SCIENTIFIC OPINION

Pest categorisation of *Sphaerulina musiva*

EFSA Panel on Plant Health (EFSA PLH Panel),
Michael Jeger, Claude Bragard, David Caffier, Thierry Candresse, Elisavet Chatzivassiliou,
Katharina Dehnen-Schmutz, Gianni Gilioli, Jean-Claude Grégoire, Josep Anton Jaques Miret,
Alan MacLeod, Maria Navajas Navarro, Björn Niere, Stephen Parnell, Roel Potting,
Trond Rafoss, Vittorio Rossi, Gregor Urek, Ariena Van Bruggen, Wopke Van der Werf,
Jonathan West, Stephan Winter, Johanna Boberg, Paolo Gonthier and Marco Pautasso

Abstract

Following a request from the European Commission, the EFSA Plant Health Panel performed a pest categorisation of *Sphaerulina musiva*, a well-defined and distinguishable fungal species of the family Mycosphaerellaceae. Following a recent phylogenetic analysis of the genus *Septoria* and other closely related genera, a new name (*S. musiva*) was introduced for the species. The former species name *Mycosphaerella populorum* is used in the Council Directive 2000/29/EC. The pathogen is regulated in Annex IAI as a harmful organism whose introduction into the EU is banned. *S. musiva* is reported from North and South America and not known to occur in the EU. *S. musiva* causes Septoria leaf spots and cankers of poplar (*Populus* spp.). Of the poplars native to Europe, *Populus nigra* is reported as susceptible and *Populus tremula* as susceptible when planted in North America. The hybrid *Populus x canadensis* (arising from a cross of *P. nigra* and the North American *Populus deltoides*), widely grown in the EU, is also susceptible. The pest could enter the EU on plants for planting, cut branches, isolated bark and wood with and without bark. *S. musiva* could establish in the EU, as hosts are common and favourable climatic conditions are widespread, and could spread following establishment by natural dispersal and movement of infected plants for planting, cut branches, isolated bark and wood with or without bark. The pest introduction would have impacts in woodlands, plantations and nurseries. The pathogen is considered the most serious disease affecting hybrid poplar production in North America. Selection, breeding and planting of resistant species and clones are the main methods used to control the damage caused by the pathogen. There is some uncertainty on the geographical distribution of the pest in the Caucasus, the Crimean Peninsula and South America and on the level of susceptibility among *Populus* species native to Europe as well as *Salix* spp. The criteria assessed by the Panel for consideration as a potential quarantine pest are met. For regulated non-quarantine pests, the criterion on the pest presence in the EU is not met.

Panel members: Claude Bragard, David Caffier, Thierry Candresse, Elisavet Chatzivassiliou, Katharina Dehnen-Schmutz, Gianni Gilioli, Jean-Claude Grégoire, Josep Anton Jaques Miret, Michael Jeger, Alan MacLeod, Maria Navajas Navarro, Björn Niere, Stephen Parnell, Roel Potting, Trond Rafoss, Vittorio Rossi, Gregor Urek, Ariena Van Bruggen, Wopke Van der Werf, Jonathan West and Stephan Winter.

Table of contents

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 categorizations 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 criterion 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.

---

[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

Aleurocantus spp.

Anthonomus bisignifer (Schenkling)

Anthonomus signatus (Say)

Aschistonyx eppoi Inouye

Carposina niponensis Walsingham

Enarmonia packardi (Zeller)

Enarmonia prunivora Walsh

Grapholita inopinata Heinrich

Hishomonus phycitis

Leucaspis japonica Ckll.

Listronotus bonariensis (Kuschel)

Numonia pyrivorella (Matsumura)

Oligonychus perditus Pritchard and Baker

Pissodes spp. (non-EU)

Scirtothrips aurantii Faure

Scirtothrips citri (Moultex)

Scolytidae spp. (non-EU)

Scrobipalpopsis solanivora Povolny

Tachypterellus quadrigibbus Say

Toxoptera citricida Kirk.

Unaspis citri Comstock

(b) Bacteria

Citrus variegated chlorosis

Erwinia stewartii (Smith) Dye

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

Elsinoe spp. Bitanc. and Jenk. Mendes

Fusarium oxysporum f. sp. *albedinis* (Kilian and Maire) Gordon

Guignardia piricola (Nosa) Yamamoto

Puccinia pittieriana Hennings

Stegophora ulmea (Schweinitz: Fries) Sydow & Sydow

Venturia nashicola Tanaka and Yamamoto

(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

Little cherry pathogen (non- EU isolates)

Naturally spreading psorosis

Palm lethal yellowing mycoplasm

Satsuma dwarf virus

Tatter leaf virus

Witches' broom (MLO)

Annex IIB

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

Anthonomus grandis (Boh.)

Cephalcia lariciphila (Klug)

Dendroctonus micans Kugelan

Gilphinia hercyniae (Hartig)

Gonipterus scutellatus Gyll.

Ips amitinus Eichhof

Ips cembrae Heer

Ips duplicatus Sahlberg

Ips sexdentatus Börner

Ips typographus Heer

Sternochetus mangiferae Fabricius

(b) Bacteria

Curtobacterium flaccumfaciens pv. flaccumfaciens (Hedges) Collins and Jones

(c) Fungi

Glomerella gossypii Edgerton

Gremmeniella abietina (Lag.) Morelet

Hypoxylon mammatum (Wahl.) J. Miller

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* Coquillet
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 indifferens* 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 mycoplasma
12) Non-EU viruses and virus-like organisms of *Cydonia Mill., Fragaria L., Malus Mill., Prunus L., Pyrus L., Ribes L., Rubus L.* and *Vitis L.*

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 IAI

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

Acleris spp. (non-EU)

Amauromyza maculosa (Malloch)

Anomala orientalis Waterhouse

Arrhenodes minutus 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 zea (Boddie)

Hirschmanniella spp., other than *Hirschmanniella gracilis* (de Man) Luc and Goodey

Liriomyza sativae Blanchard

Longidorus diadecturus Eveleigh and Allen

Monochamus spp. (non-EU)

Myndus crudus Van Duzee

Nacobbus aberrans (Thorne) Thorne and Allen

Naupactus leucoloma Boheman

Premnotrypes spp. (non-EU)

Pseudopityophthorus minutissimus (Zimmermann)

Pseudopityophthorus pruinosus (Eichhoff)

Scaphoideus luteolus (Van Duzee)

Spodoptera eridania (Cramer)

Spodoptera frugiperda (Smith)

Spodoptera litura (Fabricus)

Thrips palmi Karny

Xiphinema americanum Cobb *sensu* lato (non-EU populations)

Xiphinema californicum Lamberti and Bleve-Zacheo

(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 (Murril) Kotlaba and Pouzar

Melampsora farlowii (Arthur) Davis

Mycosphaerella larici-leptolepis Ito et al.

Mycosphaerella populorum G. E. Thompson

Phoma andina Turkensteen

Phyllosticta solitaria Ell. and Ev.

Septoria lycopersici Speg. var. *malagutii* Ciccarone and Boerema

Thecaphora solani Barrus

Trechispora brinkmannii (Bresad.) Rogers

(c) Viruses and virus-like organisms

Tobacco ringspot virus

Tomato ringspot virus

Bean golden mosaic virus

Cowpea mild mottle virus

Lettuce infectious yellows virus

Pepper mild tigré virus

Squash leaf curl virus

Euphorbia mosaic virus

Florida tomato virus

(d) Parasitic plants

Arceuthobium spp. (non-EU)

Annex IAII

(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

Mycosphaerella populorum 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 European Union (EU).

Following a phylogenetic analysis of the genus *Septoria* and other closely related genera, a new name was introduced for the species, *Sphaerulina musiva* (Quaedvlieg et al., 2013). Therefore, the recommended valid name for the fungus is *S. musiva* (Quaedvlieg et al., 2013).

2. Data and methodologies

2.1. Data

2.1.1. Literature search

A literature search on *S. musiva* was conducted at the beginning of the categorisation in the ISI Web of Science bibliographic database, using the scientific name of the pest and its synonyms/ previous names 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, 2018).

Data about the 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 State (MS) imports of *Populus* plants for planting from North America and Argentina was 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 run by the Directorate General for Health and Food Safety (DG SANTE), 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 *S. musiva*, following guiding principles and steps presented in the European Food Safety Authority (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 ToR 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. 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 regard 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?
Absence/ presence of the pest in the EU territory (Section **3.2**)	Is the pest present in the EU territory? If present, is the pest widely distributed within the EU? Describe the pest distribution briefly!	Is the pest present in the EU territory? If not, it cannot be a protected zone quarantine organism.	Is the pest present in the EU territory? If not, it cannot be a regulated non-quarantine pest. (A regulated non-quarantine pest must be present in the risk assessment area)

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
Regulatory status (Section 3.3)	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	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)	Is the pest regulated as a quarantine pest? If currently regulated as a quarantine pest, are there grounds to consider its status could be revoked?
Pest potential for entry, establishment and spread in the EU territory (Section 3.4)	Is the pest able to enter into, become established in and spread within the EU territory? If yes, briefly list the pathways!	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?	Is spread mainly via specific plants for planting, rather than via natural spread or via movement of plant products or other objects? Clearly state if plants for planting is the main pathway!
Potential for consequences in the EU territory (Section 3.5)	Would the pests' introduction have an economic or environmental impact on the EU territory?	Would the pests' introduction have an economic or environmental impact on the protected zone areas?	Does the presence of the pest on plants for planting have an economic impact, as regards the intended use of those plants for planting?
Available measures (Section 3.6)	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?	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?	Are there measures available to prevent pest presence on plants for planting such that the risk becomes mitigated?
Conclusion of pest categorisation (Section 4)	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	A statement as to whether (1) all criteria assessed by EFSA above for consideration as potential protected zone quarantine pest were met, and (2) if not, which one(s) were not met	A statement as to whether (1) all criteria assessed by EFSA above for consideration as a potential regulated non-quarantine pest were met, and (2) if not, which one(s) were not met

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

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

S. musiva (Peck) Quaedvl., Verkley & Crous is a fungus of the family Mycosphaerellaceae.

Following a phylogenetic analysis of the anamorphic genus *Septoria* and other closely related genera, a new name (*Sphaerulina musiva,* hereafter *S. musiva*) was introduced for the species (Quaedvlieg et al., 2013). The former species name *M. populorum* is used in the Council Directive 2000/29/EC.

Other species synonyms are: *Cylindrosporium oculatum*, *Davidiella populorum* and *Septoria musiva* (Index Fungorum, http://www.indexfungorum.org/names/names.asp).

3.1.2. Biology of the pest

S. musiva causes Septoria leaf spots and cankers of poplar.

The primary leaf infections start soon after the leaves unfold in the spring by airborne ascospores, which are dispersed by pseudothecia maturing in overwintering fallen leaves or in cankers (Ostry, 1987; Sinclair and Lyon, 2005). Infection may also be caused by conidia forming in overwintering pycnidia in cankers (Sinclair and Lyon, 2005). Foliar lesions develop 1–2 weeks following infection and pycnidia are formed after an additional 1–2 weeks on one or both sides of the lesion (Ostry, 1987). Early in the season, lesions on leaves are found in high numbers primarily on foliage of lower branches but will later be found throughout the crown (Ostry, 1987). The lesions increase rapidly in size and numbers during conducive environmental conditions (Sinclair and Lyon, 2005).

Conidia (hyaline, cylindric, straight or slightly curved, variously septate (1–6) 17–56 × 3–4 μm (EPPO, 1997)) are exuded in pink masses during moist conditions and are dispersed by water to infect new leaves or stems, lacking the corky bark (Sinclair and Lyon, 2005). Ascospores (hyaline, 1-septate, 17–24 × 3–6 μm (EPPO, 1997)) are airborne and dispersed in high numbers during warm (22–26°C) and moist weather. Both ascospores and conidia are present throughout the growing season (Ostry, 1987).

Ascospores and conidia infect stems through wounds, lenticels, stipules or leaf petioles (EPPO, 1997). Cankers are usually dark, slightly sunken and are often centred around a bud or infected leaf petiole (Ostry, 1987). Pycnidia and pseudothecia may be found in cankers, but neither are common in those cankers which are colonised by other secondary fungal species (Ostry, 1987; Sivanesan, 1990; Sinclair and Lyon, 2005).

Cankers generally develop on young stems and branches and only on those with infected leaves (Sinclair and Lyon, 2005). Cankers may girdle stems less than 2 cm wide during the first season (Sivanesan, 1990). Girdling may take an additional 1–2 years in more resistant clones (Sinclair and Lyon, 2005). On larger stems, the wood is killed into the pith forming a flattened distorted canker swollen at the sides (Sivanesan, 1990).

Incidence and severity of disease are to a large extent dependent on the susceptibility of the host which varies greatly between species and clones (Callan, 1998; Sinclair and Lyon, 2005), but is not dependent on tree age (Sivanesan, 1990).

Site and environmental conditions may also influence disease development. Leaf spots are especially common in years with wet mild springs (Callan, 1998). Damage by both leaf spots and cankers was more severe on harsh dry sites than on good wetter sites (Hansen et al., 1994). Water stress was also shown to enhance canker development in inoculation experiments (Maxwell et al., 1997).

3.1.3. Intraspecific diversity

S. musiva is most likely native to central and eastern North America where it co-evolved with *Populus deltoides* (Sakalidis et al., 2016).

S. musiva consists of differentiated subpopulations which correlate with geographic origin (Feau et al., 2005). No differentiation was found between subpopulation from different hosts (Feau et al., 2005).

3.1.4. Detection and identification of the pest

Are detection and identification methods available for the pest?

Yes

The symptoms caused by *S. musiva* are not unique and may be confused with those produced by other fungi. The fungus can be isolated from spores or from samples taken at the margin of cankers. However, isolation of the fungus is challenging due to the slow growth of *S. musiva* and cultures are often overgrown by other fungal species. A procedure and selective medium to overcome this difficulty has been published by Stanosz & Stanosz (2002).

The species can be identified based on molecular methods and a protocol for amplification and sequencing of the ITS region and TUB2 required for identification at species level is found at Qbank (Qbank-www.q-bank.eu). There is also a polymerase chain reaction (PCR) assay by Feau et al. (2005) available to identify *S. musiva* which differentiates the fungus from closely related *Septoria* species.

3.2. Pest distribution

S. musiva is known to occur in North and South America (EPPO, 2018) (Figure 1).
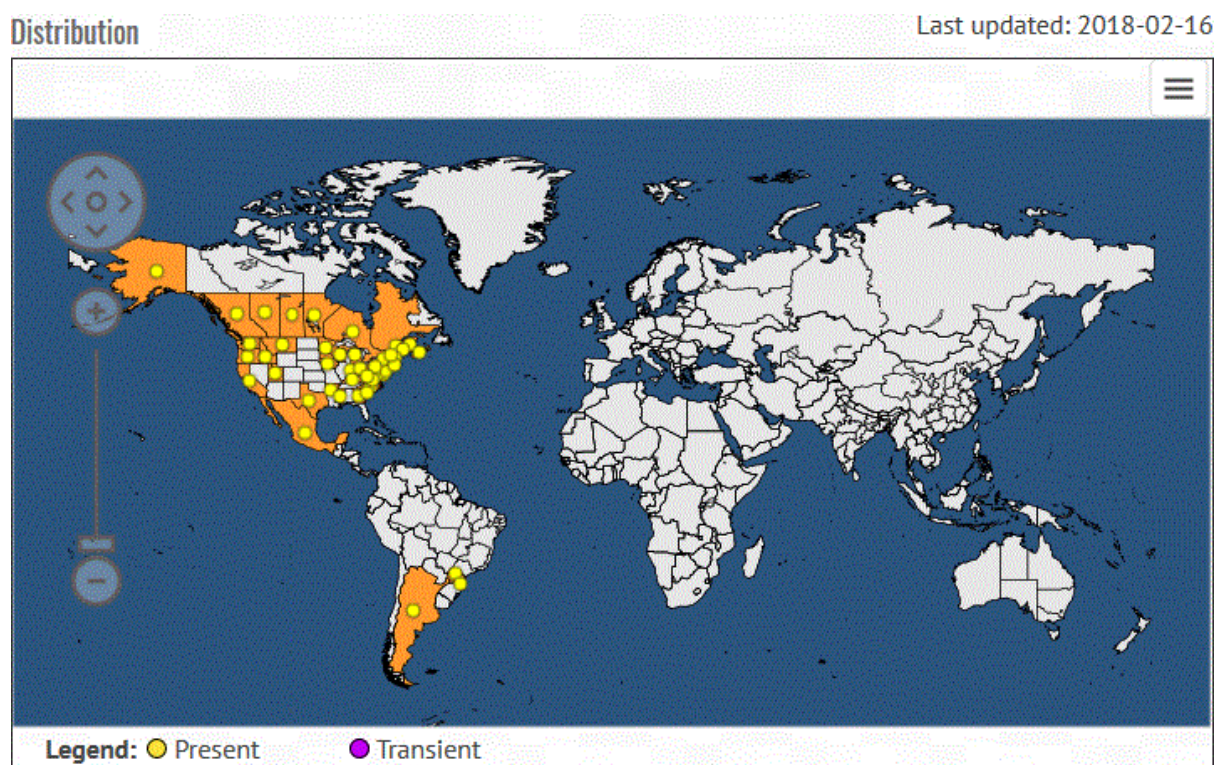
Figure 1: Global distribution map for *Sphaerulina musiva* (extracted from EPPO, 2018, accessed February 2018). There are no reports of transient populations

3.2.1. Pest distribution outside the EU

The pathogen is reported as widespread in Canada. In the USA, *S. musiva* is reported as present with restricted distribution, but is common in the eastern and central states (EPPO, 2018).

The species is also reported as present in Argentina (EPPO, 2018), Brazil (de Mio and Amorim, 2000; Santos et al., 2010) and Mexico (Romo Lozano et al., 1992). Given these reports, there is uncertainty about whether the pathogen could be present in other South American countries.

S. musiva was also reported from the Caucasus and the Crimean Peninsula (Teterevnikova-Babayan, 1976; also cited in Maxwell et al., 1997), but no confirmation of this report has subsequently been made. There is, thus, uncertainty about the presence of the fungus in these regions.

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.

There are no reports of *S. musiva* from the EU (EPPO, 2018). Slovenia has reported the pathogen as absent in July 2017 (no pest record) (EPPO, 2018). The pathogen is also listed as absent in the UK Plant Health Risk Register, as of March 2018 (https://secure.fera.defra.gov.uk/phiw/riskRegister/viewPestRisks.cfm?cslref=12418).

3.3. Regulatory status

3.3.1. Council Directive 2000/29/EC

S. musiva is listed in Council Directive 2000/29/EC as *M. populorum*. Details are presented in Tables 2 and 3.

Table 2: *S. musiva* in Council Directive 2000/29/EC

Annex I, Part A	Harmful organisms whose introduction into, and spread within, all Member States shall be banned
Section I	Harmful organisms not known to occur in any part of the community and relevant for the entire community
(c)	Fungi
	Species
11.	*Mycosphaerella populorum* G. E. Thompson

3.3.2. Legislation addressing the hosts of *Sphaerulina musiva*

Table 3: Regulated hosts and commodities that may involve *S. musiva* in Annexes III 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
Description	Country of origin
3. Plants of *Populus* L., with leaves, other than fruit and seeds	North American countries
8. Isolated bark of *Populus* L.	Countries of the American continent
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 I	Plants, plant products and other objects which are potential carriers of harmful organisms of relevance for the entire Community and which must be accompanied by a plant passport

2.1. Plants intended for planting, other than seeds, of the genus *Populus* L.	
Part B	Plants, plant products and other objects originating in territories, other than those territories referred to in part A
Section I	Plants, plant products and other objects which are potential carriers of harmful organisms of relevance for the entire Community
2. Parts of plants, other than fruits and seeds, of the genus *Populus* L.	
5. Isolated bark of *Populus* L.	
6. Wood within the meaning of the first subparagraph of Article 2(2), where it: (a) has been obtained in whole or part from one of the order, genera or species as described hereafter, except wood packaging material defined in Annex IV, Part A, Section I, Point 2:	*Populus* L., including wood which has not kept its natural round surface, originating in countries of the American continent

3.4. Entry, establishment and spread in the EU

3.4.1. Host range

S. musiva can infect all *Populus* species native to North America. Apart from the endemic host *P. deltoides*, the native species *Populus balsamifera* and *Populus trichocarpa* are reported as minor hosts (EPPO, 2018) and *Populus tremuloides* is reported as rarely infected (Callan, 1998).

Of the poplars grown in Europe, the native *Populus nigra* and the hybrid *P. x canadensis* (arising from a cross of *P. nigra* and the North American *P. deltoides*) are reported as susceptible hosts (EPPO, 1997), although *P. nigra* var. *italica* is reported as resistant (EPPO, 1997). *Populus tremula* is reported to be susceptible when planted in North America (Ostry et al., 2014). Other poplar species native to Europe, *Populus alba* and the hybrid *Populus* x *canescens* (*P. alba* × *P. tremula*) are reported as resistant (EPPO, 1997), but others report *P. alba* to be vulnerable to cankers caused by *S. musiva* (Anon, 2005). Many hybrids of susceptible parent species are also reported as susceptible (EPPO, 1997).

Japanese poplar species, e.g. *Populus maximowiczii*, are highly susceptible to stem cankers caused by *S. musiva* (Dickmann and Kuzovkina, 2014). Japanese poplar species are grown in the EU as ornamentals, with evidence that *P. maximowiczii* is supplied as ornamental in the UK. In addition, there are hybrid poplar clones with Japanese poplar parentage.

S. musiva has also been found to infect *Salix lucida* (Feau and Bernier, 2004). Given the high number of species in the *Salix* genus (about 450–520; Wang et al., 2017), this suggests that the host range of *S. musiva* is not completely known (Feau and Bernier, 2004).

In Council Directive 2000/29/EC, the pest is not regulated on a particular host or commodity; its introduction into the EU is banned (Annex IAI). However, in Annex III, only *Populus* (and not *Salix*) is listed (see Section 3.3.2).

3.4.2. Entry

> *Is the pest able to enter into the EU territory?*
>
> **Yes**, the pest could enter the EU on plants for planting, cut branches, isolated bark and wood with and without bark.

The main host commodities providing a pathway for entry for the pathogen (Anon, 2017; EPPO, 2018) are:

- plants for planting,
- cut branches,
- isolated bark
- and wood with or without bark.

S. musiva has spread from its endemic range in central and eastern North America to the north and western areas in North America and into South America (Sakalidis et al., 2016). Population studies of *S. musiva* suggest that the spread of the pathogen across North America was most likely by movement of plant material (Herath et al., 2016; Sakalidis et al., 2016).

There is a ban on importing (i) plants with leaves and (ii) isolated bark of *Populus* spp. from North American countries (see Section 3.3.2), so these two pathways are closed as far as North America is concerned. However, the pathogen has also been reported from South America (see Section 3.2.1).

As of February 2018, there were no records of interception of *S. musiva* (code: MYCOPP) in the Europhyt database.

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 climatic conditions are favourable in most of the EU.

3.4.3.1. EU distribution of main host plants

Populus species are widely distributed in the EU, in woodlands, plantations (e.g. for pulp, paper and biofuel production) and nurseries (Figure 2) (EFSA PLH Panel, 2017).

P. nigra, which is reported as highly susceptible, is found in large parts of Europe, excluding the most northern countries (Figure 3).

The distribution of *P. alba* overlaps with that of *P. nigra* to a large extent. *P. tremula* is widely distributed in the EU except for some of the Mediterranean countries (Figures 4 and 5). The susceptibility of these two species is, however, not clear.
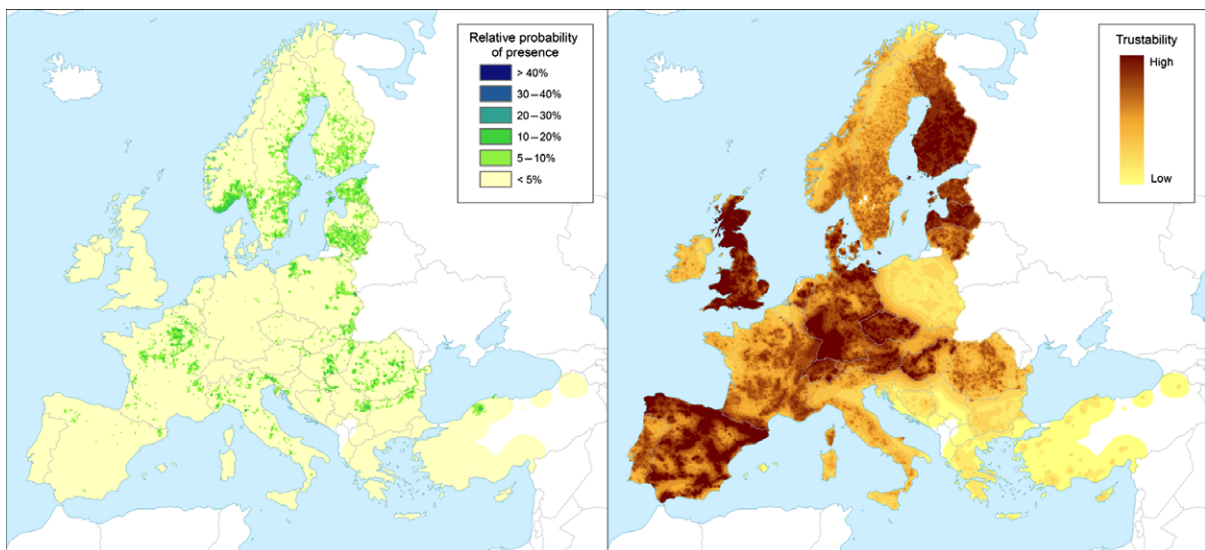
Figure 2: Left-hand panel: Relative probability of presence (RPP) of the genus *Populus* (based on data from the species: *P. tremula, P. nigra, P. alba, P. canescens, P. x hybrids* and *P. candicans*) in Europe, mapped at 100 km^2 resolution. The underlying data are from European-wide forest monitoring data sets and from national forestry inventories based on standard observation plots measuring in the order of hundreds m^2. 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 A (courtesy of Joint Research Centre (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 A)

Figure 3: Plot distribution and simplified chorology map for *Populus nigra*. Frequency of *P. nigra* occurrences within the field observations as reported by the National Forest Inventories. The chorology of the native spatial range for *P. nigra* is derived from EUFORGEN (de Rigo et al., 2016b)

Figure 4: Plot distribution and simplified chorology map for *Populus tremula*. Frequency of *P. tremula* occurrences within the field observations as reported by the National Forest Inventories. The chorology of the native spatial range for *P. tremula* is derived from several sources (Caudullo and de Rigo, 2016)
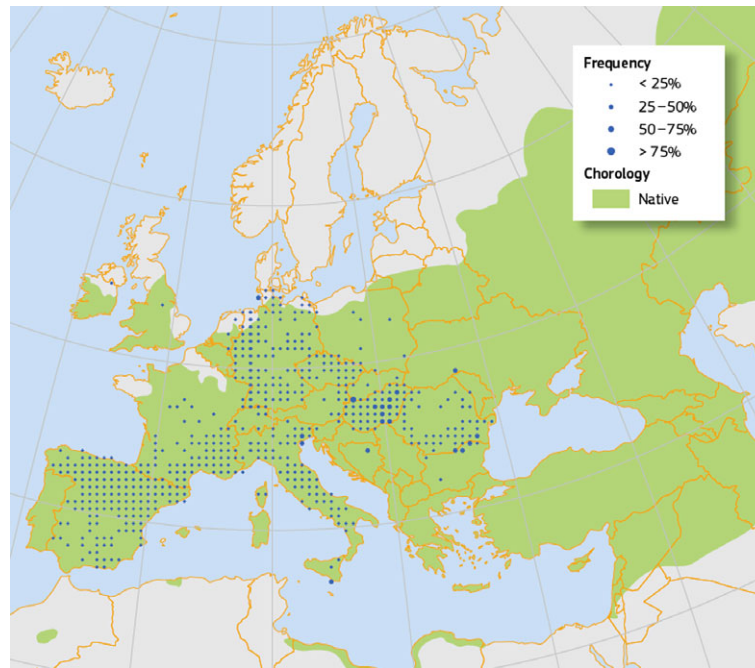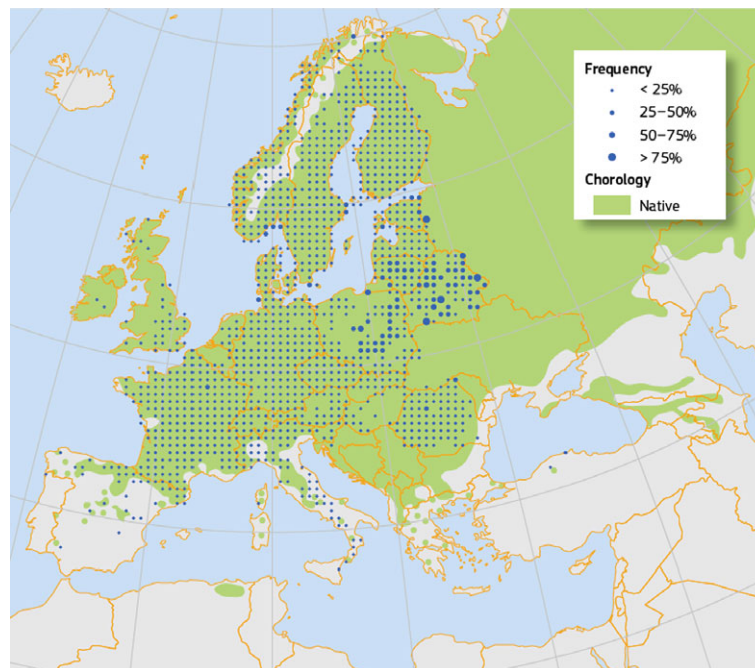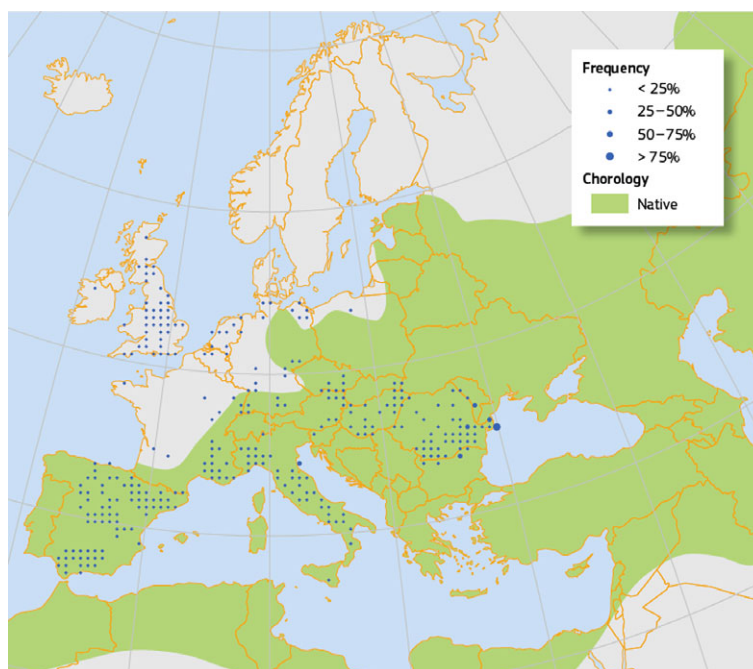
Figure 5: Plot distribution and simplified chorology map for *Populus alba*. Frequency of *P. alba* occurrences within the field observations as reported by the National Forest Inventories. The chorology of the native spatial range for *P. alba* is derived from Isebrands and Richardson (Caudullo and de Rigo, 2016)

3.4.3.2. Climatic conditions affecting establishment

The distribution of *S. musiva* in North America (Figure 1; Section 3.2.1) covers areas with a wide range of climate types which to a large extent overlaps with the distribution of native *Populus* species in Europe. Therefore, climate is assumed not to be a limiting factor for the establishment of the pathogen in the EU.

3.4.4. Spread

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

Yes, by natural dispersal and movement of infected plants for planting, cut branches, isolated bark and wood with or without bark.

RNQPs: Is spread mainly via specific plants for planting, rather than via natural spread or via movement of plant products or other objects?

No, plants for planting are just one of the means of spread of the pathogen.

Transmission of *S. musiva* within and between stands occurs via dispersal of conidia by water splash or stem flow and via windborne ascospores (Ostry, 1987).

Longer distance spread may be due to transport of infected plants or transport of wood with cankers. Transport of infected planting material is suggested to have enabled the spread of the pathogen across the North American continent (Sakalidis et al., 2016).

The Panel has found no reports of seed infection of *S. musiva*.

3.5. Impacts

> *Would the pests' introduction have an economic or environmental impact on the EU territory?*
>
> **Yes**, the pest introduction would have impacts in woodlands, plantations and nurseries.
>
> *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?*[4]
>
> **Yes**, the presence of the pest on plants for planting would have an impact on their intended use.

S. musiva causes both leaf spots and canker disease of poplars (Figure 6). *S. musiva* does not cause serious injury in stands of poplars native to North America. On the North American host *P. deltoides,* the disease only causes leaf spots (Ostry, 1987; Feau et al., 2010). However, the pathogen is considered the most serious disease affecting hybrid poplar production in North America (Feau et al., 2010).

In susceptible hosts, the disease can (i) lead to premature defoliation, (ii) reduce tree growth and wood quality and (iii) predispose the trees to wind damage and attacks from secondary pests (Feau et al., 2010). Defoliation, branch and stem breakage can lead to a complete loss of highly susceptible clones (Ostry et al., 2014). Tree death from girdling and stem breakage usually occurs within 4 years of planting (Ostry and McNabb, 1983).

In Ontario, a survey showed high incidence of cankers in plantations of hybrid poplar (*P. nigra* x *P. maximowiczii*) equivalent to 1450 ha of hybrid poplar or 11% of the total area (Strobl and Fraser, 1989). In Michigan, 5 years after planting, 86% of the poplar clones were found to have cankers caused by *S. musiva* (Ostry et al., 1989).

S. musiva is reported as especially problematic in nurseries and coppiced plantations (references in Ostry and McNabb, 1983).

Figure 6: Septoria leaf spot and canker due to *Sphaerulina musiva* (photo by Minnesota Department of Natural Resources, Bugwood.org, available online at: https://www.forestryimages.org/browse/detail.cfm?imgnum=4212089)

---

[4] 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 3.6.2.
>
> *RNQPs: Are there measures available to prevent pest presence on plants for planting such that the risk becomes mitigated?*
>
> **Yes**, production of plants for planting in pest free areas can prevent pest presence on plants for planting.

3.6.1. Phytosanitary measures

Phytosanitary measures are currently applied to *Populus* spp. (see Section 3.3.2). However, pathways exist also via other hosts (*Salix* spp.) and from countries not specified in the Directive 2000/29/EC (South America) (see Section 3.4.1). For *Salix* plants, pest-free area for the production of clean nursery stock is an available phytosanitary measure.

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

- *S. musiva* not only colonises the bark when causing cankers but may also be isolated from wood, so debarking may not be sufficient to eliminate the pathogen (Sivanesan, 1990; Anon, 2017).
- Not only leaves but also cankers on stems and branches may produce overwintering structures such as pseudothecia which then produce ascospores during the following spring (Ostry, 1987; Sinclair and Lyon, 2005).

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

- Trees of all ages are infected and shoots used as cuttings for new plantings may be infected and carry cankers (Ostry, 1987).

3.6.2. Control methods

- Selection, breeding and planting of resistant species and clones are the main methods used to control the damage caused by the pathogen (Feau et al., 2010 and references therein).
- Fungicide treatment can be efficient to reduce propagation of inoculum in stoolbeds (Feau et al., 2010).
- Removing leaf litter in nurseries is a method to reduce primary inoculum (Mottet et al., 2007).
- Biological control using antagonistic fungi, tested both in nurseries and in field conditions, may be a promising approach (Gyenis et al., 2003; Feau et al., 2010).

3.7. Uncertainty

There is some uncertainty on the geographic distribution: it is unclear whether the pathogen is established in the Caucasus and on the Crimean Peninsula and how widespread the fungus is in South America.

There is a knowledge gap on the susceptibility level of *Populus* species native to Europe as well as *Salix* spp.

The effectiveness of debarking as a measure to eliminate the pest from wood is unclear.

4. Conclusions

S. musiva 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	None
Regulatory status (Section 3.3)	*S. musiva* is regulated by Council Directive 2000/29/EC (Annex IAI, as *Mycosphaerella populorum*) as a harmful organism whose introduction into and spread within all Member States shall be banned	*S. musiva* is regulated by Council Directive 2000/29/EC (Annex IAI, as *Mycosphaerella populorum*) as a harmful organism whose introduction into and spread within all Member States shall be banned	None
Pest potential for entry, establishment and spread in the EU territory (Section 3.4)	Entry: the pest could enter the EU via plants for planting, cut branches, wood (with and without bark) and isolated bark. Establishment: hosts and favourable climatic conditions are widespread in the risk assessment (RA) area. Spread: the pest would be able to spread following establishment by various means, i.e. plants for planting, cut branches, wood (with and without bark) and isolated bark	Plants for planting are not the main means of spread, as the pathogen can also spread via cut branches, wood (with and without bark) and isolated bark	It is unclear whether the pathogen is established in the Caucasus and on the Crimean Peninsula and how widespread the fungus is in South America
Potential for consequences in the EU territory (Section 3.5)	The pest introduction would have economic and environmental impacts in woodlands, poplar plantations and nurseries	The pest introduction would have an impact on the intended use of plants for planting	There is uncertainty about the susceptibility level of some poplar species native to Europe (e.g. *P. alba*, *P. tremula*)
Available measures (Section 3.6)	Selection, breeding and planting of resistant species and clones are the main methods used to control the damage caused by the pathogen	Production of plants for planting in pest-free areas can prevent pest presence on plants for planting	The effectiveness of debarking as a measure to eliminate the pest from wood is unclear
Conclusion on pest categorisation (Section 4)	The criteria assessed by the Panel for consideration as a potential quarantine pest are met	The criterion on the pest presence in the EU is not met	
Aspects of assessment to focus on/ scenarios to address in future if appropriate	The main knowledge gaps concern (i) the distribution of the pathogen in South America, (ii) whether the pathogen is established in the Caucasus and on the Crimean Peninsula and (iii) the susceptibility level of *Populus* species native to Europe as well as *Salix* spp		

References

Anon, 2005. Vegetation management guideline: white poplar (*Populus alba* L.). Illinois Nature Preserves Commission, Illinois, USA, 8 pp. [Accessed February 2018] Available online: https://www.dnr.illinois.gov/INPC/documents/vmg/VMG%20White%20poplar%20revised%202004.pdf

Anon, 2017. Datasheet on *Mycosphaerella populorum* (septoria leaf spot). CABI, Wallingford, UK. [Accessed December 2017]. Available online: https://www.cabi.org/isc/datasheet/35317

Bossard M, Feranec J and Otahel J, 2000. CORINE land cover technical guide - Addendum 2000. Tech. Rep. 40, European Environment Agency. Available online: https://www.eea.europa.eu/ds_resolveuid/032TFUPGVR

Büttner G, Kosztra B, Maucha G and Pataki R, 2012. Implementation and achievements of CLC2006. Tech. rep., European Environment Agency. Available online: http://www.eea.europa.eu/ds_resolveuid/GQ4JECM8TB

Callan BE, 1998. *Diseases of populus* in British Columbia: a diagnostic manual. Canadian Forest Service, Victoria, British Columbia, Canada, 157 pp.

Caudullo G and de Rigo D, 2016. *Populus tremula* in Europe: distribution, habitat, usage and threats. European Atlas of Forest Tree Species. Publ. Off. EU, Luxembourg, pp. e01f148.

Chirici G, Bertini R, Travaglini D, Puletti N and Chiavetta U, 2011a. The common NFI database. In: Chirici G, Winter S and McRoberts RE (eds.). National Forest Inventories: Contributions to Forest Biodiversity Assessments. Springer, Berlin. pp. 99–119.

Chirici G, McRoberts RE, Winter S, Barbati A, Brändli U-B, Abegg M, Beranova J, Rondeux J, Bertini R, Alberdi Asensio I and Condés S, 2011b. Harmonization tests. In: Chirici G, Winter S and McRoberts RE (eds.). National Forest Inventories: Contributions to Forest Biodiversity Assessments. Springer, Berlin. pp. 121–190.

Dickmann DI and Kuzovkina J, 2014. Poplars and willows of the world, with emphasis on silviculturally important species. In: Isebrands JG and Richardson J (eds.). Poplars and Willows: Trees for Society and The Environment. FAO, Rome, Italy, pp. 8–91.

EFSA PLH Panel (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 *Entoleuca mammata*. EFSA Journal 2017;15(7):4925, 25 pp. https://doi.org/10.2903/j.efsa.2017.4925

EFSA PLH Panel (EFSA Panel on Plant Health), 2010. PLH Guidance on a harmonised framework for pest risk assessment and the identification and evaluation of pest risk management options by EFSA. EFSA Journal 2010;8(2):1495, 66 pp. https://doi.org/10.2903/j.efsa.2010.1495

EPPO (European and Mediterranean Plant Protection Organization), 1997. Data sheets on quarantine pests: *Mycosphaerella populorum*. In: Smith IM, McNamara DG, Scott PR, Holderness M (eds.). Quarantine Pests for EUROPE, 2nd Edition. CABI/EPPO, Wallingford, 1425 pp.

EPPO (European and Mediterranean Plant Protection Organization), 2018. EPPO Global Database. Available online: https://gd.eppo.int

Eschen R, Douma JC, Grégoire JC, Mayer F, Rigaux L and Potting RP, 2017. A risk categorisation and analysis of the geographic and temporal dynamics of the European import of plants for planting. Biological Invasions, 19, 3242–3257.

FAO (Food and Agriculture Organization of the United Nations), 2004. ISPM (International Standards for Phytosanitary Measures) 21—Pest risk analysis of regulated non-quarantine pests. FAO, Rome, 30 pp. Available online: https://www.ippc.int/sites/default/files/documents//1323945746_ISPM_21_2004_En_2011-11-29_Refor.pdf

FAO (Food and Agriculture Organization of the United Nations), 2013. ISPM (International Standards for Phytosanitary Measures) 11—Pest risk analysis for quarantine pests. FAO, Rome, 36 pp. Available online: https://www.ippc.int/sites/default/files/documents/20140512/ispm_11_2013_en_2014-04-30_201405121523-494.65%20KB.pdf

Feau N and Bernier L, 2004. First report of shining willow as a host plant for *Septoria musiva*. Plant Disease, 88, 770.

Feau N, Hamelin RC, Vandecasteele C, Stanosz GR and Bernier L, 2005. Genetic structure of *Mycosphaerella populorum* (anamorph *Septoria musiva*) populations in north-central and northeastern North America. Phytopathology, 95, 608–616.

Feau N, Mottet MJ, Périnet P, Hamelin RC and Bernier L, 2010. Recent advances related to poplar leaf spot and canker caused by *Septoria musiva*: minireview. Canadian Journal of Plant Pathology, 32, 122–134.

Gyenis L, Anderson NA and Ostry ME, 2003. Biological control of *Septoria* leaf spot disease of hybrid poplar in the field. Plant Disease, 87, 809–813.

Hansen EA, Ostry ME, Johnson WD, Tolsted DN, Netzer DA, Berguson WE and Hall RB, 1994. Field performance of populus in short-rotation intensive culture plantations in the north-central US. USDA, Forest Service, North Central Forest Experiment Station, Research Paper NC-320, St. Paul, Minnesota. p. 13.

Herath P, Beauseigle S, Dhillon B, Ojeda DI, Bilodeau G, Isabel N, Gros-Louis MC, Kope H, Zeglen S, Hamelin RC and Feau N, 2016. Anthropogenic signature in the incidence and distribution of an emerging pathogen of poplars. Biological Invasions, 18, 1147–1161.

Hiederer R, Houston Durrant T, Granke O, Lambotte M, Lorenz M, Mignon B and Mues V, 2007. Forest focus monitoring database system - validation methodology. Vol. EUR 23020 EN of EUR – Scientific and Technical Research. Office for Official Publications of the European Communities. https://doi.org/10.2788/51364

Hiederer R, Houston Durrant T and Micheli E, 2011. Evaluation of BioSoil demonstration project - Soil data analysis. Vol. 24729 of EUR - Scientific and Technical Research. Publications Office of the European Union. https://doi.org/10.2788/56105

Houston Durrant T and Hiederer R, 2009. Applying quality assurance procedures to environmental monitoring data: a case study. Journal of Environmental Monitoring, 11, 774–781.

Houston Durrant T, San-Miguel-Ayanz J, Schulte E and Suarez Meyer A, 2011. Evaluation of BioSoil demonstration project: forest biodiversity - Analysis of biodiversity module. Vol. 24777 of EUR – Scientific and Technical Research. Publications Office of the European Union. https://doi.org/10.2788/84823

Maxwell DL, Kruger EL and Stanosz GR, 1997. Effects of water stress on colonization of poplar stems and excised leaf disks by *Septoria musiva*. Phytopathology, 87, 381–388.

de Mio MML and Amorim L, 2000. Doenças do álamo [diseases of poplars]. Floresta, 30, 139–153.

Mottet MJ, Lamontagne D, Caron F, Fauchon A and Perinet P, 2007. Risk management of Septoria canker in Quebec hybrid poplar plantations. Conference Handbook: Poplar culture: a collaborative effort from clone to mill. Gouvernement du Quebec, Quebec, Canada, p. 59.

Ostry ME, 1987. Biology of *Septoria musiva* and *Marssonina brunnea* in hybrid *Populus* plantations and control of Septoria canker in nurseries. Forest Pathology, 17, 158–165.

Ostry ME and McNabb HS, 1983. Diseases of intensively cultured hybrid poplars: a summary of recent research in the north central region. In: Hansen EA (ed) Intensive Plantation Culture: 12 Years Research. USDA, Forest Service, North Central Forest Experiment Station, GTR NC-91. St. Paul, Minnesota, pp. 102–109.

Ostry ME, Wilson LF and McNabb HS, 1989. Impact and control of Septoria musiva on hybrid poplars. USDA Forest Service, North Central Forest Experiment Station, GTR NC-133. St. Paul, Minnesota. 8 pp.

Ostry M, Ramstedt M, Newcombe G and Steenackers M, 2014. Diseases of poplars and willows. In: Isebrands JG, Richardson J (eds.). Poplars and Willows: Trees for Society and the Environment. CABI International, Wallingford, UK, pp. 443–458.

Quaedvlieg W, Verkley GJ, Shin HD, Barreto RW, Alfenas AC, Swart WJ, Groenewald JZ and Crous PW, 2013. Sizing up Septoria. Studies in Mycology, 75, 307–390.

de Rigo D, 2012. Semantic Array Programming for environmental modelling: application of the Mastrave library. In: Seppelt R, Voinov AA, Lange S and Bankamp D (eds.). International Environmental Modelling and Software Society (iEMSs) 2012 International Congress on Environmental Modelling and Software - Managing Resources of a Limited Planet: Pathways and Visions under Uncertainty, Sixth Biennial Meeting. pp. 1167–1176.

de Rigo D, Caudullo G, Busetto L and San-Miguel-Ayanz J, 2014. Supporting EFSA assessment of the EU environmental suitability for exotic forestry pests: final report. EFSA Supporting Publications, 11(3), EN-434.

de Rigo D, Caudullo G, Houston Durrant T and San-Miguel-Ayanz J, 2016a. The European Atlas of Forest Tree Species: modelling, data and information on forest tree species. In: San-Miguel-Ayanz J, de Rigo D, Caudullo G, Houston Durrant T and Mauri A (eds.). European Atlas of Forest Tree Species. Publ. Off. EU, Luxembourg, pp. e01aa69+.

de Rigo D, Enescu CM, Houston Durrant T and Caudullo G, 2016b. *Populus nigra* in Europe: distribution, habitat, usage and threats. In: San-Miguel-Ayanz J, de Rigo D, Caudullo G, Houston Durrant T and Mauri A (eds.). European Atlas of Forest Tree Species. Publ. Off. EU, Luxembourg, pp. e0182a4+

de Rigo D, Caudullo G, San-Miguel-Ayanz J and Barredo JI, 2017. Robust modelling of the impacts of climate change on the habitat suitability of forest tree species. Publication Office of the European Union, 58 pp.

Romo Lozano Y, Moreno Rico O and Romero Cova S, 1992. Incidence and severity of quaking aspen (*Populus tremuloides*) aerial diseases in Aguascalientes, Ags. Revista Mexicana de Fitopatologia, 10, 38–43.

Sakalidis ML, Feau N, Dhillon B and Hamelin RC, 2016. Genetic patterns reveal historical and contemporary dispersal of a tree pathogen. Biological Invasions, 18, 1781–1799.

San-Miguel-Ayanz J, 2016. The European Union Forest Strategy and the Forest Information System for Europe. In: San-Miguel-Ayanz J, de Rigo D, Caudullo G, Houston Durrant T and Mauri A (eds.). European Atlas of Forest Tree Species. Publ. Off. EU, Luxembourg, pp. e012228+

San-Miguel-Ayanz J, de Rigo D, Caudullo G, Houston Durrant T and Mauri A (eds.)., 2016. European atlas of forest tree species. Publication Office of the European Union, Luxembourg.

Santos F dos A, Machado EB, Stanosz GR and Smith DR, 2010. Primeiro relato da ocorrência de *Septoria musiva* em álamo no Brasil. Tropical Plant Pathology, 35, 52–53.

Sinclair WA and Lyon HH, 2005. Diseases of trees and shrubs. 2nd Edition. Comstock Publishing Associates, a division of Cornell University Press, Ithaca, NY. 660 pp.

Sivanesan A, 1990. List of sets, index of species, and list of accepted names for some obsolete species names in CMI Descriptions of Pathogenic Fungi and Bacteria Sets 1–100, Nos. 1–1000, issued January 1964–March 1990. Mycopathologia, 111, 91–108.

Stanosz JC and Stanosz GR, 2002. A medium to enhance identification of *Septoria musiva* from poplar cankers. Forest Pathology, 32, 145–152.

Strobl S and Fraser K, 1989. Incidence of Septoria canker of hybrid poplars in eastern Ontario. Canadian Plant Disease Survey, 69, 109–112.

Teterevnikova-Babayan DN, 1976. A critical survey of *Septoria* species parasitizing Salicaceae II. *Septoria* species on poplar. (In Russian) Biol. Zh. Arm., 29, 53–61.

Wang Q, Su X, Shrestha N, Liu Y, Wang S, Xu X and Wang Z, 2017. Historical factors shaped species diversity and composition of *Salix* in eastern Asia. Scientific Reports, 7, 42038.

Abbreviations

C-SMFA	constrained spatial multiscale frequency analysis
CLC	Corine Land Cover
DG SANTE	Directorate General for Health and Food Safety
EPPO	European and Mediterranean Plant Protection Organization
EUFGIS	European Information System on Forest Genetic Resources
FAO	Food and Agriculture Organization
GD^2	Georeferenced Data on Genetic Diversity
IPPC	International Plant Protection Convention
JRC	Joint Research Centre
MS	Member State
PCR	Polymerase Chain reaction
PLH	EFSA Panel on Plant Health
RPP	relative probability of presence
ToR	Terms of Reference

Appendix A – Methodological notes on Figure 2

The relative probability of presence (RPP) reported here for *Populus* spp. in Figure 2 and in the European Atlas of Forest Tree Species (de Rigo et al., 2016a; 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 means of the constrained spatial multiscale frequency analysis (C-SMFA) (de Rigo et al., 2014, 2017) of species presence data reported in geolocated plots by different forest inventories.

A.1. Geolocated plot databases

The RPP models rely on five geodatabases that provide presence/absence data for tree species and genera: four European-wide forest monitoring data sets and a harmonised collection of records from national forest inventories (de Rigo et al., 2014, 2016a, 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., 2016a; 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 km^2 pixel size, using the ETRS89 Lambert Azimuthal Equal-Area as geospatial projection (EPSG: 3035, http://spatialreference.org/ref/epsg/etrs89-etrs-laea/).

A.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 approximately 375,000 sample points with a spatial resolution of 1km^2/pixel, covering 21 European countries (de Rigo et al., 2014, 2016a).

A.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[5]. 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 Joint Research Centre (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.

A.1.3. BioSoil data set

This data set was produced by one of a number of demonstration studies performed 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.

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

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

---

[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), 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.

A.1.5.   Georeferenced Data on Genetic Diversity (GD^2)

GD^2 (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 data set with the largest geographic extent.

A.2.   Modelling methodology

For modelling, the data were harmonised in order to have the same spatial resolution (1km^2) and filtered to a study area comprising 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 km^2 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 km^2 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 km^2 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 km^2 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 not to 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 codominant 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, 2016a).

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 km^2 and 625 km^2) by averaging the values in larger grid cells.