Pest categorisation of *Pseudocercospora pini-densiflora*

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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-densiflora*, a well-defined and distinguishable fungal species of the family Mycosphaerellaceae. The regulated harmful organism is the anamorph *Cercoseptoria pini-densiflora* (synonym *Cercospora pini-densiflora*) with the corresponding teleomorph *Mycosphaerella gibsonii*. *P. pini-densiflora* causes a needle blight of *Pinus* spp. also known as *Cercospora* blight of pines or *Cercospora* needle blight. *P. pini-densiflora* 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

**Requestor:** European Commission

**Question number:** EFSA-Q-2017-00325

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Suggested citation: EFSA Panel on Plant Health (PLH), Jeger M, Bragard C, Caffier D, Candresse T, Chatzivassiliou E, Dehnen-Schmutz K, Gilioli G, Gregoire J-C, Jaques Miret JA, MacLeod A, Navajas Navarro M, Niere B, Parnell S, Potting R, Rafoss T, Rossi V, Urek G, Van Bruggen A, Van der Werf W, West J, Winter S, Boberg J, Gonthier P and Pautasso M, 2017. Scientific opinion on the pest categorisation of Pseudocercospora pini-densiflorae. EFSA Journal 2017;15(10):5029, 27 pp. https://doi.org/10.2903/j.efsa.2017.5029

ISSN: 1831-4732

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1. Introduction

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

1.1.1. Background

Council Directive 2000/29/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.

2 Regulation (EU) 2016/2031 of the European Parliament of the Council of 26 October 2016 on protective measures against pests of plants. OJ L 317, 23.11.2016, p. 4–104.

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

Aleurocarthus spp.  
Anthonomus bisignifer (Schenkling)  
Anthonomus signatus (Say)  
Aschistonyx eppoi Inouye  
Carposina niponensis Walsingham  
Enarnonia packardi (Zeller)  
Enarnonia prunivora Walsh  
Grapholita inopinata Heinrich  
Hisnomonous phycitis  
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)  
Anisogramma anomala (Peck) E. Müller  
Apiosporina morbosa (Schwein.) v. Arx  
Ceratocystis virescens (Davidson) Moreau  
Cercoseptoria pini-densiflorae (Hori and Nambu) Deighton  
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

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(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

Group of Tephritidae (non-EU) such as:

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

(c) Viruses and virus-like organisms

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

1) Andean potato latent virus 4) Potato black ringspot virus
2) Andean potato mottle virus 5) Potato virus T
3) Arracacha virus B, oca strain 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, Fragaria, Malus, Prunus, Pyrus, Ribes, Rubus* and *Vitis*, such as:

1) Blueberry leaf mottle virus 7) Peach X-disease mycoplasm
2) Cherry rasp leaf virus (American) 8) Peach yellows mycoplasm
3) Peach mosaic virus (American) 9) Plum line pattern virus (American)
4) Peach phony rickettsia 10) Raspberry leaf curl virus (American)
5) Peach rosette mosaic virus 11) Strawberry witches’ broom mycoplasm
6) Peach rosette mycoplasm 12) Non-EU viruses and virus-like organisms of *Cydonia, Fragaria, Malus, Prunus, Pyrus, Ribes, Rubus* and *Vitis*.
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) 3) Margarodes prieskaensis Jakubski
2) Margarodes vredendalensis de Klerk

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)  Longidorus diadecturus Eveleigh and Allen
Amauromyza maculosa (Malloch)  Monochamus spp. (non-EU)
Anomalorientalis Waterhouse  Myndus crudus Van Duzee
Arrhenodes minutus Drury  Nacobbuss aberrans (Thorne) Thorne and Allen
Choristoneura spp. (non-EU)  Naupactus leucoloma Boheman
Conotrachelus nenuphar (Herbst)  Premnotrypes spp. (non-EU)
Dendrolimus sibiricus Tschetverikov  Pseudopityophthorus minutissimus (Zimmermann)
Diabrotica barberi Smith and Lawrence  Pseudopityophthorus pruinosus (Eichhoff)
Diabrotica undecimpunctata howardi Barber  Scaphoideus luteolus (Van Duzee)
Diabrotica undecimpunctata undecimpunctata Mannerheim  Spodoptera eridania (Cramer)
Hirschmanniella spp., other than Hirschmanniella gracilis (de Man) Luc and Goodey  Spodoptera litura (Fabricus)
Diaphorina citri Kuway  Thrips palmi Kamy
Heliostis zeae (Boddie)  Xiphinema americanum Cobb sensu lato (non-EU populations)
Histrionicodes gracilis (de Man) Luc and Goodey  Xiphinema californicum Lamberti and Bleve-Zacheo
Liriomyza sativae Blanchard

(b) Fungi

Ceratocystis fagacearum (Bretz) Hunt  Mycosphaerella larici-leptolepis Ito et al.
Chrysomyxa arctostaphyli Dietel  Mycosphaerella populorum G. E. Thompson
Cronartium spp. (non-EU)  Phoma andina Turkensteen
Endocronartium spp. (non-EU)  Phyllosticta solitaria Ell. and Ev.
Guignardia laricina (Saw.) Yamamoto and Ito  Septoria lycopersici Spec var. malagutii Ciccarone
Gymnosporangium spp. (non-EU) and Boerema
Inonotus weirii (Murril) Kotlaba and Pouzar  Thecaphora solani Barrus
Melampsora farlowii (Arthur) Davis  Trechispora brinkmannii (Bresad.) Rogers

(c) Viruses and virus-like organisms

Tobacco ringspot virus  Pepper mild tigré virus
Tomato ringspot virus  Squash leaf curl virus
Bean golden mosaic virus  Euphorbia mosaic virus
Cowpea mild mottle virus  Florida tomato virus
Lettuce infectious yellows virus

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(d) Parasitic plants

*Arceuthobium* spp. (non-EU)

**Annex I A II**

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

- *Meloidogyne fallax* Karssen
- *Rhizoecus hibisci* Kawai and Takagi
- *Popillia japonica* Newman

(b) Bacteria

- *Clavibacter michiganensis* (Smith) Davis et al.
  - ssp. *sepedonicus* (Spieckermann and Kotthoff) Davis et al.
- *Ralstonia solanacearum* (Smith) Yabuuchi et al.

(c) Fungi

- *Melampsora medusae* Thümen
- *Synchytrium endobioticum* (Schilbersky) Percival

**Annex I B**

(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 fulfills 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. Data

2.1.1. 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 1: Pest categorisation criteria under evaluation, as defined in Regulation (EU) 2016/2031 on protective measures against pests of plants (the number of the relevant sections of the pest categorisation is shown in brackets in the first column)

| Criterion of pest categorisation | Criterion in Regulation (EU) 2016/2031 regarding Union quarantine pest | Criterion in Regulation (EU) 2016/2031 regarding protected zone quarantine pest (articles 32–35) | Criterion in Regulation (EU) 2016/2031 regarding Union regulated non-quarantine pest |
|---------------------------------|------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------|
| Identity of the pest (Section 3.1) | Is the identity of the pest established, or has it been shown to produce consistent symptoms and to be transmissible? | Is the identity of the pest established, or has it been shown to produce consistent symptoms and to be transmissible? | Is the identity of the pest established, or has it been shown to produce consistent symptoms and to be transmissible? |
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-densi flora is an ascomycete fungus in the family of Mycosphaerellaceae.

There are many species synonymies referred to the anamorphic stage: Cercoseptoria pini-densi flora, Cercospora pini-densi flora, Mycosphaerella gibsonii (teleomorph), Pseudocercospora pini-densi flora var. pini-densi flora (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-densi flora causes a needle blight of pines (Pinus spp.) also known as Cercospora blight of pines or Cercospora needle blight.

P. pini-densi flora 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-densi flora may develop spermamia, 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-densi flora may be difficult to distinguish from closely related pine pathogens (e.g. Lecanosticta acicola), but the species has some specific morphological characteristics given...

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

Yes
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).

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

3.3.1. Council Directive 2000/29/EC

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

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

| Annex II, Part A | Plants of *Abies* Mill., *Cedrus* Trew, *Chamaecyparis* Spach, *Juniperus* L., *Larix* Mill., *Picea* A. Dietr., *Pinus* L., *Pseudotsuga* Carr. and *Tsuga* Carr., other than fruit and seeds, and wood of *Pinus* L. |
|------------------|-------------------------------------------------------------------------------------------------|
| Section I        | Harmful organisms not known to occur in the community and relevant for the entire community    |
| (c)              | Fungi                                                                                           |
| Species          | Subject of contamination                                                                        |
| 5.               | *Cercoseptoria pini-densiflora* (Hori and Nambu) Deighton                                    |
| Plants of *Pinus* L., other than fruit and seeds, and wood of *Pinus* L. |

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

| Annex III, Part A | Plants, plant products and other objects the introduction of which shall be prohibited in all Member States |
|-------------------|-----------------------------------------------------------------------------------------------------------|
| 1.                 | Plants of *Abies* Mill., *Cedrus* Trew, *Chamaecyparis* Spach, *Juniperus* L., *Larix* Mill., *Picea* A. Dietr., *Pinus* L., *Pseudotsuga* Carr. and *Tsuga* Carr., other than fruit and seeds, and wood of *Pinus* L. |

Annex V

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

Part A

Plants, plant products and other objects originating in the Community

Section II

Plants, plant products and other objects produced by producers whose production and sale is authorised to persons professionally engaged in plant production, other than those plants, plant products and other objects which are prepared and ready for sale to the final consumer, and for which it is ensured by the responsible official bodies of the Member States, that the production thereof is clearly separate from that of other products

1.1. Plants of *Abies* Mill., *Larix* Mill., *Picea* A. Dietr., *Pinus* L. and *Pseudotsuga* Carr.

3.4. Entry, establishment and spread in the EU

3.4.1. Host range

*Pseudocercospora pini-densiflora* 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

| Is the pest able to enter into the EU territory? | Yes, the pest could enter the EU via plants for planting and other means (see below). |

*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 II A (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

| Is the pest able to become established in the EU territory? | Yes, the pest could establish in the EU, as hosts are widespread and favourable climatic conditions are found in Mediterranean countries. |

### 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. strobos*, *P. brutia*, *P. banksiana*, *P. ponderosa*, *P. heldreichii*, *P. leucoderma*, *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-densiflora_ 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.

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

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

Yes. Please see section 3.6.3.

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-densiflorae* 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)

| Criterion of pest categorisation | Panel’s conclusions against criterion in Regulation (EU) 2016/2031 regarding Union quarantine pest | Panel’s conclusions against criterion in Regulation (EU) 2016/2031 regarding Union regulated non-quarantine pest | Key uncertainties |
|----------------------------------|--------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------|-------------------|
| Identity of the pest (Section 3.1) | The identity of the pest as a species is clear | The identity of the pest as a species is clear | None |
| Absence/presence of the pest in the EU territory (Section 3.2) | The pest is not reported to be present in the EU | The pest is not reported to be present in the EU | The pest may be present in the EU at low incidence, thus without causing damage and remaining undetected |
| Regulatory status (Section 3.3) | P. pini-densiflorae is regulated by Council Directive 2000/29/EC (Annex IIAI) on plants of Pinus (other than fruit and seeds), and wood of Pinus | P. pini-densiflorae is regulated by Council Directive 2000/29/EC (Annex IIAI) on plants of Pinus (other than fruit and seeds), and wood of Pinus | None |
| Pest potential for entry, establishment and spread in the EU territory (Section 3.4) | 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 | 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 | 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 |
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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
### Appendix A – List of host species of *Pseudocercospora pini-densiflorae*

Table A.1: An overview of the host species of *P. pini-densiflorae* (modified from Quintero, 2015)

| Host                                      | Comments                                                                                                           | References                      |
|-------------------------------------------|--------------------------------------------------------------------------------------------------------------------|---------------------------------|
| *Abies procera* Rehder                   |                                                                                                                    | Farr and Rossman (2017)         |
| *Abies sachalinensis* (F. Schmidt) Mast.  | Artificially inoculated                                                                                           | Suto (1979)                    |
| *Abies veitchii* Lindl.                  | Artificially inoculated                                                                                           | Suto (1979)                    |
| *Cedrus deodara* (Roxb. ex D. Don) G. Don | Artificially inoculated                                                                                           | Suto (1979)                    |
| *Larix kaempferi* (Lamb.) Carrière       | Discrepancy in inoculation examinations; Ito (1972) demonstrated no symptomatology on needles inoculated with *C. pini-densiflorae*, while Suto (1979) demonstrated the opposite | Suto (1979)                    |
| *Picea gliehnii* (F. Schmidt) Mast.      | Artificially inoculated                                                                                           | Suto (1979)                    |
| *Picea jezoensis* (Siebold & Zucc.) Carrière |                                                                                                                    | Suto (1979)                    |
| *Pinus aristata* Engelmann               |                                                                                                                    | Ito (1972)                     |
| *Pinus attenuata* Lemmon                 |                                                                                                                    | Ivory (1994)                   |
| *Pinus canariensis* C. Smith ex de Candolle | Highly susceptible                                                                                               | Mulder and Gibson (1972)       |
| *Pinus caribaea* Morelet                 |                                                                                                                    | Mulder and Gibson (1972)       |
| *Pinus cembra* L.                        |                                                                                                                    | Farr and Rossman (2017)         |
| *Pinus contorta* Douglas ex Loudon       | Highly susceptible                                                                                                 | Ito (1972)                     |
| *Pinus densiflora* Siebold & Zuccarini   | Susceptible                                                                                                       | Ito (1972)                     |
| *Pinus echinata* Mill.                   | Susceptible                                                                                                       | Chen (1965)                    |
| *Pinus elliottii* Engelmann              |                                                                                                                    | Ivory (1994)                   |
| *Pinus flexilis* Edwin James             |                                                                                                                    | Ito (1972)                     |
| *Pinus greggii* Engelmann ex Parl.       |                                                                                                                    | Singh et al. (1983)             |
| *Pinus halepensis* Mill.                 | Highly susceptible                                                                                                 | Ito (1972)                     |
| *Pinus jeffreyi* Balfour                 | Highly susceptible                                                                                                 | Ito (1972)                     |
| *Pinus keisiya* Royle ex Gordon          |                                                                                                                    | Kobayashi et al. (1979)         |
| *Pinus lambertiana* Douglas              | Highly susceptible                                                                                                 | Ito (1972)                     |
| *Pinus luchuensis* Mayr                  | Susceptible                                                                                                       | Mulder and Gibson (1972)       |
| *Pinus massoniana* Lambert               | Susceptible                                                                                                       | Chen (1965)                    |
| *Pinus maximinoi* H.E. Moore             | Slightly susceptible                                                                                                | Ivory (1987)                   |
| *Pinus merkusii* Jungh. & de Vriese      |                                                                                                                    | Kobayashi et al. (1979)         |
| *Pinus morrisonicola* Hayata             |                                                                                                                    | Chen (1965)                    |
| *Pinus muricata* D. Don                  | Highly susceptible                                                                                                 | Ivory (1987)                   |
| *Pinus nigra* J.F. Arnold                | Highly susceptible                                                                                                 | Ito (1972)                     |
| *Pinus oocarpa* Schiede ex Schlechtendal |                                                                                                                    | Ivory (1994)                   |
| *Pinus palustris* Mill.                  |                                                                                                                    | Chen (1965)                    |
| *Pinus patula* Schlechtendal & Chamisso  |                                                                                                                    | Ito (1972)                     |
| *Pinus pinaster* Alton                   | Highly susceptible                                                                                                 | Mulder and Gibson (1972)       |
| *Pinus pinea* L.                         | Highly susceptible                                                                                                 | Ito (1972)                     |
| *Pinus ponderosa* P. Lawson & C. Lawson  | Highly susceptible                                                                                                 | Ito (1972)                     |
| *Pinus pseudostrobus* Lindl.             |                                                                                                                    | Ivory (1987)                   |
| *Pinus radiata* D. Don                   | Highly susceptible                                                                                                 | Mulder and Gibson (1972)       |
| *Pinus resinosa* Alton                   |                                                                                                                    | Ito (1972)                     |
| Host                                      | Comments            | References          |
|-------------------------------------------|---------------------|---------------------|
| *Pinus roxburghii* Sargent                |                     | Ivory (1994)        |
| *Pinus taeda* L.                          |                     | Ito (1972)          |
| *Pinus taiwanensis* Hayata                |                     | Chen (1965)         |
| *Pinus tecumumanii* Egiluz & J.P. Perry   | Slightly susceptible| Ivory (1987)        |
| *Pinus thunbergii* Parlatores             | Susceptible         | Mulder and Gibson (1972) |
| *Pinus strobus* L.                        |                     | Mulder and Gibson (1972) |
| *Pinus sylvestris* L.                     | Highly susceptible  | Ito (1972)          |
| *Pinus wallichiana* A.B. Jacks            |                     | Ivory (1994)        |
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 2152/2003. 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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5 Council of the European Union, 2003. Regulation (EC) No 2152/2003 of the European Parliament and of the Council of 17 November 2003 concerning monitoring of forests and environmental interactions in the Community (Forest Focus). Official Journal of the European Union 46 (L 324), p. 1–8.
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 preforming’ 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.