep E1: from harvested wood to the number of affected pathway units of *Pinus* wood in the place of production

N_{E1} = Number of pathway units of *Pinus* wood with bark in the place of production
N'_{E1}= Number of pathway units of *Pinus* wood without bark in the place of production
N_{E2} = Number of pathway units of *Pinus* wood with bark from area where the pest is reported
N'_{E2} = Number of pathway units of *Pinus* wood without bark from area where the pest is reported
N_{E3} = Number of affected pathway units of *Pinus* wood with bark in the place of production
N'_{E3} = Number of affected pathway units of *Pinus* wood without bark in the place of production

Substep E2: from having left the place of production to the border of the exporting country

N_{E4} = Number of affected pathway units of *Pinus* wood with bark when crossing the border of the exporting country
N'_{E4} = Number of affected pathway units of *Pinus* wood without bark when crossing the border of the exporting country

Substep E3: from having left the border of the exporting country to the EU point of entry

N_{E5} = Number of affected pathway units of *Pinus* wood with bark when arriving at the EU border
N'_{E5} = Number of affected pathway units of *Pinus* wood without bark when arriving at the EU border

Substep E4: from having left the EU port of entry to the transfer to a suitable host

N_{E6} = Number of affected pathway units of *Pinus* wood with bark in locations where transfer can occur
N'_{E6} = Number of affected pathway units of *Pinus* wood without bark in locations where transfer can occur
N_{E7} = Number of potential founder populations derived from both subpathways (wood with and without bark).

The following parameters are considered in the model of entry

e_1 = Proportion of the area of production where the pest is reported
e_2 = Prevalence of the pest in the place of production (the percentage of forest stands that are affected within an affected wood production area)
e_3 = Incidence of the pest in the place of production (the percentage of affected Pinus plants in affected plots)
e_4 = Effectiveness of the Risk Reduction Options (RRO)
e_5 = Change in the number of affected pathway units during transportation
e_6 = Pathway units aggregation coefficient
e_7 = Transfer probability for *Pinus* wood with bark
e'_7 = Transfer probability for *Pinus* wood without bark

The model for entry is defined as follows

$$N_{E2} = N_{E1}e_1$$
$$N'_{E2} = N'_{E1}e_1$$
$$N_{E3} = N_{E2}e_2e_3$$
$$N'_{E3} = N'_{E2}e_2e_3$$
$$N_{E4} = N_{E3}e_4$$
$$N'_{E4} = N'_{E3}e_4$$
$$N_{E5} = N_{E4}e_5$$
$$N'_{E5} = N'_{E4}e_5$$
$$N_{E6} = N_{E5}e_6$$
$$N'_{E6} = N'_{E5}e_6$$
$$N_{E7} = N_{E6}e_7 + N'_{E6}e'_7$$

Therefore, the number of potential established population N_{E7} can be estimated as

$$N_{E7} = N_{E1}e_1e_2e_3e_4e_5e_6e_7 + N'_{E1}e_1e_2e_3e_4e_5e_6e'_7$$

3. Assessment

3.1. Entry

3.1.1. Assessment of entry for scenario A0

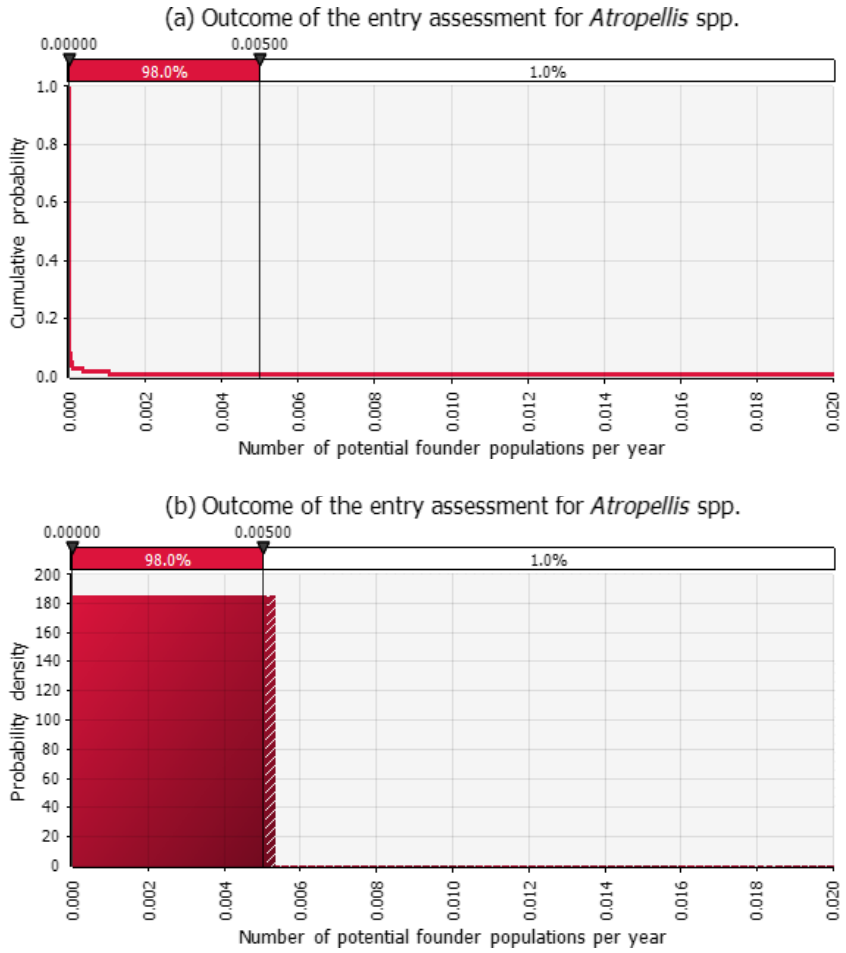
Here the Panel presents the results obtained from the estimates (based on both available data and expert judgement) described in Appendix A. The uncertainties of these estimates are discussed in Section 3.1.2.

The results of the entry assessment (described in detail in Appendix A) for the pathway wood in scenario A0 are shown in Table 3 and Figure 2. Table 3 reports five quantile values (1%, 25%, 50%, 75% and 99%) of the average number of potential founder populations of *Atropellis* spp. expected per

year due to new entries in the EU in the chosen time horizon. A definition of quantiles, quartiles and percentiles is provided in Section 2.3. Figure 2 shows the same results as a cumulative distribution and as a density distribution.

Table 3: Selected quantiles of the uncertainty distribution for the number of potential founder populations (N_{E7}) of *Atropellis* spp. expected per year due to new entries in the EU in the chosen time horizon for scenario A0 (pathway wood)

Quantile	1% quantile	1st quartile (25%)	Median (50%)	3rd quartile (75%)	99% quantile
Number of potential founder populations for scenario A0	5×10^{-10}	1×10^{-8}	1×10^{-7}	1×10^{-6}	8×10^{-4}



The values on top (e.g. 98.0%) are the percentiles of the distribution. There is a 98% probability of between 0 and 0.005 potential founder populations per year, and a 1% probability of between 0.005 and 0.020 potential founder populations per year.

Figure 2: Cumulative descending (a) and density (b) distributions for the average number of potential founder populations of *Atropellis* spp. expected per year due to entries in the EU for the scenario A0 and the pathway wood

Although the 98%-uncertainty interval (the range between the 1% percentile and the 99% percentile) of the estimated number of founder populations of *Atropellis* spp. spans about six orders of magnitude, the resulting uncertainty of the assessment does not affect the conclusion that the risk of entry is close to zero over the considered time horizon, as the 99% percentile value corresponds to roughly one potential founder population per 1000 years.

Moreover, the 50%-uncertainty interval (the range between the 25% percentile and the 75% percentile) only spans roughly two orders of magnitude, and the expected numbers of potential founder populations are in both cases very small (approximately between one potential founder population every million years and one every hundred million years).

3.1.2. Uncertainties affecting the assessment of entry

Data on which to base many of the quantitative estimates presented here were either not available or incomplete. Expert judgement was thus used in most cases. The quantitative estimates provided by the experts should be taken with caution, as different experts might provide different figures in such a situation where evidence is lacking. For all estimated distributions, consensus on the quartile values within the WG was reached and the expert knowledge elicitation procedure endorsed by EFSA was followed, starting from the estimation of the lower and upper limits, then moving to the estimation of the median value, and finally estimating the first and third quartiles as a way to express the uncertainty of the estimation (EFSA, 2014a).

The correlation coefficients between the uncertainty distributions of the factors included in the assessment and the uncertainty distribution of the number of potential founder populations of *Atropellis* spp. in the RA area for the wood pathway and scenario A0 are shown in Figure 3. Correlation (and not regression) coefficients were used, because the R^2 of the linear model was rather low (about 0.27). The correlation coefficients account for the relationship between each influencing factor and the response variable; since the dimension of the correlation coefficient is unit-less (between minus one and one, when using absolute values between zero and one), a factor is highly influencing the response variable if the correlation coefficient is close to one. These correlation coefficients were considered as an estimation of the role of the factors in explaining the uncertainty of the response variable. This means that, the greater the influence of a factor on the estimated number of potential funder populations, the greater the effect of an uncertain assessment of that factor.

The highest correlation coefficients were obtained for the incidence of *Atropellis* spp. in North America (e_3), the disaggregation factor (e_6) and the effectiveness of the RRO (e_4). Factors with lower correlation coefficients, but still higher than 0.20, were the number of pathway units of wood with bark from the USA (N_{E1a}) and the proportion of Canadian provinces with reports of *Atropellis* (e_{1b}: calculation for wood without bark).

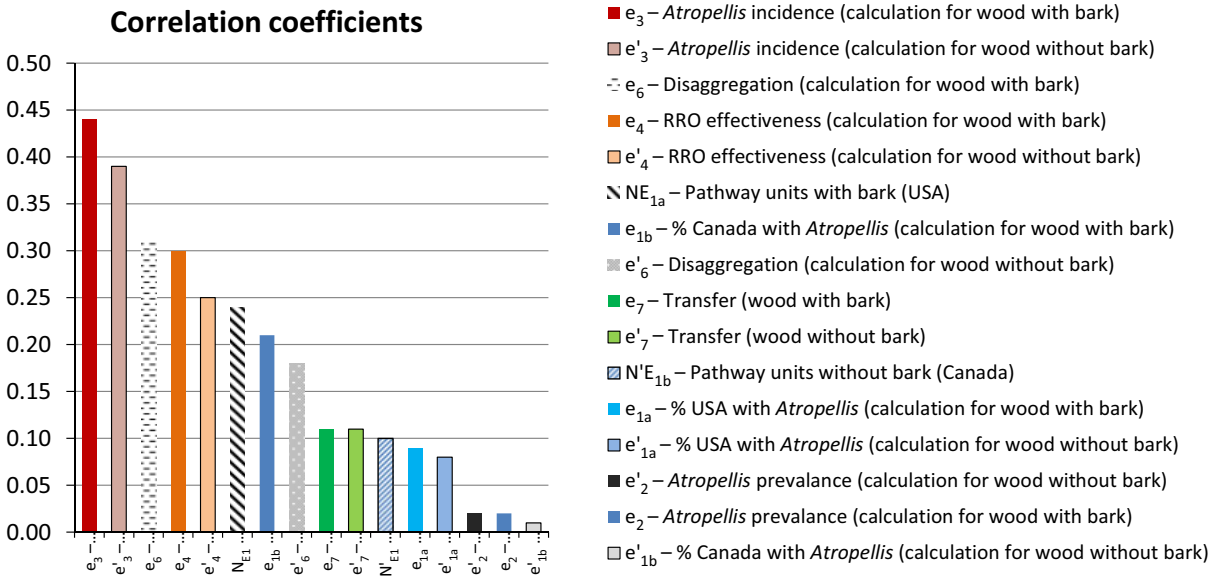


Figure 3: Correlation coefficients between the uncertainty distributions of the factors included in the assessment and the uncertainty distribution of the number of potential founder populations of *Atropellis* spp. in the RA area (wood pathway and scenario A0)

Additional uncertainties affecting the entry assessment but not quantified within the assessment model are listed in Table 4.

Table 4: List of additional uncertainties affecting the entry assessment but not quantified within the assessment model

No.	Description of source of uncertainty	Description of effect on assessment of entry
1	Entry from European non-EU countries	This uncertainty was not quantified because of lack of trade data. Moreover, at the moment *Atropellis* is not reported from these countries, and wood imported to those countries from North America is supposed not to be re-exported to the EU, so no measures can be justified to reduce the risk of entry from such countries. Three European non-EU countries (Iceland, Norway and Switzerland) list *Atropellis* spp. as a quarantine pest. Other countries (e.g. Russia) prohibit the import of *Pinus* spp. (plants, wood and/or bark) from North America. Five other European non-EU countries have some requirements for import of *Pinus* spp. from North America (Table 1) Given that the estimated risk of entry from North America into the EU is close to zero, and given that the trade volume of *Pinus* commodities from North America to European non-EU countries re-exported to the EU is expected to be low, the implication of not considering the entry from those European non-EU countries for which there is no regulation concerning *Atropellis* spp. and *Pinus* spp. should have a very small effect (underestimation) on this risk assessment
2	Isolated bark	Not included because of lack of trade data. The Panel expects this not to have a relevant effect on this assessment, because heat treatment of isolated bark is supposed to be even more effective than for wood, due to the lower thickness of isolated bark compared to wood. In the literature, there is no evidence that *Atropellis* spp. can produce ascospores on isolated bark. If no ascospores can be produced on isolated bark, the transfer would be prevented. However, some transfer through mycelia by contact could theoretically occur under particular conditions
3	Proportion of *Pinus* wood of coniferous wood imports from North America	A single value was used (one each for the USA and Canada), without estimating a distribution, so as to simplify. The value was based on data on wood harvest for different coniferous species in Canada and the USA (see Appendix A.1). The Panel expects that the consequences of not estimating a distribution for this parameter are unlikely to change the conclusions of this assessment, because of the low number of founder populations obtained
4	Temporal trend in the wood trade	The most recently available data (2011–2015) were considered, but the trade volumes may change in the near future
5	Weight of the wood	A single value was used for the conversion of *Pinus* wood tonnes into cubic metre, without estimating a distribution, to simplify. The value was based on an average value obtained from different *Pinus* spp. (from the Wood Database, http://www.wood-database.com/) The Panel expects that the consequences of not estimating a distribution for this parameter are unlikely to change the conclusions of this assessment, because of the low number of founder populations obtained

3.1.3. Conclusion on the assessment of entry for scenario A0

The conclusion on the assessment of entry for scenario A0 is that the risk of entry of *Atropellis* spp., in the current regulatory situation, is close to zero. As explained above, this assessment is expected to apply also in the case of removing the specific *Atropellis* regulations, as well as in the case of additional RRO (see Section 1.2.2).

The uncertainty associated with this assessment is relatively limited, given that all the quartiles of the estimated distribution of the number of potential founder populations are close to zero. Most of the uncertainty in the assessment is due to the estimation of the *Atropellis* incidence in North America, the disaggregation factor (due to the distribution of the pathway units in the RA area), and the effectiveness of the RRO (heat treatment of wood with bark). The Panel expects that an estimation of the distribution for these parameters on the basis of better data would be unlikely to change the conclusions of the assessment, because of the low number of founder populations obtained. Moreover,

the Panel considers that the assessments for the incidence of *Atropellis* spp. and for the effectiveness of the RRO are rather robust, as they are based on data retrieved from the literature. The effectiveness of the RRO was estimated on the basis of data concerning several fungal species affecting wood, even though *Atropellis* was not included in this list of species.

3.2. Impact

3.2.1. Host range

Table 5 summarises the available knowledge regarding the susceptibility of *Pinus* spp. to *Atropellis* spp. There is some uncertainty about the host status (major host, host, minor host, incidental host) (same categories as in EFSA PLH Panel, 2014) because the information provided in Table 5 was obtained from different sources which are difficult to compare.

Table 5: Susceptibility of *Pinus* spp. to *Atropellis* spp. (updated from EFSA PLH Panel, 2014)

***Pinus* spp.**	**Common name**	**North America**	**EU**	**Host**	***Atropellis pinicola***	***Atropellis piniphila***	***Atropellis apiculata***	***Atropellis tingens***
P. albicaulis	Whitebark p.	x	–	Host	Host	Host	?	?
P. banksiana	Jack p.	x	–	Host	?	Incidental host	?	Host
P. caribaea	Caribbean p.	x	–	Host	?	?	Minor host	Host
P. clausa	Sand p.	x	–	Host	?	?	?	Host
P. contorta	Lodgepole p.	x	x	Host	Major host	Major host	?	Host
P. densiflora	Japanese red p.	x	–	Host	?	Incidental host	?	Incidental host
P. echinata	Shortleaf p.	x	–	Host	?	Minor host	Host	Host
P. elliottii	Slash p.	x	–	Host	?	?	Host	Host
P. jeffreyi	Jeffrey p.	x	–	Host	?	Incidental host	?	?
P. lambertiana	Sugar pine	x	–	Host	Minor host	?	?	?
P. monticola	Western white p.	x	–	Host	Host	Host	?	Host
P. nigra	Black p.	x	x	Host	Incidental host	Host	?	Minor host
P. palustris	Longleaf p.	x	–	Host	?	?	Host	?
P. pinaster	Mediterranean p.	x	x	Host	?	?	?	Host
P. ponderosa	Ponderosa p.	x	–	Host	?	Minor host	?	?
P. pungens	Table mountain p.	x	–	Host	?	?	?	Host
P. resinosa	Red p.	x	–	Host	?	?	?	Host
P. rigida	Pitch p.	x	–	Host	?	?	?	Host
P. serotina	Pond p.	x	–	Host	?	?	?	Host
P. strobus	Eastern white p.	x	x	Host	Incidental host	?	?	Host
P. sylvestris	Scots p.	x	x	Host	Incidental host	?	?	Host
P. taeda	Loblolly p.	x	–	Host	?	Incidental host	?	Host
P. virginiana	Virginian p.	x	–	Host	?	Host	?	Host
P. brutia	Calabrian p.	–	x	No info	?	?	?	?
P. cembra	Arolla p., Swiss p.	–	x	no info	?	?	?	?
P. halepensis	Aleppo p., Turkish p.	x	x	No info	?	?	?	?

Pinus spp.	Common name	North America	EU	Host	*Atropellis pinicola*	*Atropellis piniphila*	*Atropellis apiculata*	*Atropellis tingens*
P. mugo	Dwarf mountain p.	–	x	No info	?	?	?	?
P. peuce	Balcan p.	–	x	No info	?	?	?	?
P. pinea	Italian stone p.	x	x	No info	?	?	?	?
P. sibirica	Siberian p.	–	x	No info	?	?	?	?

Descriptive notation of the host status (major host = known to be the most important host in the infested areas; host = known to be a host; minor host = known to be a relatively unimportant host; incidental host = species on which the pathogen is observed but it is not known whether it can complete the whole life cycle on it) of *Atropellis* spp. for the main *Pinus* spp. present in North America and in the EU (based on Lohman and Cash, 1940; Hopkins and Callan, 1992; Sinclair and Lyon, 2005; EFSA PLH Panel, 2014). Note: 'x' implies the presence of the host in forests (either in North America or in the EU, or in both); '–' implies the absence of the host in forests; '?' implies absence of information about the host status.

Several North American *Pinus* spp. are hosts of *Atropellis* spp. (Table 5).

Little information is available in the literature on the potential susceptibility of *Pinus* spp. present in the EU but not known to be present in North American forests (Table 5). The lack of information increases the uncertainty of the impact assessment in the RA area. Generally, it can be expected that host species not having co-evolved with a pest have a higher degree of susceptibility than those host species that have co-evolved with that pest (Desprez-Loustau et al., 2016).

Table 6 reports the personal communication of Daniel Stern from the Sentinel Network of Botanic Gardens in the USA and Canada concerning any observations of *Atropellis* spp. on European pine trees planted in those gardens. No infection by *Atropellis* spp. of European *Pinus* spp. planted in North American botanic gardens and arboreta was reported. But this absence of evidence does not rule out that some of these *Pinus* spp. might be susceptible to *Atropellis* spp. Only botanic gardens/arboreta in US states and Canadian provinces where *Atropellis* is reported were asked, but it is not known whether *Atropellis* is present in those botanic gardens/arboreta or not.

Table 6: Observations (including negative ones) of *Atropellis* spp. on European *Pinus* spp. planted in botanic gardens and arboreta in US states and Canadian provinces infected by *Atropellis* spp. (Daniel Stern, American Public Gardens Association, personal communication, 1 May 2017)

Botanic garden / arboretum	*Pinus* spp.	Number of observed trees	Observation
University of Washington Botanic Garden, Seattle, USA	*Pinus brutia*	3 trees	Unknown canker to be identified
Univ. of Washington Botanic Garden	*Pinus cembra* subsp. *sibirica*	2 trees	No evidence of *Atropellis*
Tohono Chul Park (Tucson, Arizona, USA)	*Pinus halepensis*	1 tree	No evidence of *Atropellis*
Univ. of Washington Botanic Garden	*Pinus halepensis*	1 tree	No evidence of *Atropellis*
Cheekwood Estate and Gardens, Nashville, Tennessee, USA	*Pinus heldreichii*	1 tree	No evidence of *Atropellis*
Santa Fe Botanical Garden, New Mexico, USA	*Pinus heldreichii*	1 tree	No evidence of *Atropellis*
Univ. of Washington Botanic Garden	*Pinus heldreichii*	5 trees	No evidence of *Atropellis*
Huntsville Botanical Garden	*Pinus leucodermis*	1 tree	No evidence of *Atropellis*
Bloedel Reserve	*Pinus mugo*	1 tree	No evidence of *Atropellis*
Cheekwood Estate and Gardens	*Pinus mugo*	2 trees	No evidence of *Atropellis*

Botanic garden / arboretum	*Pinus* spp.	Number of observed trees	Observation
Univ. of Washington Botanic Garden	*Pinus mugo* subsp. *uncinata*	3 trees	No evidence of *Atropellis*
Bloedel Reserve (on Bainbridge Island, Washington State, USA)	*Pinus nigra*	2 trees	No evidence of *Atropellis*
Cheekwood Estate and Gardens	*Pinus nigra*	7 trees	No evidence of *Atropellis*
Santa Fe Botanical Garden	*Pinus nigra*	1 tree	No evidence of *Atropellis*
Univ. of Washington Botanic Garden	*Pinus nigra*	17 trees	No evidence of *Atropellis*
Univ. of Washington Botanic Garden	*Pinus peuce*	4 trees	No evidence of *Atropellis*
Bloedel Reserve	*Pinus pinaster*	4 trees	No evidence of *Atropellis*
Univ. of Washington Botanic Garden	*Pinus pinaster*	6 trees	No evidence of *Atropellis*
Bloedel Reserve	*Pinus sylvestris*	17 trees	5 with unidentified trunk anomalies similar to *Atropellis* symptoms but without copious pitch exudation. I suspect small amounts of blackened pitch exuded from wood pecker sap feeding sites. Unfortunately these were too high up to see decently with the available binoculars. *Atropellis* thought to be unlikely but not ruled out
Cheekwood Estate and Gardens	*Pinus sylvestris*	2 trees	No evidence of *Atropellis*
Univ. of Washington Botanic Garden	*Pinus sylvestris*	13 trees	No evidence of *Atropellis*
Huntsville Botanical Garden (Huntsville, Alabama, USA)	*Pinus sylvestris*	1 tree	No evidence of *Atropellis*

We do know that some *Pinus* species present in the EU are hosts of *Atropellis* spp. These hosts include widespread and locally abundant *Pinus* spp. such as *P. nigra, P. sylvestris* and *P. pinaster* (EFSA PLH Panel, 2014). Moreover, in addition to *P. contorta*, also *P. strobus* is a North American *Pinus* spp. susceptible to *Atropellis* spp. which has been widely planted in the EU. Many North American *Pinus* spp. known to be hosts of *Atropellis* spp. have been planted in private and public parks as ornamentals, as well as in botanic gardens and arboreta.

When introduced in a new environment, *Atropellis* spp. might not be dependent on stressed hosts as in the native range (Hansen, 1985). However, forest management in the EU tends to reduce the density of young stands by thinning. Therefore, local climatic conditions for *Atropellis* spp. might not be as conducive to disease development as observed, e.g. in dense young stands of lodgepole pine in British Columbia (Baranyay et al., 1973). Prescribed burning is an uncommon practice in EU forests compared to North America, and this could affect the impact of *Atropellis* spp. (Heineman et al., 2010).

3.2.2. Potential impact of *Atropellis* spp. on *Pinus* spp. in the RA area

An overview of potential impacts is provided in EFSA PLH Panel (2014). For *Pinus* spp. present in both North America and the EU, the damage observed in North America (loss of wood quality, stem deformations, mortality in young stands, environmental consequences) is expected in the EU to a similar degree, should the pathogen be introduced. The provision of ecosystem services would be potentially affected due to the depreciation of the value of wood or, in extreme cases, the impossibility of selling wood (fibre and fuel). Also, the regulating and supporting services are at risk due to the possibility that the affected *Pinus* trees die. This could influence mainly soil erosion and formation, flood regulation, nutrient cycling and habitat provision (EFSA PLH Panel, 2014).

In case there are natural enemies or biotic agents limiting the degree of damage of *Atropellis* spp. in North America, and *Atropellis* spp. are introduced in the EU without such natural enemies or limiting biotic agents, then the impacts of *Atropellis* spp. in the EU could be higher than those observed in North America. In that case, given the importance of *Pinus* spp. throughout the EU, consequences for ecosystem services and biodiversity could be expected in addition to the increased production of

deadwood in forests (Ostry and Laflamme, 2008) where this key habitat feature has become rare due to forest management practices. An uncertainty about the potential impacts of *Atropellis* spp. on ecosystem services and biodiversity is how the disease would interact with other forest disturbances in the EU (Cobb and Metz, 2017).

As a first approximation, it can also be assumed that the environmental impact of the introduction of *Atropellis* spp. into the EU (including landscape-wide consequences for social values) could be potentially higher in the EU than in North America because of the higher incidence estimated for the disease (see Appendix C). In order to describe the potential consequences of *Atropellis* spp. in the EU, an impact model was applied to European conditions based on a study by Heineman et al. (2010) (Appendix C.1). In this paper, a model was developed in British Columbia for *P. contorta*, which is the major host for the pathogen in North America (e.g. Hopkins, 1961, 1963; Sinclair and Lyon, 2005). *P. contorta* is also present in the EU (particularly in Scandinavia and the British Isles) (for a map, see EFSA PLH Panel, 2014).

Nonetheless, the extrapolation of the model by Heineman et al. (2010) to the EU area suggests that damage probability in the EU is expected, on average, to be about two to three times higher than in British Columbia. The climate (the higher values in mean coldest monthly temperature) is the variable making the lodgepole pine stands in the EU potentially more vulnerable (Appendix C).

The model of Heineman et al. (2010) was based on the major host of *Atropellis* spp. (*P. contorta*). Considering the lower impact observed in other *Pinus* spp. in North America (Schubert, 1974; Dunham, 2008; Cerezke et al., 2014), this impact assessment could be regarded as a worse-case scenario. However, Heineman et al. (2010) studied *Atropellis* impacts within a range of temperatures which is well below what commonly experienced in many areas of the EU where lodgepole pine has been planted. Usually, when empirical models are used outside the range of the independent variables, the estimation of the response variable is fraught with uncertainty and has thus to be taken with caution. Moreover, in the EU, the probability that damage will occur is greater than the probability that it will not occur in 33% of cases, while in British Columbia only in 12% of cases. Uncertainties in this extrapolation include that: (i) the model was originally estimated for a parameter range which is outside of the range observed in the areas of the EU to which the model was extrapolated; (ii) only the factors that were significant in the original model were considered in the extrapolation, but there were other factors that could be important in the RA area (e.g. stress status of the trees, soil depth, intraspecific variation in host susceptibility); and (iii) in the original model only broad factors related to site and climate were considered.

3.2.3. Conclusions on the host range and impacts

In the EU, various *Pinus* spp. with a wide distribution are known to be hosts of *Atropellis* spp. (both native *Pinus* spp. and introduced ones). However, no information is available on the susceptibility of European *Pinus* spp. not present in the affected forests areas in Canada and the USA. There is no available evidence from the sentinel network of botanic gardens and arboreta in Canada and the USA that European *Pinus* spp. grown there have been affected by *Atropellis* spp., but this does not rule out that these *Pinus* spp. are susceptible to the pathogen.

In conclusion, the expected impact on *P. contorta* in the RA area should be comparable or even more severe than that observed in British Columbia where an average incidence of 0.8% of affected trees was reported (Heineman et al., 2010). Incidentally, *Atropellis* canker is reported to be one of the most feared tree diseases in Russia (Cannon et al., 2016). Uncertainties in this extrapolation include that (i) the model was originally estimated for a parameter range which is outside of the range observed in the areas of the EU to which the model was extrapolated, (ii) only the factors that were significant in the original model were considered in the extrapolation, but there were other factors that could be important in the RA area (e.g. water content of the trees, soil fertility, host genetic diversity), (iii) in the original model only broad factors related to site and climate were considered.

There are, moreover, large uncertainties associated with this assessment due to the unknown susceptibility of several *Pinus* spp. present in Europe. Further information on the susceptibility of *Pinus* spp. present in the RA area should be collected in order to assess more completely the potential consequences of the introduction of *Atropellis* spp. in the entire RA area.

3.3. Overall conclusions

Atropellis is a North American fungal pathogen of *Pinus* spp. The pathogen has not yet been reported in the EU. Its risk of entry was assessed by the Panel as close to zero under the current

regulatory situation, but also in a scenario without the specific *Atropellis* EU regulations (because of the remaining generic EU regulations on *Pinus* spp.), as well as in a scenario adding further requirements (Section 3.1.3). The factors contributing most to the uncertainty of the RA were the *Atropellis* incidence in North America, the disaggregation of the pathway units in the RA area, and the effectiveness of the RRO for wood (heat treatment), but the overall uncertainty associated with this assessment was relatively limited, given that all the quartiles of the estimated distribution of the number of potential founder populations are close to zero.

Nonetheless, should *Atropellis* spp. be introduced in the EU, similar or higher impacts as those observed in North America are to be expected, with the related consequences on ecosystem services. The uncertainty associated with this impact assessment is mainly due to the lack of knowledge on the susceptibility of some European *Pinus* spp. However, *P. contorta*, a susceptible pine species, has been widely planted in several EU MS. Moreover, common European *Pinus* spp. such as *P. nigra, P. pinaster* and *P. sylvestris* are known to be hosts of *Atropellis* spp.

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Abbreviations

EPPO	European and Mediterranean Plant Protection Organization
EU MS	European Union Member State
FAO	Food and Agriculture Organization
ISPM	International Standards for Phytosanitary Measures
MCMT	Mean coldest monthly temperature
MP	Montreal Protocol
PLH	EFSA Panel on Plant Health
PRA	pest risk assessment
RA	risk assessment
RRO	risk reduction option
ToR	Terms of Reference
USDA	United States Department of Agriculture

Appendix A – Assessment of Entry for scenario A0, pathway wood

A.1. Substep E1: from harvested wood to the number of affected pathway units of *Pinus* wood in the place of production

The place of production is considered to be *Pinus* forests in the USA and Canada. The pathway unit is a cubic metre of wood. Estimations were carried out for wood originating in the USA and Canada, separately, and for wood with and without bark.

Estimation of the number of pathway units of *Pinus* wood with (N_{E1}) and without bark (N'_{E1})

The number of pathways units was estimated based on data on coniferous wood imports (in tonnes) into the EU from the USA and Canada, in the period 2011 to 2015 (from UN ComTrade database).

Since these import data are for coniferous wood in aggregate, the proportion of *Pinus* wood was estimated based on the proportion of *Pinus* spp. wood production over the total conifer wood production in Canada and USA. These proportions were estimated to 15% in Canada (Natural Resources Canada) and 50% in the USA (USDA Forest Service). A single value was used to simplify the assessment, although there is some uncertainty associated with this estimation too.

To transform tonnes of imported wood in cubic metres, it was considered that – for the average of different *Pinus* spp. grown in the USA – one 1 m^3 of *Pinus* dried wood is about 0.5 tonnes, with little variation due to the *Pinus* species and time since felling (data from the Wood Database, http://www.wood-database.com/). This average value for dried wood was used considering that traded wood is more likely to be shipped after seasoning.

Table A.1: Estimation of the number of pathway units of *Pinus* wood imported from North America into the EU (wood with bark) (N_{E1})

Quantile	Value	
	For USA	For Canada
Lower (1%)	60	10
Q1 (25%)	600	100
M (50%)	900	150
Q3 (75%)	1,200	200
Upper (99%)	3,000	500

Justification for USA (Table A.1):

> Lower: Expert judgement, based on one-tenth of the estimation for Q1.
> Q1: Expert judgement, based on an average of about two-thirds of the average trade volume used for the median, using data for the 3 years with lower trade volume out of the last 5 years with available data.
> M: Based on an average of about 1,000 tonnes per year of coniferous roughwood imports from the USA into the EU over the last 5 years of available data (2011-2015; UN ComTrade database).
> Q3: Expert judgement, based on an average of about 1.4 times the average trade volume used for the median, using data for the 2 years with higher trade volume out of the last 5 years with available data.
> Upper: Expert judgement, based on 2.5 times the estimation for Q3.

Justification for Canada:

> All quantiles: half the values estimated for the USA, based on an average of coniferous roughwood imported by the EU from Canada over the last 5 years with available data (2011–2015) of about half the imported volume of the USA.

Table A.2: Estimation of the number of pathway units of *Pinus* wood imported from North America into the EU (wood without bark) (N'_{E1})

Quantile	Value	
	For USA	For Canada
Lower (1%)	2,000	2,000
Q1 (25%)	20,000	20,000
M (50%)	30,000	30,000
Q3 (75%)	42,000	42,000
Upper (99%)	100,000	100,000

Justification for USA (Table A.2):

Lower: Expert judgement, based on one-tenth of the estimation for Q1.
Q1: Expert judgement, based on an average of about two-thirds of the average trade volume used for the median, for consistency with the estimations for wood with bark.
M: Based on an average of about 30,000 tonnes per year of coniferous sawnwood imports from the USA into the EU over the last 5 years of available data (2011–2015; UN ComTrade database).
Q3: Expert judgement, based on an average of about 1.4 times the average trade volume used for the median, for consistency with the estimations for wood with bark.
Upper: Expert judgement, based on 2.5 times the estimation for Q3.

Justification for Canada

All quantiles: same values estimated for the USA, based on an average of coniferous sawnwood imported by the EU from Canada over the last 5 years with available data (2011–2015) of about 3.3 times the imported volume of the USA, considering that only 15% of coniferous wood harvested in Canada was estimated to be of *Pinus* spp.

Estimation of the proportion of the area of production where *Atropellis* spp is known to occur (e_1)

The parameter e_1 was used to derive the number of pathway units of *Pinus* wood with bark (N_{E2}) and without bark (N'_{E2}) from areas where the pest is reported. The parameter e_1 was used for wood with and without bark because its value does not change based on the debarking treatment.

The proportion of the USA and Canadian wood production affected by *Atropellis* spp. over the total production was estimated by using data from the acreage of timberland in the different US States and from the total harvesting acreage in the Canadian provinces, under the assumption that the proportion of *Pinus* spp. over the total timberland and harvested wood (in USA and Canada, respectively) is constant over States and provinces. A single value was used to simplify the assessment, although there is some uncertainty associated with this estimation too. The data were retrieved from the web sites of the Forest Service of USDA (https://apps.fs.usda.gov/fia/datamart/FIADB6_pop_estimates.html) and of Natural Resources of Canada (http://www.nrcan.gc.ca/forests/report/area/16399).

These proportions were used to estimate the proportion of wood import originating from areas known to be affected by *Atropellis* spp., under the assumption that the geographical distribution of the imported wood is proportional to the geographical distribution of the produced wood. The fact that *Pinus* forests in affected US States and Canadian provinces are not entirely affected by the pathogen was taken into account in the following substep.

The undetected presence of *Atropellis* in some US States or Canadian provinces is possible, but the Panel considers that it has low probability because of the presence of routine, extensive surveys in both countries. The Panel took into account this consideration as uncertainty reflected in the estimated distributions.

Table A.3: Estimation of the proportion of the area of production where *Atropellis* spp. is known to occur (e_1)

Quantile	Value	
	For USA	For Canada
Lower (1%)	70%	40%
Q1 (25%)	76%	43%
M (50%)	79%	45%
Q3 (75%)	84%	48%
Upper (99%)	97%	55%

Justification for Canada (Table A.3)

Lower: Expert judgement, based on 2% less than the value calculated for Q1.
Q1: Based on 42% of the total forest harvesting area located in Canadian provinces with a reported presence of *Atropellis* spp., with 1% more to make the Q1 value closer to the median than to the lower limit, so as to facilitate fitting a distribution to the quantiles. The 42% was used for the estimation of Q1, and not the median, because regions with reports of *Atropellis* can be confidently assumed to be affected by the pathogen, whereas regions without reports of *Atropellis* may actually be affected even if not known to be so.
M: Expert judgement, based on 3% more than the value calculated for Q1.
Q3: Expert judgement, based on 7% more than the value calculated for Q1.
Upper: Expert judgement, based on 13% more than the value calculated for Q3.

Justification for the USA

Based on about 74% of the timberland located in US States with a reported presence of *Atropellis* spp., with estimation of the quartiles using the same relative distance from each other as for Canada.

Estimation of the prevalence of the pest in the place of production where *Atropellis* spp is known to occur (e_2)

The prevalence, i.e. the percentage of forest stands that are affected within an affected wood-production area was estimated based on the evidence that the pest has been found: occasionally (general remark in Hansen, 1985), in 27% (Heineman et al., 2010; sample size = 66 plots), 37% (Roach et al., 2015; sample size = 27), 46% (Van der Kamp, 1994; 28 locations), 52% of stands (Hopkins and Callan, 1991; 169 sampled stands) and in many stands (general remark in Dunham, 2008).

The same distribution was used for USA and Canada, because the above evidence is coming from both countries.

The Panel is aware that this is a limited data set and that the data were not obtained from systematic spatial surveys. Thus, the data are heterogeneous both spatially and temporally. However, the Panel considers that the data are suitable for the purpose of this risk assessment. In fact: (i) low variation in the frequency of affected plots is expected over time (if a plot is affected, it will tend to remain affected, as the disease is persistent, Van der Kamp, 1994); (ii) trees may be infected for a very long time and cankers have been estimated to remain active for more than 20 years (Hopkins, 1961); (iii) *Pinus* forests last many years. The Panel took into considerations all the above consideration as uncertainties reflected in the estimated distribution.

Table A.4: Estimation of the prevalence of *Atropellis* spp. in the place of production known to be affected (e_2)

Percentile	Value
Lower (1%)	5%
Q1 (25%)	30%
M (50%)	44%
Q3 (75%)	60%
Upper (99%)	85%

Justification (Table A.4):

Lower: Expert judgement, interpretation of 'occasionally' (Hansen, 1985)
Q1: Expert judgement, accounts for the variability of the available four data points used to estimate the median.
M: Expert judgement, assuming a symmetric distribution, weighted estimation based on the above mentioned four data sources (Hopkins and Callan, 1991; Van der Kamp, 1994; Heineman et al., 2010; Roach et al., 2015).
Q3: Expert judgement, accounts for the variability of the available three data points used to estimate the median.
Upper: Expert judgement, higher than the highest value reported in the literature (52%; Hopkins and Callan, 1991) we have, but lower than 100% (estimated as unrealistic).

Estimation of the incidence of the pest in the affected *Pinus* stands (e_3)

The incidence, i.e. the percentage of plants that are affected within an affected forest stand, together with the parameter e_2 previously estimated was used to calculate the number of affected pathway units of *Pinus* wood with bark N_{E3} and without bark N'_{E3} in the place of production.

The distribution of incidence of affected *Pinus* plants in affected plots was estimated based on the following available data: 0.2–29.1% (2.4% = average) (Heineman et al., 2010), 1.5–16.9% (weighted average = 7.3%) (Van der Kamp, 1994: 16 plots), up to 19% (1.3% average incidence) in an individual site (Roach et al., 2015), > 50% (Hansen, 1985), over 70% (Bourchier, 1956), 78% (max) (Hopkins and Callan, 1991), > 80% (Baranyay et al., 1973).

The same distribution was used for USA and Canada, because the above evidence is coming from both countries.

The Panel is aware that the available data: (i) only refer to *A. piniphila* infecting lodgepole pine; (ii) have been recorded from sites with different environmental conditions and forest management practices (both known as factors that may strongly influence the incidence of the disease); and (iii) were not obtained from systematic surveys. Therefore, the available data cannot be representative of the whole range of conditions. In addition, the temporal variation in the proportion of affected plants in an affected stand can be more rapid than the temporal variation in the proportion of affected forest stands. The temporal variation in the percentage affected trees within a stand over 12 years was about 0.15% per year (Van der Kamp, 1994). The Panel took into account all the above considerations as uncertainties reflected in the estimated distribution.

Table A.5: Estimation of the incidence of *Atropellis* spp. in the affected *Pinus* stands (e_3)

Percentile	Value
Lower (1%)	0.05%
Q1 (25%)	1%
M (50%)	2%
Q3 (75%)	20%
Upper (99%)	90%

Justification (Table A.5):

Lower: Expert judgement, based on Heineman et al. (2010).
Q1: Expert judgement, based on the lower values of the intervals reported in: Van der Kamp (1994); Heineman et al. (2010); Roach et al. (2015).
Median: Expert judgement, weighted average of the mean incidence value of the intervals reported in Van der Kamp (1994) (n plots = 5); Heineman et al. (2010) (n plots = 66); Roach et al. (2015) (n plots = 27)
Q3: Expert judgement, based on the upper values of the intervals reported in: Van der Kamp (1994), Heineman et al. (2010) and Roach et al. (2015).
Upper: Expert judgement, higher than the highest values reported in the literature (based on > 70% in Bourchier (1956); 78% in Hopkins and Callan (1991); > 80% in Baranyay et al. (1973)).

A.2. Substep E2: from having left the place of production to the border of the exporting country

Estimation of the effectiveness of RRO (e_4)

This parameter was used to calculate the number of affected pathway units of *Pinus* wood with bark N_{E4} and without bark N'_{E4} when crossing the border of the exporting country.

The RRO considered in this substep were heat treatments of *Pinus* wood to be exported (see Section 1.2.2). The parameter for estimating the effectiveness of these RRO was based on the assumed *Atropellis* survival after treatment with high temperature.

Literature data were used to estimate the parameter based on heat treatment at 56°C (Ramsfield et al., 2010; Allen, 2014; Mayfield et al., 2014). The Panel, however, considers that the temperature on the wood surface (were cankers and ascocarps are present) will tend to be higher than inside the wood. It has been observed that at 61°C even those fungi surviving at 56°C were killed (Ramsfield et al., 2010).

The estimations refer to mycelium because data on ascospore survival of relevant species at high temperatures were not available. However, the Panel considers that ascocarps and ascospores are produced only on visible and old cankers; therefore, for wood quality selection reasons, it is unlikely that wood with such cankers is traded.

Table A.6: Estimation of the effectiveness of RRO (e_4), expressed in terms of *Atropellis* survival after heat treatment

Quantile	Value
Lower (1%)	0.00000
Q1 (25%)	0.00005
M (50%)	0.0001
Q3 (75%)	0.001
Upper (99%)	0.01

Justification (Table A.6):

Lower Limit: In 82% of ascomycete fungi (out of 22 species; Ramsfield et al., 2010; Allen, 2014; Mayfield et al., 2014) from which data were available, the survival of mycelium in wood was 0 when temperature was 56°C for 30 min. Among these fungi, the lethal threshold in the worst case (for ascomycete mycelium in wood) was 68°C for an exposure of 30 min. The temperature inside the heat treatment chamber is higher than the target of 56°C so as to reach the target temperature inside the wood (USDA, 2001; Allen, 2014), which implies that the temperature reached on the surface and the first external layer of the wood (where *Atropellis* is mainly located) will be higher than the target temperature in the core.

Lower quartile: 0.00005 (0.005%). Expert judgement, based on half of the median value.

Median: 0.0001 (0.01%). Expert judgement, the Panel accounts for a marginal probability of survival despite heat treatment.

Upper quartile: 0.001 (0.1%). Expert judgement, as above. 'Research reports show that various fungi in wood can survive 1 to several hours of heat treatment at a temperature ranging from 56°C to 70°C, but were destroyed by a treatment of 71.1°C for 75 minutes' (these numbers include basidiomycetes and those producing chlamydospores, that is not the case of *Atropellis* spp.) (from Allen, 2014).

Upper Limit: 0.01 (1%). Expert judgement, based on 10 times the upper quartile.

A.3. Substep E3: from having left the border of the exporting country to the EU point of entry

This substep was introduced into the model to account for the change in the number of affected pathway units during transportation. The parameter (e_5) was then used to calculate the number of affected pathway units of *Pinus* wood with bark N_{E5} and without bark N'_{E5} when arriving at the EU border. However, the Panel considers that no change in the number of infected units is expected during transport, for the following reasons.

In the case of wood without bark, if an infected unit of wood makes contact with uninfected units of wood, there is a theoretical possibility of transmission via mycelial growth, dependent on contact, transport conditions and speed of transport. However, since transport is usually fairly fast (maximum a few weeks) and mycelial growth is expected to be rather slow (Hopkins and Callan, 1991), it is unlikely that the pathogen will spread between units of wood.

In the case of wood with bark, assuming there are no cankers present after inspection, it is considered very unlikely that ascocarps could be produced during the short transport since normally at least 2 years are needed between infection and fruit body formation (Lockman, 2005). If some cankers escape visual inspection, the appropriate conditions of moisture and temperature for the ascospore ejection and germination is unlikely to occur during the transport (Hopkins, 1961). Thus, the abundance of the pathogen is unlikely to change during transport.

Therefore, to simplify, this parameter was kept equal to 1. There are, however, uncertainties about all the above-mentioned factors.

A.4. Substep E4: from having left the EU port of entry to the transfer to a suitable host

Estimation of the pathway units aggregation coefficient (e_6)

This parameter was used to calculate the number of affected pathway units of *Pinus* wood with bark N_{E5} and without bark N'_{E5} in the locations where transfer can occur.

There is a lack of data on the aggregation or disaggregation of imported wood from North America. For the estimation of this parameter, the Panel considers the truck transport capacity (which was estimated using expert judgement to be roughly 100 m^3 of wood) as the disaggregation unit that may be delivered to a location where the transfer of the pest can occur.

Table A.7: Estimation of the pathway units aggregation coefficient (e_6)

Quantile	Value
Lower (1%)	0.001
Q1 (25%)	0.005
M (50%)	0.01
Q3 (75%)	0.02
Upper (99%)	0.10

Justification (Table A.7):

Lower: Expert judgement, in case the 10 trucks are delivered to one location.
Q1: Expert judgement, based on one-half of the median.
M: Expert judgement, in case one truck is delivered to one location.
Q3: Expert judgement, based on one-fifth of the upper limit.
Upper: Expert judgement, in case one truck is delivered to 10 different locations.

Estimation of the transfer probability for *Pinus* wood with bark (e_7) and without bark (e'_7)

These parameters were used to estimate the number of potential founder populations N_{E6}. The following factors were considered: (i) the dispersal mechanisms allowing movement from the pathway to a suitable host; (ii) proximity of entry, transit and destination points to suitable hosts; and (iii) risks from by-products and waste (ISPM 11). The intended use of the commodity was not considered as relevant.

i) Dispersal mechanism. The dispersal of *Atropellis* from infected wood to a suitable host is expected to occur through ascospores only. Ascospores are formed in ascocarps that are produced in stromata on the surface of the bark over the cankers, in the central sunken canker zone (Hopkins and Callan, 1991). Therefore, debarked wood, even though it is affected by *Atropellis*, cannot transfer the pest. Ascocarps are produced after widely varying intervals after infection has occurred. A period of 2–5 years usually elapses between infection and the onset of inoculum formation on small branches and trunks (Lockman, 2005; Sinclair and Lyon, 2005). Inoculum production, once it has begun, continues each year until a few years after death of the host (Hopkins, 1969). Therefore, ascocarps are unlikely to be produced in small, young cankers. There is no information on whether ascocarp formation can

start on cut wood. This missing information is relevant for this assessment because it makes uncertain the possibility that a latent infection or a small canker present in the imported wood produce stromata and ascocarps on the cut wood during transportation or storage. This is considered as an uncertainty in the quantitative assessment.
There is no detailed information on the environmental conditions favouring the production of ascocarps and ascospores in *Atropellis* spp. In other Ascomycota, moistening of the substrate for a long period is a critical factor (Lyon et al., 1984) and absorption of water by the ascocarp is necessary for ejection of mature ascospores (Webster and Weber, 2007); water is usually provided by rain. After ejection, ascospores are then dispersed by air currents to varying distances (Savage et al., 2012). Therefore, it can be reasonably assumed that the pine bark has to be moistened for a long time to support inoculum production and, once ascospores are mature, they are released following rain events and wind dispersed. For *Atropellis*, the travelling distance of ascospores has been estimated up to 300 m from the inoculum source (Hopkins, 1962). Rain is considered to play a secondary role in the dispersal of *Atropellis* ascospores (Lockman, 2005). Dispersal of *Atropellis* ascospores occurs between early summer and early autumn (Lockman, 2005; Thomas and Pickel, 2010).

ii) Proximity of suitable hosts. The proximity of susceptible hosts is not considered as a limiting factor because *Pinus* trees are widespread in the RA area as isolated trees, ornamental plantations and forests.

iii) Risks from by-products and waste. If the bark surface holds viable ascocarps, the bark pieces resulting from processing can be a potential source of inoculum in case they are disposed outside and exposed to rain in the vicinity of susceptible *Pinus* trees; e.g. bark pieces are used as growing media or for mulching in gardens. Since there is no quantitative information about the volume of bark pieces resulting from the processing of wood in the EU and on how they are disposed, this factor is considered in the present quantitative assessment as an uncertainty.

Based on the previous considerations, for the transfer of *Atropellis* inoculum, it is then necessary that: (i) wood has bark; (ii) visible, old and viable cankers are present on the bark; (iii) the bark is wetted for enough time to allow formation of ascocarps and maturation of ascospores; (iv) cankers are exposed to rainfall between early summer and early autumn; and (v) susceptible hosts are grown in a radius of 300 m (there is uncertainty on whether some ascospores can travel over longer distances). These requirements restrict the possibility of transfer between early summer and early autumn from barked wood with visible, viable cankers (or portions of cankers) exposed outside for long time (months to year depending on the canker age). The Panel considers that all these conditions are unlikely to be satisfied at the same time, for the following reasons: (i) the presence of cankers able to support ascocarp formation may be difficult because it is unlikely that wood with old cankers comply with wood quality requirements; (ii) wood usually does not stay outside exposed to rainfall for months or years; (iii) both round wood and wooden boards are stored in piles, so that only a minor part of the bark is directly exposed to rain.

The Panel estimates the following two distributions for the parameter affecting transfer, which reflects the considerations and uncertainties previously discussed.

Table A.8: Estimation of the transfer probability of *Atropellis* spp. for *Pinus* wood with bark (e_7) and without bark (e'_7)

Quantile	Value	
	e_7	e'_7
Lower	0.000001	0.0001
Q1	0.000005	0.0005
M	0.00001	0.001
Q3	0.00002	0.002
Upper	0.00005	0.005

Justification for wood without bark (Table A.8):

Lower: Expert judgement, same considerations of the upper value, but only 0.02% of the imported wood with the presence of bark.

Q1: Expert judgement, same considerations of the upper value, but only 0.1% of the imported wood with the presence of bark.
M: Expert judgement, same considerations of the upper value, but only 10% of the environmental conditions conducive to ascospore production (the presence of roofs in open-air wood storage facilities)
Q3: Expert judgement, same considerations of the upper value, but only 20% of the environmental conditions conducive to ascospore production (the presence of roofs in open-air wood storage facilities)
Upper: Expert judgement, based on an unlikely expectation of about 1% of imported wood with the presence of bark residue after debarking, 1% of imported wood with the presence of cankers, and environmental conditions conducive to ascospore production in 50% of cases.

Justification for wood with bark:

All quantiles: same as for wood without bark, but considering that there is bark in 100% of imported wood with bark.

Finally, according to the formal model for Entry presented in Section 2.4, the estimated number of potential established population is calculated and reported in Table 3.

Appendix B – Risk reduction options that may be applied to wood and bark

This Appendix considers only risk reduction options (RRO) that aim to make safe wood or bark that could harbour mycelium or spores of *Atropellis* spp. Even if those RRO may also be effective for other pests (e.g. arthropods and nematodes), only potential effects on *Atropellis spp*. are considered here. In Directive 2000/29/EC, the RRO in force aim to manage a wide range of pests.

These RRO can technically be applied in the country of origin, at destination or during transport, nevertheless, treatments in the country of origin are recommended in order to avoid difficulties with management of wastes (untreated part of wood or bark, leftovers).

The internationally recognised standard ISPM 15 is applicable for those RRO, but additional information can also be found in the USDA treatment manual as well as in EPPO standards.

The relevant pathways considered here were:

- wood (any form of wood, including wood packaging material);
- isolated bark.

B.1. RRO applied specifically to wood

Wood may be submitted to mechanical, physical or chemical treatments for various purposes, among others compliance to regulation, protection against damaging living organisms (e.g. those causing holes) and enhancement of the durability and service life of timber.

Beside official export requirements, treatments are applied to wood to protect it against insect or fungal attacks during the drying process; to enhance its durability and service life against bioagents, weather conditions, fire; to prevent the increase of insects and pathogens during transport; etc. Several of these technical treatments are effective also against fungi. Nevertheless, it should be considered that non-quarantine treatments depend on the end use of the commodities, and that they are done within the exporting country only if requested by the buyer. Moreover, chemicals used to protect wood are subject to regulations aimed at protecting the environment and human health (Salminen et al., 2014), which can limit their use.

Wood is also treated to reduce water content and prevent uptake of water during the use of the end products, for instance methylation and other processes (Vignali, 2011). These treatments are most often applied after processing, including debarking. Although bark removal with mechanical debarkers on *Atropellis* canker faces is difficult (Hansen, 1985), debarking is generally supposed to be effective in removing fruiting bodies and spores of *Atropellis* spp. The mentioned moisture-reducing treatments may negatively affect the dispersal of spores if these are present on small residues of bark escaping debarking and may limit the growth of mycelium in case of its survival in bark or xylem vessels.

Considering all the above-mentioned treatments which may be applied to wood before exportation to the EU, the Panel estimates that the combination of measures applied to wood may be viewed as a phytosanitary systems approach which may reduce the risk of entry of *Atropellis* spp.

B.1.1. Mechanical treatments (debarking)

Debarking is applied during wood processing to improve or maintain the quality of wood commodities, and for complying with quarantine requirements. In the case of *Atropellis* spp., which are essentially bark fungi (fruiting bodies are formed and produce spores only on bark), the treatment is supposed to be efficient in eliminating the association of these pathogenic agents with the wood pathway.

Nevertheless, in some cases, infected bark can adhere to the underlying wood or cannot be entirely removed for various reasons, making debarking incomplete (Baranyay et al., 1973). Appropriated machinery and processes combined with quality monitoring and removal of insufficiently debarked pieces of wood could limit this drawback to some extent, but it remains difficult to assure that all bark is correctly removed from all exported consignments.

Debarking is commonly used as a step prior to heat treatment or fumigation of wood pieces. Often, debarked pieces of wood are sawn before heat or fumigants are applied (FAO, 1990).

The use of debarking reduces the likelihood of association of *Atropellis* spp. with consignments.

B.1.2. Heat treatments

Heat treatments consist in making all wood parts hot enough, and for a sufficient time, to kill *Atropellis* spp. mycelium and spores. Heat can be air or steam transmitted.

The effectiveness of a heat treatment depends on the application of processes and schedules which, without causing any unacceptable prejudice to the treated material, can kill or inactivate the target pest. In all cases, such a treatment can be effective only if all parts of the submitted plant material which harbour the pest are exposed to a temperature above a minimum value during a long enough lapse of time. No experimental data on the lethal temperature for *Atropellis* spp. were found in the literature. Nevertheless, information is available for other fungi. In a study on mountain pine beetle, Uzunovic et al. (2008) investigated the effect of heat on fungi associated with the insect and concluded that treatment schedules that achieve 56°C for 30 min in the core will be sufficient to eradicate most undesirable fungi associated with mountain pine beetle. Those values (minimum of 56°C for a minimum time lapse of 30 min) are included in Directive 2000/29/CE and ISPM 15 for wood and bark. The fungal pathogen *Ceratocystis platani* can survive in wood at temperatures of 40°C for more than 24 h, but 45°C for the same time were lethal for the fungus (P. Tsopelas, unpublished data, mentioned in EFSA PLH Panel, 2016d). See Appendix A (Section A.2) for additional references on this topic.

Considering (i) the lethal temperatures known for other fungal species, (ii) that the fruiting bodies of *Atropellis* sp. are produced on the bark, i.e. at the surface or close to the surface of wood fragments, and (iii) that to reach the scheduled core temperature the surface is exposed for longer times and/or to relatively higher temperature, the prescribed temperature and time in Directive 2000/29/CE and ISPM 15 are likely to be effective against *Atropellis* fruiting bodies, spores and mycelium, if these are associated with the materials.

Various processes may be applied to achieve required treatment parameters: conventional steam heating, kiln-drying, dielectric heating (e.g. microwaves), etc.

According to a paper prepared recently by a NAPPO Forestry Panel (Allen, 2014), most wood heat treatments are achieved using existing moisture reduction wood kilns (where controlled application of heat is a part of the drying process) or chambers specifically designed for heat treatment. To achieve a core temperature of 56°C for every piece of wood in a large load, several variables must be considered, e.g. wood species, wood density, initial moisture and piece size, initial temperature, evenness of heat distribution in the chamber. To compensate for these variables, temperature monitoring probes are placed strategically in sentinel pieces of wood or temperature time schedules are developed. In either case, ambient chamber temperatures are set higher than 56°C, often at 70–90°C. Since the heat treatment process requires many hours for all wood pieces to reach 56°C, much of the wood, in particular the outer layers of each wood piece, is heated to temperatures higher than 56°C for times far in excess of 30 min.

It is not customary to kiln dry large timbers or poles of many species because of the long drying times required. Such wood is usually air-dried or used green. One notable exception is southern pine. Because of its relative ease of drying and extensive use, successful high-temperature schedules have been developed for southern pine. Schedules for cross-arms and poles include reaching 180°F–82°C (USDA, 2001).

Heat treatment of wood packaging material, as described in ISPM 15 ['to achieve a minimum temperature of 56°C for a minimum duration of 30 continuous minutes throughout the entire profile of the wood (including its core)]' and 'where dielectric heating is used (e.g. microwave), wood packaging material composed of wood not exceeding 20 cm^2, when measured across the smallest dimension of the piece or the stack, must be heated to achieve a minimum temperature of 60°C for 1 continuous minute throughout the entire profile of the wood (including its surface)'. Heat-treated wood shall be physically identified with the marks HT (heat treatment, when applied through steam or air-mediated heat) or DH (dielectric heating, when based on microwaves).

The use of heat treatment reduces the likelihood of survival of *Atropellis* spp. on wood consignments.

B.1.3. Chemical treatments

Some chemical treatments that are effective at killing or deactivating *Atropellis* spp. can be applied by fumigation or impregnation processes. These can require specific facilities and trained personnel and are subject to limitations by regulations concerning the environment, human health etc.

B.1.3.1. Fumigation treatments

Fumigation consists in applying biocides in the form of gas that can enter in the depth of wood by diffusion.

Among fumigation treatments applied in different countries, methyl bromide is still the most largely used at present because it is cheap, relatively easy to apply and its biocidal activity covers a large range of organisms including fungi. Current international agreements on ozone-depleting chemicals (Montreal Protocol (MP)) nevertheless severely restrict their use, although applications for export purposes are still exempted under the MP. The search for alternative treatments and the stringent new regulations on safe use of methyl bromide open new scenarios in which high temperature treatments or other chemicals, may gradually replace methyl bromide also for export purposes.

Fumigants include also sulfuryl fluoride on red oak, it eradicated *Ceratocystis fagacearum* while some organism populations, including fungi, were reduced but not eradicated (Schmidt et al., 1997). Phosphyne can also be used to protect against insects and fungi. The search for alternatives to methyl bromide has led to the evaluation of phosphyne as a preshipment and in-transit treatments for logs and sawn timber (Pant and Tripathi, 2011).

No experimental results for *Atropellis* spp. have been found regarding the efficacy of methyl bromide or other fumigation treatments. Methyl bromide fumigation is included in ISPM 15.

Currently, the only fumigant that seems to be registered for use in material entering the EU is methyl bromide. Increasing limitations nevertheless apply and the registration or availability of new or ecofriendly fumigants in a near future does not seem to be realistic (Ducom, 2012).

B.1.3.2. Impregnation treatments

Impregnation treatments are currently used to protect wood against (i) wood decaying fungi (brown rot agents, which attack cellulose; white rot agents, attacking cellulose and lignin; soft rot fungi, (ii) wood discolouring fungi (staining fungi), (iii) moulds with (coloured) surface growth, that may increase permeability to moisture so enabling access for rot.

Impregnation agents may be waterborne (copper chrome arsenic, alkaline copper quaternary, copper azole, ammonium copper zinc arsenate, ammoniacal copper arsenate, copper naphthalate, borates), solvent-borne (light organic solvent preservatives, to which fungicides may be added) or oil-borne (creosote, pigment emulsified creosote). All the active ingredients mentioned above are considered as active against fungi, even if no specific information has been found for *Atropellis spp*. Before these treatments, all timber is seasoned (air or kiln-dried). For waterborne and oil-borne treatments, the wood is usually dried to a moisture content of about 20% (for some end uses: up to 15%). Timber to be treated with light organic solvent preservatives is machined to its final size. Light organic solvent preservative treatment uses relatively low pressures. In the case of round wood treatment, logs should be debarked. Incising is another process to prepare wood for treatment: sharp steel teeth are pressed into the sides of timber or poles to increase the penetration of the chemical (Hiziroglu, 2003). Impregnation may be associated with high temperature to favour the penetration of chemical into the wood.

As assumed for the temperature treatments, also fumigation and impregnation treatments may be more effective on the wood surface, where the fruiting bodies and spores of *Atropellis* spp. are produced.

The use of chemical treatments reduces the likelihood of survival of *Atropellis* spp. on wood consignments.

At the moment, no chemical is registered for use in material entering the EU. Nevertheless, this risk reduction option remains potentially available as new biocides may be registered for such a use in the future (Ducom, 2012).

B.2. RRO applied specifically to bark

B.2.1. Heat treatments and fumigation

Under the current EU regulation, isolated bark imported from non-European countries must be subjected to an appropriate fumigation with an approved fumigant or undergo an appropriate heat treatment to achieve a minimum temperature of 56°C for a minimum duration of 30 continuous minutes throughout the entire profile of the bark. Heat treatments described above for wood are

therefore equally effective for bark, providing heat reaches the minimum temperature in the entire bark volume.

Such methods lead to conclusions similar to those described above for wood and are not repeated here. The only difference is that bark cannot be marked directly with the TH or DT marks, only packaging can harbour the marks with associated limitations in terms of traceability.

Additional heat parameters can be applied to bark for special uses.

A protocol for hot steam treatment (continuous bark treatment for more than 30 min with temperatures above 80°C) of coniferous bark has been developed in Portugal for the elimination of the pinewood nematode (Fonseca et al., 2013). The parameters of this protocol, because of the high temperature and exposure time and reduced thickness of the substrate to be treated, are estimated adequate to inactivate also *Atropellis* spp.

B.2.2. Composting and fermentation

Bark could also be fermented or composted [EPPO Standard PM 3/53(1)], even if such a risk reduction option is not included into directive 2000/29/CE or ISPM 15 for import matters. Fermenting is an anaerobic process while composting is done under open air conditions. Both methods involve relatively high temperature on fragments of bark of small dimensions (more than 60°C for days). Moreover, the processes cause an increase of thermophilic bacterial populations which can compete with the fungi present in the substrate.

No specific experimental data were found for *Atropellis* spp., nevertheless it is estimated that an appropriate process and schedule can be effective in inactivating *Atropellis* spp. in fermented or composted bark. Managing composting workstations is not an easy task, it requires much experience and it should be well monitored, otherwise not all bark fragments may reach the appropriate minimum temperature values.

The use of the described RRO reduces the likelihood of survival of the pest acting on its association with the isolated bark pathway.

B.3. Practical feasibility of the above described RRO

The described treatments (debarking, heat or chemical treatments, composting) require special equipment or facilities that are not available everywhere and at any time. The decision to treat or not needs to be taken far before the final destination of the commodities is known, which may make treatments more difficult to anticipate. Nevertheless, in the case of wood or isolated bark, treatments can be done over a relatively wide time window and with limited physiological constraints. As treated wood has to be physically marked with a special mark (HT or DH as mentioned above), traceability of treatment is facilitated.

On the other hand, treatments are often performed for reasons other than phytosanitary regulations. For instance, wood is (i) debarked before further processing (sawing, etc.), (ii) kiln dried for technical reasons, and (iii) heat treated for increased resistance or preservation.

Treatments entail direct and indirect costs for producers or traders, nevertheless several wood processes include heat or chemical treatments for technical purposes which, if appropriate schedules are applied, can be considered as effective RRO, thus additional costs, if any, should remain low or acceptable.

According to Directive 2000/29/EC Annex IV, point 1.1., where *Pinus* wood from USA and Canada is included, it is stated in the special requirements that, either: a (heat treatment), b (fumigation) or c (chemical pressure impregnation) can be used. The b and c options must be done 'in accordance with the procedure laid down in article 18.2' of the directive. Currently, there is no biocide authorised for these treatments for this type of wood, because of environmental or social reasons (preservation of the ozone layer, toxicity of chemical compounds, public reluctance for pesticides). Therefore, the only treatment available for this category of wood is heat treatment. The same applies to wood chips, particles, saw dust, etc., of pines from Canada and USA (Point 1.2). The lack of specification/products applicable to the type of wood approved under Article 18.2 results also from other NPPS's documents (Forestry Commission, 2014).

Thus, in the absence of any approved procedure related to pine wood treatments with biocides, the currently solely available RRO under the scenario A0 for the wood pathway is limited to heat treatments (practically most often combined with debarking), except for packaging material. For bark, heat treatment also appears to be the solely available effective RRO.

It should also be considered that, because of the provisional exemption for methyl bromide use in plant quarantine under the MP, alternative treatments (Ducom, 2012) should be adopted in the future, therefore it is advisable to keep treatments with biocides in the list of potential RRO for wood, wood parts and bark.

Table B.1: Potential limitations to the practical application of the considered RRO[(a)]

Limits to be considered regarding applicability	RRO for wood and bark			
	Debarking*	**Heat treatment**	**Fumigation**	**Chemical impregnation***
Regulatory limitations	Already included in current regulations for wood from some countries	Already included in current regulations for wood from some countries	Chemicals need to be authorised in the EU for the intended use, which may become more and more difficult because of environmental regulations	Chemicals need to be authorised in the EU for the intended use, which may become more and more difficult because of environmental regulations
Technical difficulties	Debarking, with minor exceptions, is already included in technical procedures for timber for other reasons	It requires dedicated facilities or equipment and trained staff	It requires dedicated facilities or equipment and trained staff, availability of registered biocides	It requires dedicated facilities or equipment and trained staff, availability of registered biocides
Environmental limitations	–	–	Potential negative effects on human health and the environment. Methyl bromide use is limited by the Montreal Protocol. Plant quarantine use is exempted if authorised by NPPOs [(b)]	Potential negative effects on human health and the environment
Social or ethical aspects	–	–	Social reluctance for biocides	Social reluctance for biocides
Potential side effects: economic considerations	Debarking, with minor exceptions, is already included in technical procedures for timber commodities, therefore no extra costs are expected	Heat treatment is already commonly used for other technical reasons	Extra costs	Extra costs in case of specific quarantine requirements not included in treatments already used for the commodity

(a): Composting of bark could also be considered as a potential RRO.
(b): In 1995, the Parties to the Montreal Protocol, while recognising the need for exempting the use of methyl bromide for quarantine and pre-shipment purposes, urged all countries 'to refrain from use of methyl bromide and to use non-ozone-depleting technologies wherever possible' and further urged the Parties 'to minimize emissions and use of methyl bromide through containment and recovery and recycling methodologies to the extent possible' (UNEP and IPPC, 2007).
*: Implies that the RRO applies to wood only.

Conclusion

Wood debarking is an efficient practice to remove most of the fruiting bodies of *Atropellis* spp. from wood. But it is difficult to get rid of all bark parts, so that some bark may remain on the wood. Debarking is commonly done prior to further wood processing for technical reasons.

Wood treatments based on heat, fumigation and impregnation, often done after debarking, are known to be efficient on the wood and especially on the wood surface, where *Atropellis* spp. produce the fruiting bodies, therefore, they may be considered effective against *Atropellis* spp. Nevertheless, due to lack of registered biocides, heat treatments are practically the only possible option.

Therefore, the Panel considers that a systematic approach consisting in debarking followed by heat treatment is highly effective and straightforward to implement, with little additional costs as it is commonly done for reasons others than compliance to regulation.

For isolated bark, either fumigation, heating or composting/fermentation may be considered effective against *Atropellis* spp. Evidence is missing, but because of the limited size of the bark fragments, such treatments are likely to be effective. As for wood, the use of biocides on isolated bark is limited because of other regulations.

All such RRO are expected to be able to strongly reduce the association of the pest with the relevant pathways at the origin.

Potential limitations to the practical application of the RRO hereby considered are summarised in Table B.1.

Appendix C – Exploration of the potential impact of *Atropellis* spp. on lodgepole pine in the EU

Quantitative information data on the impact of *Atropellis* spp. is scarce; this makes it difficult to estimate the potential impact of *Atropellis* spp. in the EU. The only attempt to systematically investigate the contribution of environmental and management factors to the risk posed by *Atropellis* spp. to *Pinus* spp. appears to be the model on the impact of the pathogen to lodgepole pine proposed by Heineman et al. (2010).

The model was estimated using a large data set on the impact of several forest pests, snow and ice, in southern interior British Columbia. The analysis of Heineman et al. (2010) was conducted in 66 sites (randomly selected) where lodgepole pine was the most abundant tree species. Sites were 15 ha in size, with 15- to 30-year-old lodgepole pines, and met provincial health standards before 2007 (British Columbia Ministry of Forests 2000). They included six biogeoclimatic zones: ESSF (Engelmann Spruce – Subalpine Fir); ICH (Interior Cedar – Hemlock); IDF (Interior Douglas-fir); MS (Montane Spruce); SBS (Sub-Boreal Spruce) and SBPS (Sub-Boreal Pine–Spruce). Heineman et al. (2010) considered 13 *Pinus* diseases/pests (Western gall rust, Stalactiform blister rust, Comandra blister rust, *Atropellis* canker, Pine needle cast, *Dothistroma* needle blight, *Armillaria* root rot, Tomentosus root rot, Lodgepole pine dwarf mistletoe, Sequoia pitch moth, Mountain pine beetle, Warren's root collar weevil and Pine terminal weevil) as well as snow and ice. The Panel focused on *Atropellis* only.

The potential impact of *Atropellis* spp. in the EU was investigated through the extrapolation of the model proposed by Heineman et al. (2010) to the European forest stands of lodgepole pine. The extrapolation was performed using the logistic regression in Heineman et al. (2010) to predict the relationship between the incidence of the disease and climatic-, site-, location- and management-related factors in an area in the EU corresponding to the area in British Colombia were the model was estimated. Among the variables which resulted significantly related to the impact, the site (eastness, northness), the microclimate (MCMT; see Table C.1) and the treatment (spacing, broadcast burn) did not require any change for model application to the EU.

Latitude cannot be directly extrapolated since the latitudinal range in the distribution of lodgepole pine in EU is different from the one observed in North America, because of the difference in the macroclimate of the two geographic regions. This required some adjustment in the model extrapolation in order to estimate the latitude for the model in the EU. Details of the procedure that was followed are given below. Regarding the interval in the longitude, we considered an area in Sweden with the same range as in British Columbia.

C.1. The Heineman et al. (2010) model

Heineman et al. (2010) applied a logistic regression model in which the dependent variable was the occurrence of damage on lodgepole pine; the damage was classified as a dummy variable: 1 = 'potentially nonproductive', 0 = 'potentially productive'. The variables that were considered as potential regressors (i.e. explanatory variables) are shown in Table C.1.

Table C.1: Explanatory variables in the Heineman et al. (2010) model

Type	Variable	Canadian Values Range
Location	**Latitude** (°N)	[49.00, 52.89]
	Longitude (°W)	[−115.50, −123.38]
	Elevation (m)	[620, 1690]
Site	**Slope** (%)	[0, 74]
	Average soil moisture	[2 very dry, 6 very moist]
	Northness $\cos\left[\text{aspect}\left(\frac{3.14159}{180}\right)\right]$	[−1, 1]
	Eastness $\sin\left[\text{aspect}\left(\frac{3.14159}{180}\right)\right]$	[−1, 1]
	Slope position (LW vs MD)	
	Stand age (1 year)	
	Pine density (200 stems/ha)	

Type	Variable	Canadian Values Range
Climatic	**MWMT** (°C) – Mean warmest monthly temperature	[13, 14.9]
	MCMT (°C) – Mean coldest monthly temperature	[−9.2, −6.7]
	MAP (mm) – Mean annual precipitation	[552, 941]
	MSP (mm) – Mean summer precipitation	[264, 354]
	NFFD (days) – Total no. of frost-free days	[138, 162]
	FFP (days) – No. of continuous frost-free days	[37, 89]
	bFFP – Julian date on which FFP begins	[155, 170]
	eFFP – Julian date on which FFP ends	[230, 243]
	TD (°C) – Continentality (MWMT minus MCMT)	[20.8, 22.7]
	AH:M – Annual heat/moisture index [(MAT + 10)/(MAP/1000)]	[13.8, 24.3]
	SH:M – Summer heat/moisture index [(MWMT)/(MSP/1000]	[38.3, 55.0]
	DD > 5 – Growing degree-days (degree-days above 5 °C)	[872, 1183]
	DD < 0 – Cooling degree-days (degree-days below 0 °C)	[784, 1018]
Treatment Factors	**Broadcast burning**	[Yes, No]
	Mechanical site preparation	[Yes, No]
	Brushing	[Yes, No]
	Juvenile spacing	[Yes, No]
	Pruning	[Yes, No]

The estimated model for *Atropellis* spp. was the following

$$\text{logit}\,P(Y) = -76.881 + 3.538\,(\text{spacing}) + 1.478\,(\text{latitude}) + 2.081\,(\text{broadcast burn}) - 0.966\,(\text{eastness}) + 0.748\,(\text{MCMT}) - 0.854\,(\text{northness}),$$

where $\text{logit}\,P(Y) = \ln\left(\frac{P(Y=1)}{P(Y=0)}\right)$

To describe the dependence relationship of the probability that the damage occurs with respect to all possible explanatory variables, in the logistic regression model $\pi(x) = P\,(Y = 1 \mid \mathbf{x})$ is used

$$\pi(x) = \frac{e^{\beta_0+\beta_1x_1+\beta_2x_2+\cdots+\beta_px_p}}{1+e^{\beta_0+\beta_1x_1+\beta_2x_2+\cdots+\beta_px_p}} = \frac{e^{\beta_0+\sum_{j=1}^{p}\beta_jx_j}}{1+e^{\beta_0+\sum_{j=1}^{p}\beta_jx_j}}$$

Now consider the following function of $\pi\,(x)$, called logit,

$$\text{logit}\,[\pi(x)] = \ln\left[\frac{\pi(x)}{1-\pi(x)}\right] = \ln\left[\frac{P(Y=1)}{P(Y=0)}\right].$$

The ratio between probabilities associated with a dichotomy, i.e. between complementary probabilities, is called odds. It is possible to show that

$$\text{logit}\,[\pi(x)] = \beta_0 + \sum_{j=1}^{p}\beta_jx_j$$

Thus, while $\pi\,(x)$ is a nonlinear function of the variables $X_1, X_2, \ldots, X_p$, the logarithm of the odds, called logit, is a linear function of these variables.

In the case of *Atropellis*, the model was estimated using all 28 explanatory variables, but only 6 variables were significant: spacing, latitude, broadcast burn, eastness, MCMT, northness.

C.2. Extrapolation of the impact to the EU

To extrapolate the model from Heineman et al. (2010) to the EU and thus obtaining an estimation of the potential impact of *Atropellis* spp., the Panel adopted the following scheme:

1) The Panel started from the estimated model on Canadian data and considered the 6 significant regressors in the *Atropellis* damage model: spacing, latitude, broadcast burn, eastness, MCMT, northness.
2) The Panel determined the values of the regressors in the EU. For spacing, broadcast burn, eastness, and northness, all the possible values observed in Canada were assumed to be plausible.

The latitudinal interval in the Canadian model was between 49°N (LC_s) and 52.9°N (LC_N), which is internal to the latitudinal distribution of lodgepole pine in North America considered in this Opinion, ranging between 42°N (LA_s) and 64°N (LA_N) (Godbout et al., 2008).

The comparison between the latitudinal range in the distribution of lodgepole pine in North America and in the EU shows important differences (Figure C.1). In particular in the EU, a northward shift in the latitude is noticed, which ranges between 51.5°N (LE_s) and 67.6°N (LE_N). To find in the EU an area corresponding to that in British Columbia, the distribution of lodgepole pine in Sweden between LS_s and LS_N was considered as follows:

$$LS_N = \frac{(LE_N - LE_S) * (LC_N - LA_S)}{LA_N - LA_S} - LE_N = 59.4$$

$$LS_S = \frac{(LE_N - LE_S) * (LC_S - LA_S)}{LA_N - LA_S} - LE_S = 56.6$$

where 'corresponding' means here that the area located in the same position in the latitudinal interval of the distribution of lodgepole pine in the two geographic regions (North America and Europe).

The amplitude of longitudinal interval in Sweden is equal to the Canadian area considered in Heineman et al. (2010).

As the range of the latitude variable in the logistic regression model was changed, the intercept of the model was corrected, from −76.88 (I_c) to −88.11 (I_s)

$$I_S = I_C - (LS_S - LC_S) * \widehat{\beta}_2 = -76.88 - (56.6 - 49) * 1.478 = -88.11,$$

where $\widehat{\beta}_2$ is the estimated coefficient for the latitude variable in the logistic regression model.

The variable mean coldest month temperature (MCMT) was derived from the climatic data set E-OBS version 14.0 which is a daily gridded data set based on ECA&D (European Climate Assessment & Dataset) information (Haylock et al., 2008). The data set contains information on daily mean temperature, daily minimum temperature, daily maximum temperature, daily precipitation sum and daily averaged sea level pressure, covering Europe over a geographic extension between 25N–75N × 40W–75E and with a resolution of 0.25 degrees available on a regular latitude–longitude grid. Therefore, the data set is suitable for the extrapolation of the MCMT variable used in the model. To derive the MCMT, a time span of 10 years was considered, from 2007 to 2016. Then, the coldest month (January) daily mean temperature was selected to determine the average for the whole month for each year; finally, the average for the whole time span was derived, obtaining the 2007–2016 MCMT. In the considered Swedish area, MCMT ranges from −4 to 0°C.

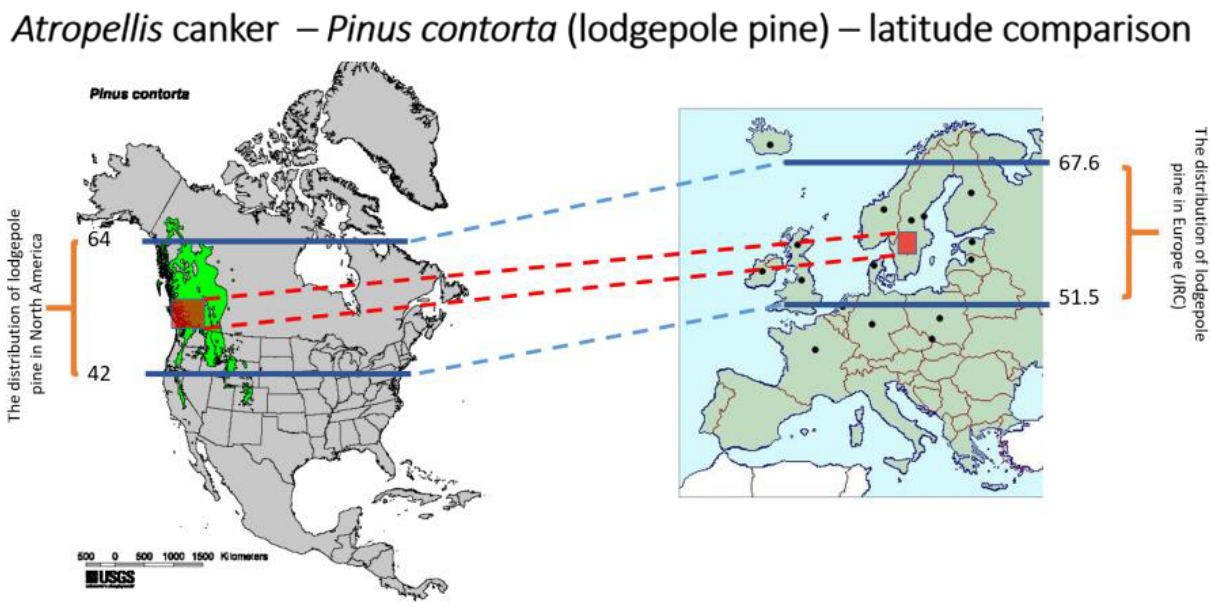

Figure C.1: Comparison of the latitude in the area of British Columbia where the model of Heineman et al. (2010) was developed and in the area of Sweden where the model was extrapolated (modified from maps of the United States Geological Service and the Joint Research Centre)

3) A plausible set of scenarios was derived from the combinations of the values of the predictive variables. More in detail, for each variable the two extreme values (i.e. the lower and the upper) were taken into account and the scenarios were defined as all the possible combinations of these extreme values; this generated 64 scenarios (2^6 = 64).
4) We estimated the probability of damage from *Atropellis* for the specific conditions defining each scenario and compared it with the probability of damage from *Atropellis* for the same scenario defined for the conditions in British Columbia (see Figure C.2). The blue line represents the probabilities estimated in British Columbia and the green line represents the probabilities estimated in the EU. The mean value of damage probability in British Columbia was 0.15 ± 0.26, while in the EU it was 0.40 ± 0.38.

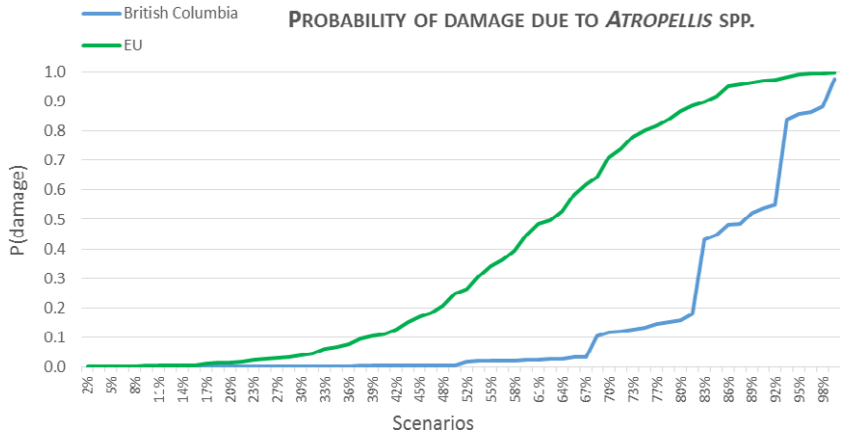

Figure C.2: Comparison between the probability of damage from *Atropellis* in British Columbia (blue line) and in the EU (green line). The scenarios have been sorted in increasing order based on the probability of damage due to *Atropellis* spp. The scenario order is different between the two models

The blue curve is always lower than the green curve, so the probability of damage is significantly lower in British Columbia than in the EU. An interesting cutoff is P(Y = 1) = 0.5, which corresponds to the point where the probability that the damage will occur or not is equal. In the EU, P(Y = 1) > 0.5 (so the probability that the damage will occur is greater than the probability that it will not occur) in 33% of cases, while in Canada only in 12% of cases.

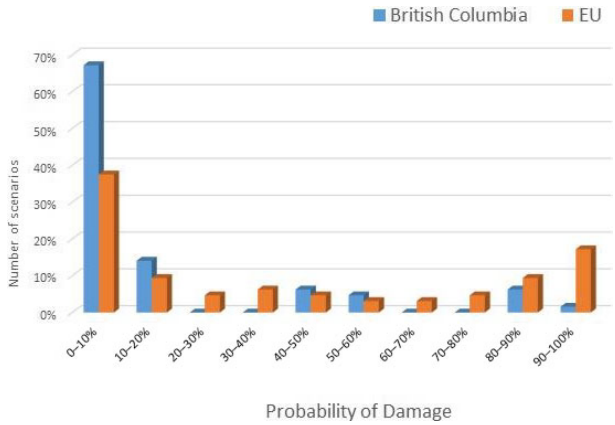

Figure C.3: Frequency distribution comparing classes of the probability of damage from *Atropellis* spp. in British Columbia (blue bars) and in the EU (orange bars)

Figure C.3 shows the distribution of the scenarios based on the estimated probability of damage in that environmental context. We can note that the Canadian distribution is mainly concentrated on the left side of the chart, with a probability lower than 60%. There is a small group of 10 scenarios with a probability ranging from 80% to 100%. The EU distribution, on the other hand, follows a U trend, with higher frequencies for extreme cases. In 30% of cases, there is an estimated probability of damage higher than 70%.

The results of the extrapolation of the model by Heineman et al. (2010) to the EU area suggest that damage probability in the EU is expected, on average, to be about 2.5 higher than in British Columbia. The climate (the higher value in MCMT) is the regressor making the lodgepole pine stands in the EU potentially more vulnerable.