Pest categorisation of *Pseudocercospora pini-densiflorae*

EFSA Panel on Plant Health (PLH),
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Abstract

Following a request from the European Commission, the EFSA Plant Health (PLH) Panel performed a pest categorisation of *Pseudocercospora pini-densiflorae*, a well-defined and distinguishable fungal species of the family Mycosphaerellaceae. The regulated harmful organism is the anamorph *Cercoseptoria pini-densiflorae* (synonym *Cercospora pini-densiflorae*) with the corresponding teleomorph *Mycosphaerella gibsonii*. *P. pini-densiflorae* causes a needle blight of *Pinus* spp. also known as *Cercospora* blight of pines or *Cercospora* needle blight. *P. pini-densiflorae* is reported from sub-Saharan Africa, Central and South America, Asia and Oceania, but not from the EU. The pathogen is regulated in Council Directive 2000/29/EC (Annex IIAI) as a quarantine organism whose introduction into the EU is banned on plants (other than fruit and seeds) and wood of *Pinus* spp. The pest could enter the EU via plants for planting and other means (uncleaned seed, cut branches of pine trees, isolated bark, growing media accompanying plants, and mycorrhizal soil inocula). Hosts are widespread in the EU and favourable climatic conditions are present in Mediterranean countries. *Pinus halepensis, Pinus nigra, Pinus pinea, Pinus pinaster* and *Pinus sylvestris* are reported to be highly susceptible to the pathogen. The pest would be able to spread following establishment after introduction in the EU mainly on infected plants for planting. The pest introduction could have impacts in nurseries and young plantations. Cleaning seeds from needles and removing infected seedlings and pine litter from affected nurseries can reduce the risk of establishment in nurseries and of spread from nurseries to forests, especially given the limited scale of splash dispersal. The main knowledge gaps concern (i) the role of means of entry/spread other than plants for planting and (ii) the potential consequences in mature tree plantations and forests. The criteria assessed by the Panel for consideration as potential quarantine pest are met. For regulated non-quarantine pests, the criterion on the pest presence in the EU is not met.

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Keywords: European Union, forest pathology, pest risk, plant health, plant pest, quarantine, tree health

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## Table of contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>1</td>
</tr>
<tr>
<td>1. Introduction</td>
<td>4</td>
</tr>
<tr>
<td>1.1. Background and Terms of Reference as provided by the requestor</td>
<td>4</td>
</tr>
<tr>
<td>1.1.1. Background</td>
<td>4</td>
</tr>
<tr>
<td>1.1.2. Terms of Reference</td>
<td>4</td>
</tr>
<tr>
<td>1.1.2.1. Terms of Reference: Appendix 1</td>
<td>5</td>
</tr>
<tr>
<td>1.1.2.2. Terms of Reference: Appendix 2</td>
<td>6</td>
</tr>
<tr>
<td>1.1.2.3. Terms of Reference: Appendix 3</td>
<td>7</td>
</tr>
<tr>
<td>1.2. Interpretation of the Terms of Reference</td>
<td>8</td>
</tr>
<tr>
<td>2. Data and methodologies</td>
<td>8</td>
</tr>
<tr>
<td>2.1. Data</td>
<td>8</td>
</tr>
<tr>
<td>2.1.1. Literature search</td>
<td>8</td>
</tr>
<tr>
<td>2.1.2. Database search</td>
<td>8</td>
</tr>
<tr>
<td>2.2. Methodologies</td>
<td>9</td>
</tr>
<tr>
<td>3. Pest categorisation</td>
<td>11</td>
</tr>
<tr>
<td>3.1. Identity and biology of the pest</td>
<td>11</td>
</tr>
<tr>
<td>3.1.1. Identity and taxonomy</td>
<td>11</td>
</tr>
<tr>
<td>3.1.2. Biology of the pest</td>
<td>11</td>
</tr>
<tr>
<td>3.1.3. Intraspecific diversity</td>
<td>11</td>
</tr>
<tr>
<td>3.1.4. Detection and identification of the pest</td>
<td>11</td>
</tr>
<tr>
<td>3.2. Pest distribution</td>
<td>12</td>
</tr>
<tr>
<td>3.2.1. Pest distribution outside the EU</td>
<td>12</td>
</tr>
<tr>
<td>3.2.2. Pest distribution in the EU</td>
<td>12</td>
</tr>
<tr>
<td>3.3. Regulatory status</td>
<td>13</td>
</tr>
<tr>
<td>3.3.2. Legislation addressing plants and plant parts on which <em>P. pini-densiflorae</em> is regulated</td>
<td>13</td>
</tr>
<tr>
<td>3.4. Entry, establishment and spread in the EU</td>
<td>13</td>
</tr>
<tr>
<td>3.4.1. Host range</td>
<td>13</td>
</tr>
<tr>
<td>3.4.2. Entry</td>
<td>14</td>
</tr>
<tr>
<td>3.4.3. Establishment</td>
<td>14</td>
</tr>
<tr>
<td>3.4.3.1. EU distribution of main host plants</td>
<td>14</td>
</tr>
<tr>
<td>3.4.3.2. Climatic conditions affecting establishment</td>
<td>17</td>
</tr>
<tr>
<td>3.4.4. Spread</td>
<td>17</td>
</tr>
<tr>
<td>3.5. Impacts</td>
<td>17</td>
</tr>
<tr>
<td>3.6. Availability and limits of mitigation measures</td>
<td>18</td>
</tr>
<tr>
<td>3.6.1. Biological or technical factors limiting the feasibility and effectiveness of measures to prevent the entry, establishment and spread of the pest</td>
<td>18</td>
</tr>
<tr>
<td>3.6.2. Biological or technical factors limiting the ability to prevent the presence of the pest on plants for planting</td>
<td>18</td>
</tr>
<tr>
<td>3.6.3. Control methods</td>
<td>18</td>
</tr>
<tr>
<td>3.7. Uncertainty</td>
<td>19</td>
</tr>
<tr>
<td>4. Conclusions</td>
<td>19</td>
</tr>
<tr>
<td>References</td>
<td>20</td>
</tr>
<tr>
<td>Abbreviations</td>
<td>22</td>
</tr>
<tr>
<td>Appendix A – List of host species of <em>Pseudocercospora pini-densiflorae</em></td>
<td>23</td>
</tr>
<tr>
<td>Appendix B – Methodological notes on Figure 2</td>
<td>25</td>
</tr>
</tbody>
</table>
1. Introduction

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

1.1.1. Background

Council Directive 2000/29/EC\(^1\) on protective measures against the introduction into the Community of organisms harmful to plants or plant products and against their spread within the Community establishes the present European Union plant health regime. The Directive lays down the phytosanitary provisions and the control checks to be carried out at the place of origin on plants and plant products destined for the Union or to be moved within the Union. In the Directive’s 2000/29/EC annexes, the list of harmful organisms (pests) whose introduction into or spread within the Union is prohibited, is detailed together with specific requirements for import or internal movement.

Following the evaluation of the plant health regime, the new basic plant health law, Regulation (EU) 2016/2031\(^2\) on protective measures against pests of plants, was adopted on 26 October 2016 and will apply from 14 December 2019 onwards, repealing Directive 2000/29/EC. In line with the principles of the above mentioned legislation and the follow-up work of the secondary legislation for the listing of EU regulated pests, EFSA is requested to provide pest categorisations of the harmful organisms included in the annexes of Directive 2000/29/EC, in the cases where recent pest risk assessment/pest categorisation is not available.

1.1.2. Terms of Reference

EFSA is requested, pursuant to Article 22(5.b) and Article 29(1) of Regulation (EC) No 178/2002\(^3\), to provide scientific opinion in the field of plant health.

EFSA is requested to prepare and deliver a pest categorisation (step 1 analysis) for each of the regulated pests included in the appendices of the annex to this mandate. The methodology and template of pest categorisation have already been developed in past mandates for the organisms listed in Annex II Part A Section II of Directive 2000/29/EC. The same methodology and outcome is expected for this work as well.

The list of the harmful organisms included in the annex to this mandate comprises 133 harmful organisms or groups. A pest categorisation is expected for these 133 pests or groups and the delivery of the work would be stepwise at regular intervals through the year as detailed below. First priority covers the harmful organisms included in Appendix 1, comprising pests from Annex II Part A Section I and Annex II Part B of Directive 2000/29/EC. The delivery of all pest categorisations for the pests included in Appendix 1 is June 2018. The second priority is the pests included in Appendix 2, comprising the group of Cicadellidae (non-EU) known to be vector of Pierce’s disease (caused by *Xylella fastidiosa*), the group of Tephritidae (non-EU), the group of potato viruses and virus-like organisms, the group of viruses and virus-like organisms of *Cydonia* Mill., *Fragaria* L., *Malus* Mill., *Prunus* L., *Pyrus* L., *Ribes* L., *Rubus* L. and *Vitis* L., and the group of *Margarodes* (non-EU species). The delivery of all pest categorisations for the pests included in Appendix 2 is end 2019. The pests included in Appendix 3 cover pests of Annex I part A section I and all pests categorisations should be delivered by end 2020.

For the above mentioned groups, each covering a large number of pests, the pest categorisation will be performed for the group and not the individual harmful organisms listed under ‘such as’ notation in the Annexes of the Directive 2000/29/EC. The criteria to be taken particularly under consideration for these cases, is the analysis of host pest combination, investigation of pathways, the damages occurring and the relevant impact.

Finally, as indicated in the text above, all references to ‘non-European’ should be avoided and replaced by ‘non-EU’ and refer to all territories with exception of the Union territories as defined in Article 1 point 3 of Regulation (EU) 2016/2031.

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


1.1.2.1. Terms of Reference: Appendix 1

List of harmful organisms for which pest categorisation is requested. The list below follows the annexes of Directive 2000/29/EC.

**Annex IIAI**

(a) Insects, mites and nematodes, at all stages of their development

- Aleurocactus spp.
- Anthonomus bisignifer (Schenkling)
- Anthonomus signatus (Say)
- Aschistonyx eppoi Inouye
- Carposina niponensis Walsingham
- Enarmonia packardi (Zeller)
- Hishomonus phycitis Toxoptera citricida
- Leucaspis japonica Ckll.
- Listronotus bonariensis (Kuschel)

(b) Bacteria

- Citrus variegated chlorosis
- Erwinia stewartii (Smith) Dye

(c) Fungi

- Alternaria alternata (Fr.) Keissler (non-EU pathogenic isolates)
- Anisogarma anomala (Peck) E. Müller
- Apiosporina morbosa (Schwein.) v. Arx
- Ceratocystis virescens (Davidson) Moreau
- Cercoseptoria pini-densiflorae (Hori and Nambu)
- Cercospora angolensis Carv. and Mendes

(d) Virus and virus-like organisms

- Beet curly top virus (non-EU isolates)
- Black raspberry latent virus
- Blight and blight-like
- Cadang-Cadang viroid
- Citrus tristeza virus (non-EU isolates)
- Leprosis

**Annex IIB**

(a) Insect mites and nematodes, at all stages of their development

- Anthonomus grandis (Boh.)
- Cephalcia lariciphila (Klug)
- Dendroctonus micans Kugelan
- Ips cembrae Heer
- Ips duplicatus Sahlberg
- Ips sexdentatus Börner

- Gonipterus scutellatus Gyll.
- Gilphinia hercyniae (Hartig)
- Ips amitinus Eichhof
- Ips typographus Heer
- Sternochetus mangiferae Fabricius

Xanthomonas campestris pv. oryzae (Ishiyama)
Dye and pv. oryzicola (Fang. et al.) Dye

Elsinoe spp. Bitanc. and Jenk. Mendes
Fusarium oxysporum f. sp. albedinis (Kilian and Maire) Gordon
Guignardia pircola (Nosa) Yamamoto
Puccinia pittieriana Hennings
Stegophora ulmea (Schweinitz: Fries) Sydow & Sydow
Venturia nashicola Tanaka and Yamamoto

Little cherry pathogen (non-EU isolates)
Naturally spreading psorosis
Palm lethal yellowing mycoplasma
Satsuma dwarf virus
Tatter leaf virus
Witches’ broom (MLO)
(b) Bacteria

*Curtobacterium flaccumfaciens pv. flaccumfaciens* (Hedges) Collins and Jones

(c) Fungi

*Glomerella gossypii* Edgerton  
*Hypoxylon mammatum* (Wahl.) J. Miller  
*Gremmeniella abietina* (Lag.) Morelet

1.1.2.2. Terms of Reference: Appendix 2

List of harmful organisms for which pest categorisation is requested per group. The list below follows the categorisation included in the annexes of Directive 2000/29/EC.

**Annex IAI**

(a) Insects, mites and nematodes, at all stages of their development

Group of Cicadellidae (non-EU) known to be vector of Pierce’s disease (caused by *Xylella fastidiosa*), such as:

1) *Carneocephala fulgida* Nottingham  
2) *Draeculacephala minerva* Ball  
3) *Graphocephala atropunctata* (Signoret)

Group of Tephritidae (non-EU) such as:

1) *Anastrepha fraterculus* (Wiedemann)  
2) *Anastrepha ludens* (Loew)  
3) *Anastrepha obliqua* Macquart  
4) *Anastrepha suspensa* (Loew)  
5) *Dacus ciliatus* Loew  
6) *Dacus curcurbitae* Coquillett  
7) *Dacus dorsalis* Hendel  
8) *Dacus tryoni* (Froggatt)  
9) *Dacus tsuneonis* Miyake  
10) *Dacus zonatus* Saund.  
11) *Epochra canadensis* (Loew)  
12) *Pardalaspis cyanescens* Bezzi  
13) *Pardalaspis quinaria* Bezzi  
14) *Pterandrus rosa* (Karsch)  
15) *Rhacochlaena japonica* Ito  
16) *Rhagoletis completa* Cresson  
17) *Rhagoletis fausta* (Osten-Sacken)  
18) *Rhagoletis indifferentes* Curran  
19) *Rhagoletis mendax* Curran  
20) *Rhagoletis pomonella* Walsh  
21) *Rhagoletis suavis* (Loew)

(c) Viruses and virus-like organisms

Group of potato viruses and virus-like organisms such as:

1) Andean potato latent virus  
2) Andean potato mottle virus  
3) Arracacha virus B, oca strain  
4) Potato black ringspot virus  
5) Potato virus T  
6) non-EU isolates of potato viruses A, M, S, V, X and Y (including Yo, Yn and Yc) and Potato leafroll virus

Group of viruses and virus-like organisms of *Cydonia Mill.*, *Fragaria L.*, *Malus Mill.*, *Prunus L.*, *Pyrus L.*, *Ribes L.*, *Rubus L.* and *Vitis L.*, such as:

1) Blueberry leaf mottle virus  
2) Cherry rasp leaf virus (American)  
3) Peach mosaic virus (American)  
4) Peach phony rickettsia  
5) Peach rosette mosaic virus  
6) Peach rosette mycoplasm  
7) Peach X-disease mycoplasm  
8) Peach yellows mycoplasm  
9) Plum line pattern virus (American)  
10) Raspberry leaf curl virus (American)  
11) Strawberry witches’ broom mycoplasm  
Annex IIAI

(a) Insects, mites and nematodes, at all stages of their development

Group of Margarodes (non-EU species) such as:

1) Margarodes vitis (Phillipi)  
2) Margarodes vredendalensis de Klerk  
3) Margarodes prieskaensis Jakubski

1.1.2.3. Terms of Reference: Appendix 3

List of harmful organisms for which pest categorisation is requested. The list below follows the annexes of Directive 2000/29/EC.

Annex IIAI

(a) Insects, mites and nematodes, at all stages of their development

Acleris spp. (non-EU)  
Amauromyza maculosa (Malloch)  
Anomal orientalis Waterhouse  
Arrhenodes minutas Drury  
Choristoneura spp. (non-EU)  
Conotrachelus nenuphar (Herbst)  
Dendrolimus sibiricus Tschetverikov  
Diabrotica barberi Smith and Lawrence  
Diabrotica undecimpunctata howardi Barber  
Diabrotica undecimpunctata undecimpunctata Mannerheim  
Diabrotica virgifera zeae Krysan & Smith  
Diaphorina citri Kuway  
Heliothis zeae (Boddie)  
Hirschmanniella spp., other than  
Hirschmanniella gracilis (de Man) Luc and Goodey  
Liriomyza sativae Blanchard

(b) Fungi

Ceratocystis fagacearum (Bretz) Hunt  
Chrysomyxa arctostaphyli Dietel  
Cronartium spp. (non-EU)  
Endocronartium spp. (non-EU)  
Guignardia laricina (Saw.) Yamamoto and Ito  
Gymnosporangium spp. (non-EU)  
Inonotus weirii (Murill) Kotlaba and Pouzar  
Melampsora farlowii (Arthur) Davis

(c) Viruses and virus-like organisms

Tobacco ringspot virus  
Tomato ringspot virus  
Bean golden mosaic virus  
Cowpea mild mottle virus  
Lettuce infectious yellows virus

Pseudocercospora pini-densiflorae: pest categorisation
(d) Parasitic plants

Arceuthobium spp. (non-EU)

**Annex IIAI**

(a) Insects, mites and nematodes, at all stages of their development

Meloidogyne fallax Karssen, Rhizococcus hibisci Kawai and Takagi

Popillia japonica Newman

(b) Bacteria

Clavibacter michiganensis (Smith) Davis et al., Ralstonia solanacearum (Smith) Yabuuchi et al.

ssp. sepedonicus (Spieckermann and Kotthoff) Davis et al.

(c) Fungi

Melampsora medusae Thümen, Synchytrium endobioticum (Schilbersky) Percival

**Annex IB**

(a) Insects, mites and nematodes, at all stages of their development

Leptinotarsa decemlineata Say

Liriomyza bryoniae (Kaltenbach)

(b) Viruses and virus-like organisms

Beet necrotic yellow vein virus

1.2. Interpretation of the Terms of Reference

*Cercoseptoria pini-densiflorae* is one of a number of pests listed in the Appendices to the Terms of Reference (ToR) to be subject to pest categorisation to determine whether it fulfils the criteria of a quarantine pest or those of a regulated non-quarantine pest (RNQP) for the area of the EU.

The regulated harmful organism is the anamorph *Cercoseptoria pini-densiflorae* (synonyms: *Cercospora pini-densiflorae*, *Pseudocercospora pini-densiflorae*) with the corresponding teleomorph *Mycosphaerella gibsonii* (EPPO, 1997). In accordance with the International Code of Nomenclature for Algae, Fungi and Plants, the dual nomenclature system for fungi has been abandoned since 1 January 2013. The choice of anamorph or teleomorph names is based on priority as determined by the International Commission on the Taxonomy of Fungi and its Working Groups. The recommended valid name for the fungus is *Pseudocercospora pini-densiflorae* (Quintero, 2015; Sullivan, 2016).

2. Data and methodologies

2.1. Literature search

A literature search on *P. pini-densiflorae* was conducted at the beginning of the pest categorisation in the ISI Web of Science bibliographic database, using the scientific names (see Sections 1.2 and 3.1.1) of the pest as search terms. Relevant papers were reviewed, and further references and information were obtained from experts, from citations within the references and grey literature.

2.1.2. Database search

Pest information, on host(s) and distribution, was retrieved from the EPPO Global Database (EPPO, 2017).

Data about import of commodity types that could potentially provide a pathway for the pest to enter the EU and about the area of hosts grown in the EU were obtained from EUROSTAT.
Information on EU Member States (MS) imports of Pinus plants for planting from North America were sought in the ISEFOR database (Eschen et al., 2017). The Europhyt database was consulted for pest-specific notifications on interceptions and outbreaks. Europhyt is a web-based network launched by the Directorate General for Health and Consumers (DG SANCO), and is a subproject of PHYSAN (Phyto-Sanitary Controls) specifically concerned with plant health information. The Europhyt database manages notifications of interceptions of plants or plant products that do not comply with EU legislation, as well as notifications of plant pests detected in the territory of the MSs and the phytosanitary measures taken to eradicate or avoid their spread.

2.2. Methodologies

The Panel performed the pest categorisation for *P. pini-densiflorae* following guiding principles and steps presented in the EFSA guidance on the harmonised framework for pest risk assessment (EFSA PLH Panel, 2010) and as defined in the International Standard for Phytosanitary Measures No 11 (FAO, 2013) and No 21 (FAO, 2004).

In accordance with the guidance on a harmonised framework for pest risk assessment in the EU (EFSA PLH Panel, 2010), this work was started following an evaluation of the EU’s plant health regime. Therefore, to facilitate the decision-making process, in the conclusions of the pest categorisation, the Panel addresses explicitly each criterion for a Union quarantine pest and for a Union RNQP in accordance with Regulation (EU) 2016/2031 on protective measures against pests of plants, and includes additional information required as per the specific terms of reference received by the European Commission. In addition, for each conclusion, the Panel provides a short description of its associated uncertainty.

Table 1 presents the Regulation (EU) 2016/2031 pest categorisation criteria on which the Panel bases its conclusions. All relevant criteria have to be met for the pest to potentially qualify either as a quarantine pest or as a RNQP. If one of the criteria is not met, the pest will not qualify. In such a case, the working group should consider the possibility to terminate the assessment early and to be concise in the sections preceding the question for which the negative answer is reached. Note that a pest that does not qualify as a quarantine pest may still qualify as a RNQP, which needs to be addressed in the opinion. For the pests regulated in the protected zones only, the scope of the categorisation is the territory of the protected zone, thus the criteria refer to the protected zone instead of the EU territory.

It should be noted that the Panel’s conclusions are formulated respecting its remit and particularly with regards to the principle of separation between risk assessment and risk management (EFSA founding regulation (EU) No 178/2002); therefore, instead of determining whether the pest is likely to have an unacceptable impact, the Panel will present a summary of the observed pest impacts. Economic impacts are expressed in terms of yield and quality losses and not in monetary terms, while addressing social impacts is outside the remit of the Panel, in agreement with the EFSA guidance on a harmonised framework for pest risk assessment (EFSA PLH Panel, 2010).

<table>
<thead>
<tr>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Identity of the pest (Section 3.1)</td>
<td>Is the identity of the pest established, or has it been shown to produce consistent symptoms and to be transmissible?</td>
<td>Is the identity of the pest established, or has it been shown to produce consistent symptoms and to be transmissible?</td>
<td>Is the identity of the pest established, or has it been shown to produce consistent symptoms and to be transmissible?</td>
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<tr>
<td><strong>Absence/presence of the pest in the EU territory (Section 3.2)</strong></td>
<td>Is the pest present in the EU territory? If present, is the pest widely distributed within the EU? Describe the pest distribution briefly!</td>
<td>Is the pest present in the EU territory? If not, it cannot be a protected zone quarantine organism</td>
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</tr>
<tr>
<td><strong>Regulatory status (Section 3.3)</strong></td>
<td>If the pest is present in the EU but not widely distributed in the risk assessment area, it should be under official control or expected to be under official control in the near future.</td>
<td>The protected zone system aligns with the pest free area system under the International Plant Protection Convention (IPPC). The pest satisfies the IPPC definition of a quarantine pest that is not present in the risk assessment area (i.e. protected zone)</td>
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</tr>
<tr>
<td><strong>Pest potential for entry, establishment and spread in the EU territory (Section 3.4)</strong></td>
<td>Is the pest able to enter into, become established in, and spread within, the EU territory? If yes, briefly list the pathways!</td>
<td>Is the pest able to enter into, become established in, and spread within, the protected zone areas? Is entry by natural spread from EU areas where the pest is present possible?</td>
<td></td>
</tr>
<tr>
<td><strong>Potential for consequences in the EU territory (Section 3.5)</strong></td>
<td>Would the pests’ introduction have an economic or environmental impact on the EU territory?</td>
<td>Would the pests’ introduction have an economic or environmental impact on the protected zone areas?</td>
<td></td>
</tr>
<tr>
<td><strong>Available measures (Section 3.6)</strong></td>
<td>Are there measures available to prevent the entry into, establishment within or spread of the pest within the EU such that the risk becomes mitigated?</td>
<td>Are there measures available to prevent the entry into, establishment within or spread of the pest within the protected zone areas such that the risk becomes mitigated? Is it possible to eradicate the pest in a restricted area within 24 months (or a period longer than 24 months where the biology of the organism so justifies) after the presence of the pest was confirmed in the protected zone?</td>
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</tr>
<tr>
<td><strong>Conclusion of pest categorisation (Section 4)</strong></td>
<td>A statement as to whether (1) all criteria assessed by EFSA above for consideration as a potential quarantine pest were met and (2) if not, which one(s) were not met</td>
<td>A statement as to whether (1) all criteria assessed by EFSA above for consideration as a potential protected zone quarantine pest were met, and (2) if not, which one(s) were not met</td>
<td></td>
</tr>
</tbody>
</table>

The Panel will not indicate in its conclusions of the pest categorisation whether to continue the risk assessment process, but, following the agreed two-step approach, will continue only if requested by the risk managers. However, during the categorisation process, experts may identify key elements and knowledge gaps that could contribute significant uncertainty to a future assessment of risk. It would be useful to identify and highlight such gaps so that potential future requests can specifically target the major elements of uncertainty, perhaps suggesting specific scenarios to examine.
3. **Pest categorisation**

3.1. **Identity and biology of the pest**

3.1.1. **Identity and taxonomy**

*Pseudocercospora pini-densiflorae* is an ascomycete fungus in the family of Mycosphaerellaceae. There are many species synonymies referred to the anamorphic stage: *Cercoseptoria pini-densiflorae*, *Cercospora pini-densiflorae*, *Mycosphaerella gibsonii* (teleomorph), *Pseudocercospora pini-densiflorae* var. *pini-densiflorae* (Index Fungorum, http://www.indexfungorum.org/names/names.asp). *Asteromella* spp. have been reported as spermatial anamorphs (Sullivan, 2016).

3.1.2. **Biology of the pest**

*P. pini-densiflorae* causes a needle blight of pines (*Pinus* spp.) also known as Cercospora blight of pines or Cercospora needle blight. *P. pini-densiflorae* overwinters as mycelium or immature stromata in host needles. The main infection source consists of airborne conidia produced in the spring from these needles. The stroma of the fungus erupts through stomata, and under humid conditions conidia develop on the stromata. Conidia are liberated and dispersed by rain splash during wet weather or by overhead irrigation (Sullivan, 2016). Two to three days of moist humid conditions are required for dispersal and infection (Ivory and Wingfield, 1986; Ivory, 1987), which occurs through stomata apertures. Due to the major role played by rain water rather than wind in dispersal, the pathogen spreads efficiently only locally, for instance through closely spaced seedlings in nursery beds. Dispersal has been reported to be less efficient between trees in plantations (Ivory, 1987). Conidia germinate between 10°C and 35°C, with 25°C being optimal (EPPO, 1997). A period of approximately 3–7 days can be enough for the production of conidia, their dispersal, and needle infection to occur (Ivory, 1987).

In general, about 5–6 weeks are needed for the symptoms to develop, although symptoms may develop faster in highly susceptible pine species (Ivory and Wingfield, 1986; EPPO, 1997; Sullivan, 2016). The production of stromata and conidia begins soon after the development of symptoms. In addition or instead to conidia, *P. pini-densiflorae* may develop spermatia, which are thought to be important for fertilisation, and subsequently sexual meiospores in ascomata (Ivory, 1987), although the role of sexual spores in the development of epidemics is unknown (Diekmann, 2002). The fungus can remain viable for many months in dry infected needles and subsequently produce large numbers of conidia when wetted (Ivory, 1987). Conidia remain viable for approximately one month, but under moist conditions will promptly germinate and infect needles.

3.1.3. **Intraspecific diversity**

Isolates from Asia have been reported to differ distinctly from African and Jamaican isolates. A third type was reported from *Pinus caribaea* in the Philippines (Ivory, 1994). Due to the differences in conidial morphology, Ivory (1994) suggested that they may be three different ecotypes (Asia, Africa-Central America, and Philippines). Although findings of the species in Central America were reported as infrequent, it was speculated that the ecotype present there could be endemic to the region (Evans, 1984; Ivory, 1994). Findings of the Asian ecotype from remote native pine forests in Nepal suggest a Himalayan origin (Ivory, 1990).

3.1.4. **Detection and identification of the pest**

Are detection and identification methods available for the pest?  **Yes**, detection and identification methods are available.

The symptoms caused by *P. pini-densiflorae* may be difficult to distinguish from closely related pine pathogens (e.g. *Lecanosticta acicola*), but the species has some specific morphological characteristics given

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**Is the identity of the pest established, or has it been shown to produce consistent symptoms and to be transmissible?**  **Yes**

**Pseudocercospora pini-densiflorae** is an ascomycete fungus in the family of Mycosphaerellaceae. There are many species synonymies referred to the anamorphic stage: *Cercoseptoria pini-densiflorae*, *Cercospora pini-densiflorae*, *Mycosphaerella gibsonii* (teleomorph), *Pseudocercospora pini-densiflorae* var. *pini-densiflorae* (Index Fungorum, http://www.indexfungorum.org/names/names.asp). *Asteromella* spp. have been reported as spermatial anamorphs (Sullivan, 2016).

**3.1.2. Biology of the pest**

*P. pini-densiflorae* causes a needle blight of pines (*Pinus* spp.) also known as Cercospora blight of pines or Cercospora needle blight.

*P. pini-densiflorae* overwinters as mycelium or immature stromata in host needles. The main infection source consists of airborne conidia produced in the spring from these needles. The stroma of the fungus erupts through stomata, and under humid conditions conidia develop on the stromata. Conidia are liberated and dispersed by rain splash during wet weather or by overhead irrigation (Sullivan, 2016). Two to three days of moist humid conditions are required for dispersal and infection (Ivory and Wingfield, 1986; Ivory, 1987), which occurs through stomata apertures. Due to the major role played by rain water rather than wind in dispersal, the pathogen spreads efficiently only locally, for instance through closely spaced seedlings in nursery beds. Dispersal has been reported to be less efficient between trees in plantations (Ivory, 1987). Conidia germinate between 10°C and 35°C, with 25°C being optimal (EPPO, 1997). A period of approximately 3–7 days can be enough for the production of conidia, their dispersal, and needle infection to occur (Ivory, 1987).

In general, about 5–6 weeks are needed for the symptoms to develop, although symptoms may develop faster in highly susceptible pine species (Ivory and Wingfield, 1986; EPPO, 1997; Sullivan, 2016). The production of stromata and conidia begins soon after the development of symptoms. In addition or instead to conidia, *P. pini-densiflorae* may develop spermatia, which are thought to be important for fertilisation, and subsequently sexual meiospores in ascomata (Ivory, 1987), although the role of sexual spores in the development of epidemics is unknown (Diekmann, 2002). The fungus can remain viable for many months in dry infected needles and subsequently produce large numbers of conidia when wetted (Ivory, 1987). Conidia remain viable for approximately one month, but under moist conditions will promptly germinate and infect needles.

**3.1.3. Intraspecific diversity**

Isolates from Asia have been reported to differ distinctly from African and Jamaican isolates. A third type was reported from *Pinus caribaea* in the Philippines (Ivory, 1994). Due to the differences in conidial morphology, Ivory (1994) suggested that they may be three different ecotypes (Asia, Africa-Central America, and Philippines). Although findings of the species in Central America were reported as infrequent, it was speculated that the ecotype present there could be endemic to the region (Evans, 1984; Ivory, 1994). Findings of the Asian ecotype from remote native pine forests in Nepal suggest a Himalayan origin (Ivory, 1990).

**3.1.4. Detection and identification of the pest**

Are detection and identification methods available for the pest?  **Yes**, detection and identification methods are available.

The symptoms caused by *P. pini-densiflorae* may be difficult to distinguish from closely related pine pathogens (e.g. *Lecanosticta acicola*), but the species has some specific morphological characteristics given...
in the EPPO diagnostic protocol PM 7/46(3): _Lecanosticta acicola_ (formerly _Mycosphaerella dearnessii_), _Dothistroma septosporum_ (formerly _Mycosphaerella pini_) and _Dothistroma pini_ (Anon, 2015).

The species can be identified and distinguished from other _Mycosphaerella_ (sensu lato) species using molecular methods (Quaedvlieg et al., 2012; DNA sequence data given in Qbank- www.qbank.eu).

### 3.2. Pest distribution

#### 3.2.1. Pest distribution outside the EU

_P. pini-densiflorae_ is reported from sub-Saharan Africa, Central and South America, Asia and Oceania (Figure 1) (EPPO, 2017).

**Figure 1:** Global distribution map for _Pseudocercospora pini-densiflorae_ (extracted from EPPO, 2017, accessed June 2017). There are no records of transient populations for this species.

In Africa, the pathogen is reported from Kenya, Madagascar, Malawi, South Africa, Swaziland, Tanzania and Zambia (EPPO, 2017), as well as Zimbabwe (Sullivan, 2016).

In America, _P. pini-densiflorae_ is reported from Jamaica and Nicaragua (EPPO Global Database), as well as Brazil, Chile, Costa Rica and Honduras (Sullivan, 2016).

In Asia, the pathogen is reported from Bangladesh, China, India, Japan, North and South Korea, Malaysia, Nepal, the Philippines, Sri Lanka, Taiwan, Thailand and Vietnam (Sullivan, 2016; EPPO, 2017).

In Oceania, _P. pini-densiflorae_ is reported from Papua New Guinea (Sullivan, 2016; EPPO, 2017).

#### 3.2.2. Pest distribution in the EU

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

**No,** the pest is not reported to be present in the EU.
3.3. Regulatory status


*P. pini-densiflorae* is listed in Council Directive 2000/29/EC as *Cercoseptoria pini-densiflorae*. Details are presented in Tables 2 and 3.

**Table 2:** *Pseudocercospora pini-densiflorae* in Council Directive 2000/29/EC

<table>
<thead>
<tr>
<th>Annex II, Part A</th>
<th>Plants, plant products and other objects the introduction of which shall be prohibited in all Member States</th>
</tr>
</thead>
<tbody>
<tr>
<td>Section I</td>
<td>Harmful organisms whose introduction into, and spread within, all member states shall be banned if they are present on certain plants or plant products</td>
</tr>
<tr>
<td>5.</td>
<td><em>Cercoseptoria pini-densiflorae</em> (Hori and Nambu) Deighton Plants of <em>Pinus</em> L., other than fruit and seeds, and wood of <em>Pinus</em> L.</td>
</tr>
</tbody>
</table>

3.3.2. Legislation addressing plants and plant parts on which *P. pini-densiflorae* is regulated

**Table 3:** Regulated hosts and commodities that may involve *Pseudocercospora pini-densiflorae* in Annexes III, IV and V of Council Directive 2000/29/EC

<table>
<thead>
<tr>
<th>Annex III, Part A</th>
<th>Plants, plant products and other objects which must be subject to a plant health inspection (at the place of production if originating in the Community, before being moved within the Community—in the country of origin or the consignor country, if originating outside the Community) before being permitted to enter the Community</th>
</tr>
</thead>
</table>

3.4. Entry, establishment and spread in the EU

3.4.1. Host range

*Pseudocercospora pini-densiflorae* infects several species within the genus *Pinus*, in particular *P. caribaea*, *P. densiflora*, *P. thunbergii*, *P. halepensis*, *P. pinaster*, *P. radiata*, *P. canariensis*, *P. luchuensis*, *P. massoniana*, *P. merkusii*, *P. resinosa*, *P. strobus* and *P. sylvestris* (EPPO, 1997). The fungus is known to infect at least 36 *Pinus* species (Quintero, 2015) (Appendix A).

Of these, the European native species *P. halepensis*, *P. nigra*, *P. pinaster*, and *P. sylvestris*, and the American species *P. radiata* are widely cultivated in European nurseries and present in European forests (EPPO, 1997).

*P. halepensis*, *P. nigra*, *P. pinea*, *P. pinaster*, *P. radiata* and *P. sylvestris* are reported to be highly susceptible to the pathogen (Quintero, 2015).
Through artificial inoculation, further conifer species have been successfully infected (*Abies veitchii*, *Abies sachalinensis*, *Cedrus deodara*, *Larix kaempferi*, *Picea glehnii*, *Picea jezoensis*) by Suto (1979) who also reports successful artificial inoculation for *Pseudotsuga menziesii*.

All the above named hosts are regulated at the genus level.

### 3.4.2. Entry

<table>
<thead>
<tr>
<th>Is the pest able to enter into the EU territory?</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Yes</strong>, the pest could enter the EU via plants for planting and other means (see below).</td>
</tr>
</tbody>
</table>

*P. pini-densiflorae* is currently reported as absent from the EU but is widely distributed in parts of Africa and Asia, with presence also reported in Jamaica, Nicaragua (EPPO, 2017) and South Africa (Ivory and Wingfield, 1986; EPPO, 2017). It is unlikely the pathogen could arrive in the EU naturally from these locations even though airborne conidia can be dispersed via the wind. However, it has been stated that it could enter as infected seedlings and on cut branches of *Pinus* (EPPO, 1997) facilitated by the long asymptomatic and latent periods of the pathogen. The asymptomatic period has been reported as about 5–6 weeks depending on environmental conditions (Ivory and Wingfield, 1986; EPPO, 1997; Sullivan, 2016).

The main pathway of entry would thus be:

- Plants for planting

However, under current regulation, this is a closed pathway.

Wood is currently regulated regarding *P. pini-densiflorae* in Annex IIAI (see Section 3.3.1), but there is no evidence that the pathogen can be present and viable on timber, especially as timber would not originate from young plantations, where the pathogen is most prevalent.

Other plant parts capable of carrying the pathogen in trade or transport include uncleaned seed, cut branches of pine trees, isolated bark, leaves, stems and growing media accompanying plants (Venette, 2008; Quintero, 2015). Mycorrhizal soil inocula can also assist in the transmission of the fungus (Singh et al., 1988).

There were no records of interception of *P. pini-densiflorae* in the Europhyt database as of June 2017.

### 3.4.3. Establishment

<table>
<thead>
<tr>
<th>Is the pest able to become established in the EU territory?</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Yes</strong>, the pest could establish in the EU, as hosts are widespread and favourable climatic conditions are found in Mediterranean countries.</td>
</tr>
</tbody>
</table>

#### 3.4.3.1. EU distribution of main host plants

The pathogen can infect a wide range of native and exotic *Pinus* spp., as specified in Section 3.4.1, some of which are present in European forests, nurseries and as ornamental trees (EPPO, 1997) (Figure 2). Of the species that are particularly vulnerable (EPPO, 1997) natural and naturalised populations of *P. halepensis* and *P. pinaster* occur only in southern and south-western Europe (Figures 3 and 4) due to sensitivity to cold conditions.
Figure 2: Left-hand panel: Relative probability of presence (RPP) of the genus *Pinus* (based on data from the species: *P. sylvestris*, *P. pinaster*, *P. halepensis*, *P. nigra*, *P. pinea*, *P. contorta*, *P. cembra*, *P. mugo*, *P. radiata*, *P. canariensis*, *P. strobus*, *P. brutia*, *P. banksiana*, *P. ponderosa*, *P. heldreichii*, *P. leucodermis*, *P. wallichiana*) in Europe, mapped at 100 km² pixel resolution. The underlying data are from European-wide forest monitoring data sets and from national forestry inventories based on standard observation plots measuring in the order of hundreds m². RPP represents the probability of finding at least one individual of the taxon in a standard plot placed randomly within the grid cell. For details, see Appendix B (courtesy of JRC, 2017). Right-hand panel: Trustability of RPP. This metric expresses the strength of the underlying information in each grid cell and varies according to the spatial variability in forestry inventories. The colour scale of the trustability map is obtained by plotting the cumulative probabilities (0–1) of the underlying index (for details see Appendix B).
**Figure 3:** Native range of *Pinus pinaster* (map prepared by Euforgen in 2008). Blue dots represent isolated occurrences of the species.

**Figure 4:** Native range of *Pinus halepensis* (map prepared by Euforgen in 2008). Blue dots represent isolated occurrences of the species.
3.4.3.2. Climatic conditions affecting establishment

The pathogen is mainly associated with tropical and sub-tropical climates (Ivory, 1994). In the EU, hosts are widespread and favourable climatic conditions are found in Mediterranean countries. In addition, the pathogen is reported also from North and South Korea (Mulder and Gibson, 1972; Quintero, 2015), where climatic conditions are similar to those found in continental parts of the EU. Infection occurs mainly by airborne conidia which require wet conditions for splash dispersal (Singh et al., 1988). The optimum temperature for conidia germination is 25°C and occurs over the range 10–35°C (EPPO, 1997).

3.4.4. Spread

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

Yes, mainly by human movement of infected plants for planting.

The pathogen is largely restricted to localised spread via splash dispersal during rainfall or irrigation events (Sullivan, 2016). Spread from plant to plant in closely spaced nursery beds has been observed but is less efficient between plantations (Ivory, 1987). Ivory (1994) observed that the pathogen had failed to occur in many countries with appropriate climates and abundant host species, suggesting that is dispersal-limited and cannot spread well. Longer range spread may occur by human movement of infected material. Symptoms can take about 5–6 weeks to occur and conidia remain viable for up to a month (Ivory and Wingfield, 1986; EPPO, 1997; Sullivan, 2016). Plants for planting may therefore be the main means of spread.

Other means of spread are possible (see Entry section), but with uncertainty on their role.

3.5. Impacts

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

Yes, the pest introduction could have impacts in nurseries and young plantations.

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

Yes, the introduction of the pest could have an impact on the intended use of plants for planting.

P. pini-densifloraе affects older leaves in young saplings (1–2 years old) of both exotic and native pine species (Figure 5). Thus, the pathogen is particularly damaging at the later nursery stage. It has been reported as a major obstacle to the production of pine seedlings (especially P. pinaster, P. thunbergii, and P. densiflora) in southern/central Japan and Taiwan (Ito, 1972; EPPO, 1997; Sullivan, 2016). The disease is important on P. merkusii and P. caribaea nurseries in West Malaysia (Ivory, 1975). Disease incidence of 100% and mortality rates as high as 85% have been reported (Ito, 1972; Ivory, 1987). Few pine species, including P. halepensis, P. pinaster and P. radiata, have been reported to be commonly attacked not only in nurseries but also in young plantations (Hidaka, 1932; Kiyohara and Tokushige, 1969 (both cited in Ito, 1972); Mulder and Gibson, 1972) up to 5 years of age (Ivory, 1987). Indeed, severe defoliations resulting in reduced growth and even tree death have been reported in young plantations of P. radiata in Tanzania (Mulder and Gibson, 1972).

Similar impacts can be expected in the EU if the pathogen will be introduced. The pathogen might not be limited by summer drought in Mediterranean nurseries because of irrigation. Moreover, P. halepensis, P. nigra, P. pinea, P. pinaster and P. sylvestris are reported to be highly susceptible to the pathogen.

*See Section 2.1 on what falls outside EFSA’s remit.
3.6. Availability and limits of mitigation measures

3.6.1. Biological or technical factors limiting the feasibility and effectiveness of measures to prevent the entry, establishment and spread of the pest

- Due to the asymptomatic phase (5-6 weeks) in host plants, *P. pini-densiflora* can be inadvertently introduced and can be moved during commercial exchanges (Ivory, 1987).
- The fungus can be introduced and moved not only through the movement of infected host plants or plant parts (e.g. bark, leaves and stems), but also through growing media accompanying plants (Venette, 2008) and mycorrhizal soil inocula (Singh et al., 1988).

3.6.2. Biological or technical factors limiting the ability to prevent the presence of the pest on plants for planting

- It is difficult to obtain seed completely clean from needle debris.
- Collecting and destroying diseased seedlings early enough may be difficult. This is also because needles can be infected but asymptomatic.
- Removing pine litter from nurseries is impractical.
- Chemical control in nurseries may result in masking the symptoms, thus making it more likely that infected asymptomatic plants for planting will carry the pathogen over long distances.

3.6.3. Control methods

- Seeds coming from infested areas should be completely free of needle debris before sowing in nurseries (Singh et al., 1988).
- Diseased seedlings should be collected and destroyed early in the season before infections occur (Ito, 1972).
- Pine litter in diseased nurseries should be collected and burnt (Singh et al., 1988).
- Young seedlings should be physically separated from older plants where the nursery cycle exceeds 12 months (Ivory, 1987).
- Planting schedules should be arranged outside of rainy months (Singh et al., 1988).
Chemical control can be achieved by treating foliage with fungicides at 2-4 week intervals under optimal conditions for the spread of the fungus (Ivory, 1987). Several active ingredients have been reported to be effective and have hence been recommended (Singh et al., 1988).

3.7. Uncertainty

Although there are no reports of the pathogen in the risk assessment area, the pest may be present in the EU at low incidence, thus without causing damage and remaining undetected.

The plants for planting pathway is currently closed, but the importance of other means of entry and spread is unclear (there is a lack of data to ascertain their importance).

The documented damage comes from nurseries and young plantations; therefore there is uncertainty about the potential consequences in mature plantations and forests. There could be a lag phase between introduction and widespread/noticeable impacts.

It is uncertain whether chemical control in nurseries could mask symptoms, therefore favouring in easier dispersal of the pathogen via asymptomatic plants for planting.

4. Conclusions

*P. pini-densiflorae* meets the criteria assessed by EFSA for consideration as a potential quarantine pest (Table 4).

### Table 4: The Panel’s conclusions on the pest categorisation criteria defined in Regulation (EU) 2016/2031 on protective measures against pests of plants (the number of the relevant sections of the pest categorisation is shown in brackets in the first column)

<table>
<thead>
<tr>
<th>Criterion of pest categorisation</th>
<th>Panel’s conclusions against criterion in Regulation (EU) 2016/2031 regarding Union quarantine pest</th>
<th>Panel’s conclusions against criterion in Regulation (EU) 2016/2031 regarding Union regulated non-quarantine pest</th>
<th>Key uncertainties</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Identity of the pest (Section 3.1)</strong></td>
<td>The identity of the pest as a species is clear</td>
<td>The identity of the pest as a species is clear</td>
<td>None</td>
</tr>
<tr>
<td><strong>Absence/presence of the pest in the EU territory (Section 3.2)</strong></td>
<td>The pest is not reported to be present in the EU</td>
<td>The pest is not reported to be present in the EU</td>
<td>The pest may be present in the EU at low incidence, thus without causing damage and remaining undetected</td>
</tr>
<tr>
<td><strong>Regulatory status (Section 3.3)</strong></td>
<td><em>P. pini-densiflorae</em> is regulated by Council Directive 2000/29/EC (Annex IIAI) on plants of <em>Pinus</em> (other than fruit and seeds), and wood of <em>Pinus</em></td>
<td><em>P. pini-densiflorae</em> is regulated by Council Directive 2000/29/EC (Annex IIAI) on plants of <em>Pinus</em> (other than fruit and seeds), and wood of <em>Pinus</em></td>
<td>None</td>
</tr>
<tr>
<td><strong>Pest potential for entry, establishment and spread in the EU territory (Section 3.4)</strong></td>
<td>Entry: the pest could enter the EU via the plants for planting pathway and other means (uncleaned seed, cut branches of pine trees, isolated bark, leaves, stems, growing media accompanying plants, and mycorrhizal soil inocula) Establishment: hosts are widespread in the risk assessment (RA) area and favourable climatic conditions are present in Mediterranean countries Spread: the pest would be able to spread following establishment mainly on infected plants for planting</td>
<td>Entry: the pest could enter the EU via the plants for planting pathway and other means (uncleaned seed, cut branches of pine trees, isolated bark, leaves, stems, growing media accompanying plants, and mycorrhizal soil inocula) Establishment: hosts are widespread in the RA area and favourable climatic conditions are present in Mediterranean countries Spread: the pest would be able to spread following establishment mainly on infected plants for planting</td>
<td>The importance of the means of entry and spread other than plants for planting is unclear The need to regulate wood as a pathway of entry is questionable, given that the pathogen is unlikely to be present on timber</td>
</tr>
</tbody>
</table>
Anon, 2015. PM 7/46 (3) Lecanosticta acicola (formerly Mycosphaerella dearnessii), Dothistroma septosporum (formerly Mycosphaerella pini) and Dothistroma pini. EPPO Bulletin, 45, 163–182.


EPPO (European and Mediterranean Plant Protection Organization), 2017. EPPO Global Database (available online). Available online: https://gd.eppo.int


Abbreviations

- **CLC**: Corine Land Cover
- **EPPO**: European and Mediterranean Plant Protection Organization
- **EU MS**: European Union Member State
- **EUFGIS**: European Information System on Forest Genetic Resources
- **FAO**: Food and Agriculture Organization
- **GD²**: Georeferenced Data on Genetic Diversity
- **IPPC**: International Plant Protection Convention
- **JRC**: Joint Research Centre of the European Commission
- **PLH**: EFSA Panel on Plant Health
- **RA**: risk assessment
- **RNQP**: regulated non-quarantine pest
- **RPP**: relative probability of presence
- **SMFA**: spatial multiscale frequency analysis
- **ToR**: Terms of Reference
### Table A.1: An overview of the host species of *P. pini-densiilflora* (modified from Quintero, 2015)

<table>
<thead>
<tr>
<th>Host</th>
<th>Comments</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Abies procera</em> Rehder</td>
<td></td>
<td>Farr and Rossman (2017)</td>
</tr>
<tr>
<td><em>Abies veitchii</em> Lindl.</td>
<td>Artifically inoculated</td>
<td>Suto (1979)</td>
</tr>
<tr>
<td><em>Cedrus deodara</em> (Roxb. ex D. Don) G. Don</td>
<td>Artifically inoculated</td>
<td>Suto (1979)</td>
</tr>
<tr>
<td><em>Larix kaempferi</em> (Lamb.) Carrière</td>
<td>Discrepancy in inoculation examinations; Ito (1972) demonstrated no symptomatology on needles inoculated with <em>C. pini-densiilflora</em>, while Suto (1979) demonstrated the opposite</td>
<td>Suto (1979)</td>
</tr>
<tr>
<td><em>Picea jezoensis</em> (Siebold &amp; Zucc.) Carrière</td>
<td></td>
<td>Ivory (1994)</td>
</tr>
<tr>
<td><em>Pinus aristata</em> Engelmann</td>
<td></td>
<td>Ito (1972)</td>
</tr>
<tr>
<td><em>Pinus attenuata</em> Lemmon</td>
<td></td>
<td>Ivory (1994)</td>
</tr>
<tr>
<td><em>Pinus canariensis</em> C. Smith ex de Candolle</td>
<td>Highly susceptible</td>
<td>Mulder and Gibson (1972)</td>
</tr>
<tr>
<td><em>Pinus caribaea</em> Morelet</td>
<td></td>
<td>Mulder and Gibson (1972)</td>
</tr>
<tr>
<td><em>Pinus cembra</em> L.</td>
<td></td>
<td>Farr and Rossman (2017)</td>
</tr>
<tr>
<td><em>Pinus contorta</em> Douglas ex Loudon</td>
<td>Highly susceptible</td>
<td>Ito (1972)</td>
</tr>
<tr>
<td><em>Pinus densiflora</em> Siebold &amp; Zuccarini</td>
<td>Susceptible</td>
<td>Ito (1972)</td>
</tr>
<tr>
<td><em>Pinus echinata</em> Mill.</td>
<td>Susceptible</td>
<td>Chen (1965)</td>
</tr>
<tr>
<td><em>Pinus elliottii</em> Engelmann</td>
<td></td>
<td>Ivory (1994)</td>
</tr>
<tr>
<td><em>Pinus flexilis</em> Edwin James</td>
<td></td>
<td>Ito (1972)</td>
</tr>
<tr>
<td><em>Pinus gregii</em> Engelmann ex Parl.</td>
<td></td>
<td>Singh et al. (1983)</td>
</tr>
<tr>
<td><em>Pinus halepensis</em> Mill.</td>
<td>Highly susceptible</td>
<td>Ito (1972)</td>
</tr>
<tr>
<td><em>Pinus jeffreyi</em> Balfour</td>
<td>Highly susceptible</td>
<td>Ito (1972)</td>
</tr>
<tr>
<td><em>Pinus kesiya</em> Royle ex Gordon</td>
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<td>Kobayashi et al. (1979)</td>
</tr>
<tr>
<td><em>Pinus lambertiana</em> Douglas</td>
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<td>Ito (1972)</td>
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<tr>
<td><em>Pinus luchuensis</em> Mayr</td>
<td>Susceptible</td>
<td>Mulder and Gibson (1972)</td>
</tr>
<tr>
<td><em>Pinus massoniana</em> Lambert</td>
<td>Susceptible</td>
<td>Chen (1965)</td>
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<tr>
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<td>Ivory (1987)</td>
</tr>
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<td></td>
<td>Kobayashi et al. (1979)</td>
</tr>
<tr>
<td><em>Pinus morrisonicola</em> Hayata</td>
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<td>Chen (1965)</td>
</tr>
<tr>
<td><em>Pinus muricata</em> D. Don</td>
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<td>Ivory (1987)</td>
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<tr>
<td><em>Pinus nigra</em> J.F. Arnold</td>
<td>Highly susceptible</td>
<td>Ito (1972)</td>
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<tr>
<td><em>Pinus oocarpa</em> Schiede ex Schlechtendal</td>
<td></td>
<td>Ivory (1994)</td>
</tr>
<tr>
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<td><em>Pinus pinaster</em> Alton</td>
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<td>Mulder and Gibson (1972)</td>
</tr>
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<td>Ito (1972)</td>
</tr>
<tr>
<td><em>Pinus ponderosa</em> P. Lawson &amp; C. Lawson</td>
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<td>Ito (1972)</td>
</tr>
<tr>
<td><em>Pinus radiata</em> D. Don</td>
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<td>Mulder and Gibson (1972)</td>
</tr>
<tr>
<td><em>Pinus resinosa</em> Alton</td>
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<td>Ito (1972)</td>
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<td>References</td>
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<td>Ivory (1994)</td>
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<td><em>Pinus taeda</em> L.</td>
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<td>Ito (1972)</td>
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<td><em>Pinus taiwanensis</em> Hayata</td>
<td></td>
<td>Chen (1965)</td>
</tr>
<tr>
<td><em>Pinus tecunumanii</em> Egiluz &amp; J.P. Perry</td>
<td>Slightly susceptible</td>
<td>Ivory (1987)</td>
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<td><em>Pinus thunbergii</em> Parlare</td>
<td>Susceptible</td>
<td>Mulder and Gibson (1972)</td>
</tr>
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<td><em>Pinus strobus</em> L.</td>
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<td>Mulder and Gibson (1972)</td>
</tr>
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<td><em>Pinus sylvestris</em> L.</td>
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<td><em>Pinus wallichiana</em> A.B. Jacks</td>
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Appendix B – Methodological notes on Figure 2

The relative probability of presence (RPP) reported here for *Pinus* spp. in Figure 2 and in the European Atlas of Forest Tree Species (de Rigo et al., 2016; San-Miguel-Ayanz et al., 2016) is the probability of that genus to occur in a given spatial unit (de Rigo et al., 2017). In forestry, such a probability for a single taxon is called ‘relative’. The maps of RPP are produced by spatial multiscale frequency analysis (C-SMFA) (de Rigo et al., 2017) of species presence data reported in geolocated plots by different forest inventories (de Rigo et al., 2014).

B.1. Geolocated plot databases

The RPP models rely on five geodatabases that provide presence/absence data for tree species and genera (de Rigo et al., 2014, 2016, 2017). The databases report observations made inside geolocalised sample plots positioned in a forested area, but do not provide information about the plot size or consistent quantitative information about the recorded species beyond presence/absence. The harmonisation of these data sets was performed within the research project at the origin of the European Atlas of Forest Tree Species (de Rigo et al., 2016; San-Miguel-Ayanz, 2016; San-Miguel-Ayanz et al., 2016). Given the heterogeneity of strategies of field sampling design and establishment of sampling plots in the various national forest inventories (Chirici et al., 2011a,b), and also given legal constraints, the information from the original data sources was harmonised to refer to an INSPIRE compliant geospatial grid, with a spatial resolution of 1 km² pixel size, using the ETRS89 Lambert Azimuthal Equal-Area as geospatial projection (EPSG: 3035, http://spatialreference.org/ref/epsg/etrs89-etrs-laea/).

B.1.1. European National Forestry Inventories database

This data set was derived from National Forest Inventory data and provides information on the presence/absence of forest tree species in ~ 375,000 sample points with a spatial resolution of 1 km²/pixel, covering 21 European countries (de Rigo et al., 2014, 2016).

B.1.2. Forest Focus/Monitoring data set

This project is a Community scheme for harmonised long-term monitoring of air pollution effects in European forest ecosystems, normed by EC Regulation No 2152/20035. Under this scheme, the monitoring is carried out by participating countries on the basis of a systematic network of observation points (Level I) and a network of observation plots for intensive and continuous monitoring (Level II). For managing the data, the JRC implemented a Forest Focus Monitoring Database System, from which the data used in this project were taken (Hiederer et al., 2007; Houston Durrant and Hiederer, 2009). The complete Forest Focus data set covers 30 European Countries with more than 8,600 sample points.

B.1.3. BioSoil data set

This data set was produced by one of a number of demonstration studies initiated in response to the ‘Forest Focus’ Regulation (EC) No 2152/2003 mentioned above. The aim of the BioSoil project was to provide harmonised soil and forest biodiversity data. It comprised two modules: a Soil Module (Hiederer et al., 2011) and a Biodiversity Module (Houston Durrant et al., 2011). The data set used in the C-SMFA RPP model came from the Biodiversity module, in which plant species from both the tree layer and the ground vegetation layer were recorded for more than 3,300 sample points in 19 European Countries.

B.1.4. European Information System on Forest Genetic Resources (EUFGIS)

EUFGIS (http://portal.eufgis.org) is a smaller geodatabase that provides information on tree species composition in over 3,200 forest plots in 34 European countries. The plots are part of a network of

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forest stands managed for the genetic conservation of one or more target tree species. Hence, the plots represent the natural environment to which the target tree species are adapted.

B.1.5. Georeferenced Data on Genetic Diversity (GD2)

GD² (http://gd2.pierroton.inra.fr) provides information about 63 species of interest for genetic conservation. The database covers 6,254 forest plots located in stands of natural populations that are traditionally analysed in genetic surveys. While this database covers fewer species than the others, it covers 66 countries in Europe, North Africa, and the Middle East, making it the dataset with the largest geographic extent.

B.2. Modelling methodology

For modelling, the data were harmonised in order to have the same spatial resolution (1 km²) and filtered to a study area that comprises 36 countries in the European continent. The density of field observations varies greatly throughout the study area and large areas are poorly covered by the plot databases. A low density of field plots is particularly problematic in heterogeneous landscapes, such as mountainous regions and areas with many different land use and cover types, where a plot in one location is not representative of many nearby locations (de Rigo et al., 2014). To account for the spatial variation in plot density, the model used here (C-SMFA) considers multiple spatial scales when estimating RPP. Furthermore, statistical resampling is systematically applied to mitigate the cumulated data-driven uncertainty.

The presence or absence of a given forest tree species then refers to an idealised standard field sample of negligible size compared with the 1 km² pixel size of the harmonised grid. The modelling methodology considered these presence/absence measures as if they were random samples of a binary quantity (the punctual presence/absence, not the pixel one). This binary quantity is a random variable having its own probability distribution which is a function of the unknown average probability of finding the given tree species within a plot of negligible area belonging to the considered 1 km² pixel (de Rigo et al., 2014). This unknown statistic is denoted hereinafter with the name of ‘probability of presence’.

C-SMFA performs spatial frequency analysis of the geolocated plot data to create preliminary RPP maps (de Rigo et al., 2014). For each 1 km² grid cell, the model estimates kernel densities over a range of kernel sizes to estimate the probability that a given species is present in that cell. The entire array of multiscale spatial kernels is aggregated with adaptive weights based on the local pattern of data density. Thus, in areas where plot data are scarce or inconsistent, the method tends to put weight on larger kernels. Wherever denser local data are available, they are privileged ensuring a more detailed local RPP estimation. Therefore, a smooth multiscale aggregation of the entire arrays of kernels and data sets is applied instead of selecting a local ‘best performing’ one and discarding the remaining information. This array-based processing, and the entire data harmonisation procedure, are made possible thanks to the semantic modularisation which defines the Semantic Array Programming modelling paradigm (de Rigo, 2012).

The probability to find a single species (e.g. a particular coniferous tree species) in a 1 km² grid cell cannot be higher than the probability of presence of all the coniferous species combined. The same logical constraints applied to the case of single broadleaved species with respect to the probability of presence of all the broadleaved species combined. Thus, to improve the accuracy of the maps, the preliminary RPP values were constrained so as to not exceed the local forest-type cover fraction with an iterative refinement (de Rigo et al., 2014). The forest-type cover fraction was estimated from the classes of the Corine Land Cover (CLC) maps which contain a component of forest trees (Bossard et al., 2000; Büttner et al., 2012).

The resulting probability of presence is relative to the specific tree taxon, irrespective of the potential co-occurrence of other tree taxa with the measured plots, and should not be confused with the absolute abundance or proportion of each taxon in the plots. RPP represents the probability of finding at least one individual of the taxon in a plot placed randomly within the grid cell, assuming that the plot has negligible area compared with the cell. As a consequence, the sum of the RPP associated with different taxa in the same area is not constrained to be 100%. For example, in a forest with two co-dominant tree species which are homogeneously mixed, the RPP of both may be 100% (see e.g. the Glossary in San-Miguel-Ayanz et al. (2016), http://forest.jrc.ec.europa.eu/media/atlas/Glossary.pdf).
The robustness of RPP maps depends strongly on sample plot density, as areas with few field observations are mapped with greater uncertainty. This uncertainty is shown qualitatively in maps of ‘RPP trustability’. RPP trustability is computed on the basis of the aggregated equivalent number of sample plots in each grid cell (equivalent local density of plot data). The trustability map scale is relative, ranging from 0 to 1, as it is based on the quantiles of the local plot density map obtained using all field observations for the species. Thus, trustability maps may vary among species based on the number of databases that report a particular species (de Rigo et al., 2014, 2016).

The RPP and relative trustability range from 0 to 1 and are mapped at a 1 km spatial resolution. To improve visualisation, these maps can be aggregated to coarser scales (i.e. 10 × 10 pixels or 25 × 25 pixels, respectively, summarising the information for aggregated spatial cells of 100 and 625 km²) by averaging the values in larger grid cells.