Pest categorisation of *Gremmeniella abietina*

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Abstract

Following a request from the European Commission, the EFSA Plant Health (PLH) Panel performed a pest categorisation of *Gremmeniella abietina*, a well-defined species and distinguishable fungus of the family Godroniaceae. The species *G. abietina* includes several varieties, races and biotypes that are found in different geographical locations, on different hosts and that vary in aggressiveness. The pathogen causes diseases on *Pinus* species and other conifers such as *Abies* spp., *Picea* spp., *Larix* spp. and *Pseudotsuga* spp. known as Scleroderris canker in North America and Brunchorstia dieback in Europe. *G. abietina* has been reported from 19 EU Member States, without apparent ecoclimatic factors limiting establishment. The pathogen is a protected zone (PZ) quarantine pest (Annex IIB) for Ireland and the UK (Northern Ireland). The main European hosts are widespread throughout most of the EU and have been frequently planted in the PZ. The main means of spread are wind-blown ascospores, rain-splashed conidia, plants for planting and traded Christmas trees. Given that *G. abietina* is most damaging to species that are grown towards the limit of their range, impacts can be expected in the PZ, should the pathogen be introduced there. Risk reduction options include selection of disease-free planting material, nursery inspections, selection of planting sites at some distance from infested plantations, appropriate spacing between plants and thinning. The main uncertainties concern the indeterminate endophytic stage of the fungus, the pathogen distribution and the future taxonomic status of *G. abietina*, given its intraspecific diversity. All the criteria assessed by the Panel for consideration as potential PZ quarantine pest are met. The criterion of plants for planting being the main pathway for spread for regulated non-quarantine pests is not met: plants for planting are only one of the means of spread of the pathogen.

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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 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 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

| Insects, mites and nematodes | Scientific name |
|------------------------------|-----------------|
| Aleurocanthus spp.           | Numonia pyrivorella (Matsumura) |
| Anthonomus bisignifer (Schenkling) | Oligonychus perditus Pritchard and Baker |
| Anthonomus signatus (Say)    | Pissodes spp. (non-EU) |
| Aschistonyx eppoi Inouye      | Scirtothrips auranti Faure |
| Carposina niponensis Walsingham | Scirtothrips citri (Moulten) |
| Enarmonia packardi (Zeller)   | Scolytidae spp. (non-EU) |
| Enarmonia prunivora Walsh     | Scrobipalpopsis solanivora Povolny |
| Grapholita inopinata Heinrich | Tachypterellus quadrigibbus Say |
| Hisphonous phycitis           | Toxoptera citricida Kirk. |
| Leucaspis japonica Kuhl.      | Unasps citri Comstock |
| Listronotus bonariensis (Kuschel) | |

(b) Bacteria

| Bacteria | Scientific name |
|----------|-----------------|
| Citrus variegated chlorosis | Xanthomonas campestris pv. oryzae (Ishiyama) |
| Erwinia stewartii (Smith) Dye | Dye and pv. oryzicola (Fang. et al.) Dye |

(c) Fungi

| Fungi | Scientific name |
|-------|-----------------|
| Alternaria alternata (Fr.) Keissler (non-EU pathogenic isolates) | Elsinoe spp. Bitanc. and Jenk. Mendes |
| Anisogramma anomala (Peck) E. Müller | Fusarium oxysporum f. sp. albedinis (Kilian and Maire) Gordon |
| Apiosporina morbosa (Schwein.) v. Arx | Guignardia piricola (Nosa) Yamamoto |
| Ceratocystis virescens (Davidson) Moreau | Puccinia pittieriana Henning |
| Cercoseptoria pini-densiflorae (Hori and Nambu) Deighton | Stegophora ulmea (Schweinitz: Fries) Sydow & Sydow |
| Cercospora angolensis Carv. and Mendes | Venturia nashicola Tanaka and Yamamoto |

(d) Virus and virus-like organisms

| Virus and virus-like organisms | Scientific name |
|--------------------------------|-----------------|
| Beet curly top virus (non-EU isolates) | Little cherry pathogen (non-EU isolates) |
| Black raspberry latent virus | Naturally spreading psorosis |
| Blight and blight-like | Palm lethal yellowing mycoplasma |
| Cadang-Cadang viroid | Satsuma dwarf virus |
| Citrus tristeza virus (non-EU isolates) | Tatter leaf virus |
| Leprosis | Witches’ broom (MLO) |

Annex IIB

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

| Insect mites and nematodes | Scientific name |
|---------------------------|-----------------|
| Anthonomus grandis (Boh.) | Ips amitinus Eichhof |
| Cephalcia laricophila (Klug) | Ips cembrae Heer |
| Ips duplicatus Sahlberg | Ips sexdentatus Börner |
| Dendroctonus micans Kugelan | Ips typographus Heer |
| Gilphinia hercyniae (Hartig) | Sternocchetus mangiferarum Fabricius |
| Gonipterus scutellatus Gyll. | |
(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 indifferens Curran
8) Dacus tryoni (Froggatt) 19) Rhagoletis mendax Curran
9) Dacus tsuneonis Miyake 20) Rhagoletis pomonella Walsh
10) Dacus zonatus Saund.
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 Mill., Fragaria L., Malus Mill., Prunus L., Pyrus L., Ribes L., Rubus L. and Vitis L., such as:
1) Blueberry leaf mottle virus 8) Peach yellows mycoplasm
2) Cherry rasp leaf virus (American) 9) Plum line pattern virus (American)
3) Peach mosaic virus (American) 10) Raspberry leaf curl virus (American)
4) Peach phony rickettsia 11) Strawberry witches’ broom mycoplasma
5) Peach rosette mosaic virus 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 IIAI**

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

| Insects | Mites | Nematodes |
|---------|-------|-----------|
| Acleris spp. (non-EU) | Longidorus diadecturus | Eyeleigh and Allen |
| Amauromyza maculosa (Malloch) | Monochamus spp. (non-EU) | |
| Anoma orientalis Waterhouse | Myndus crudus | Van Duzee |
| Arrhenodes minutus Drury | Nacobbus aberrans (Thorne) | Thorne and Allen |
| Choristoneura spp. (non-EU) | Naupactus leucoloma | Boheman |
| Conotrachelus nemuphar (Herbst) | Premnotypes spp. (non-EU) | |
| Dendrolimus sibiricus Tschetverikov | Pseudopityophthorus minutissimus (Zimmermann) | |
| Diabrotica barberi Smith and Lawrence | Pseudopityophthorus pruiniosus (Eichhoff) | |
| Diabrotica undecimpunctata howardi Barber Mannerheim | Scaphoideus luteolus (Van Duzee) | |
| Diabrotica undecimpunctata undecimpunctata | Spodoptera eridania (Cramer) | |
| | Spodoptera frugiperda (Smith) | |
| Diabrotica virgifera zeae Krysan & Smith | Spodoptera litura (Fabricus) | |
| Diaphorina citri Kuway | Thrips palmi Karny | |
| Heliothis zeae (Boddie) | Xiphinema americanum Cobb sensu lato (non-EU populations) | |
| Hirschmanniella spp., other than | | |
| | Xiphinema californicum Lamberti and Bleve-Zacheo | |
| Hirschmanniella gracilis (de Man) Luc and Goodey | | |
| Liriomyza sativae Blanchard | | |

(b) **Fungi**

| 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) | Phylllosticta solitaria Ell. and Ev. |
| Guignardia laricina (Saw.) Yamamoto and Ito | Septoria lycopersici Speg. var. malagutii Ciccarone and Boerema |
| Gymnosporangium spp. (non-EU) | Thecaphora solani Barrus |
| Inonotus weirii (Murril) Kotlaba and Pouzar | Trechispora brinkmannii (Bresad.) Rogers |
| Melampsora farlowii (Arthur) Davis | |

(c) **Viruses and virus-like organisms**

| Viruses | 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 | |
(d) Parasitic plants

*Arceuthobium* spp. (non-EU)

**Annex IAII**

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

*Meloidogyne fallax* Karssen
*Popillia japonica* Newman

(b) Bacteria

*Clavibacter michiganensis* (Smith) 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

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

Since *G. abietina* is regulated in the protected zones (PZ) only, the scope of the categorisation is the territory of the PZ (Ireland and the UK (Northern Ireland)); thus, the criteria refer to the PZ instead of the EU territory.

2. Data and methodologies

2.1. Data

2.1.1. Literature search

A literature search (until June 2017) on *G. abietina* was conducted at the beginning of the categorisation in both the ISI Web of Science and Scopus bibliographic databases, using the scientific name of the pathogen as search term. 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 distribution of hosts grown in the EU were obtained from EUROSTAT (http://epp.eurostat.ec.europa.eu/newxtweb/) and EUFORGEN (http://www.euforgen.org/), respectively. National forest inventories were also consulted.

Information on EU Member state (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 MS and the phytosanitary measures taken to eradicate or avoid their spread.

2.2. Methodologies

The Panel performed the pest categorisation for *G. abietina*, 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 regulated non-quarantine pest. If one of the criteria is not met, the pest will not qualify. 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 PZ only, the scope of the categorisation is the territory of the PZ; thus, the criteria refer to the PZ 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? Briefly describe the pest distribution | Is the pest present in the EU territory? If not, it cannot be a PZ quarantine organism | Is the pest present in the EU territory? If not, it cannot be a regulated non-quarantine pest (RNQP). A RNQP must be present in the risk assessment area |
| Regulatory status (Section 3.3) | If the pest is present in the EU but not widely distributed in the RA area, it should be under official control or expected to be under official control in the near future | The PZ 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 PRA 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? |
The Panel will not state 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, currently the identity of *G. abietina* is well-established, but potential changes in species designation may occur (see the Section 3.1.3 on Intraspecific diversity). |

*Gremmeniella abietina* (Lagerberg) Morelet is a fungus of the family Godroniaceae (Helotiales).
There are many species synonyms: Ascocalyx abietina, Brunchorstia destruens, Brunchorstia pinea, Brunchorstia pinea var. cembrae, Brunchorstia pinea var. pinea, Crumenula abietina, Crumenula pinea, Excipulina pinea, Godronia abietina, Gremmeniella abietina var. abietina, Gremmeniella abietina var. balsamea, Lagerbergia lagerbergii, Pragmopora abietina, Scleroderris abietina, Scleroderris lagerbergii, Septoria pinea (Index Fungorum, http://www.indexfungorum.org/names/names.asp).

3.1.2. Biology of the pest

G. abietina causes diseases on Pinus species and other conifers such as Abies spp., Picea spp., Larix spp. and Pseudotsuga spp. known as Scleroderris canker in North America and Brunchorstia dieback in Europe.

During late spring and summer, conidia or ascospores infect the apical buds and developing shoot, generally at the bracts (scales) at the axis of short shoots via the stomata, but direct penetration of the epidermis has also been reported (Sinclair and Lyon, 2005). Wounded needles, buds and shoots are particularly susceptible to infection (EPPO, 1997). Further spread into the shoot does not start until the trees reach dormancy during the winter (Hellgren and Barklund, 1994). During the winter, the fungus begins to colonise the shoot and cortical tissue. A brown resinous necrotic area beneath the bract is the first symptom of infection. The lesion extends into needle bases and buds and girdles the shoots (Sinclair and Lyon, 2005). The following spring the needles on affected shoots turn reddish brown, fall off and flushing fails. Pycnidia are produced later in the autumn or the following spring, 1 year after symptom development (Hellgren and Barklund, 1992). Black 1 mm pycnidia form in the bark, in cankers or at the needle bases of affected shoots either in clusters or isolated (Sinclair and Lyon, 2005). Conidia are colourless, usually four-celled, 30 × 3 μm with pointed ends (Sinclair and Lyon, 2005). Most of the conidia have been observed to be dispersed during the spring and summer and coincide with the flush of the current year shoots 2 years after initial infection (Hellgren and Barklund, 1992). Apothecia are found on shoots that have been dead for 1 year, are produced later during the vegetation season and appear to disperse ascospores during a longer time period (Hellgren and Barklund, 1992). Apothecia can also be found concentrated to stem cankers (e.g. on Pinus contorta; Witzell, 2001). Apothecia are brown cuplike, 1 mm with short stalks and ascospores are colourless, ellipsoid, four-celled, often slightly curved with rounded ends and 15–22 × 3–5 μm (Sinclair and Lyon, 2005).

Sexual reproduction requires at least 2 years (Sinclair and Lyon, 2005), but the fungus can survive in an endophytic stage for an undetermined time period prolonging the cycle (Petrini et al., 1990).

The pathogen also causes canker on branches and stem that are typically recognised as oval ‘thumb marks’ on young pine bark (Witzell, 2001). Cankers can grow quite fast, especially vertically and extend more than 20 cm (Witzell, 2001).

Rain and high air humidity enhance the release of conidia and ascospores, and are conducive to the establishment of infection. Milder temperatures (−5 to +5°C) have been reported to facilitate the infection during the winter, when the dormant host is colonised (Marosy et al., 1989). Large outbreaks of the disease have been associated with long periods of cool, moist weather during the spring and summer (Uotila and Petitäisi, 2007; Thomsen, 2009) and to periods of frost (Yokota, 1975; Sairanen, 1990). A long-lasting and deep snow cover has been shown to promote the development of disease in newly established plantations (Karlan et al., 1994).

While conidia are dispersed under wet conditions by a water splash mechanism (Votila, 1985), ascospores may be responsible for long-distance dispersal of the fungus through wind (EPPO, 1997). Ascospores of the European race (see Section 3.1.3 on Intraspecific diversity) were originally thought to be absent or rare (EPPO, 1997), although this statement was provided without reference. In fact, apothecia were produced abundantly on diseased Pinus contorta plantations in northern Sweden (Karlan et al., 1994; Hamelin et al., 1996) and on Pinus sylvestris in southern Sweden (Hellgren and Barklund, 1992). The high apothecial production may have been caused by a long-lasting and deep snow cover (Hamelin et al., 1996).

The survival period of G. abietina conidia, European race, has been reported to be over 18 months on Pinus sylvestris slash in Sweden (Witzell et al., 2006) and 2 years on Pinus resinosa slash in Canada (Laflamme and Rioux, 2015).

3.1.3. Intraspecific diversity

The species G. abietina includes several varieties, races and biotypes that are found in different geographical locations, on different hosts and that vary in aggressiveness (Hamelin et al., 2000; Sinclair and Lyon, 2005). Two different varieties of the pathogen have been described:
1) *G. abietina* var. *abietina* found mainly on *Pinus* spp. and *Picea* spp. in North America, Europe and Asia, and

2) *G. abietina* var. *balsamea* which is found mainly in *Abies balsamea* and *Picea* spp. in Canada (Petrini et al., 1989).

Within the former, three different races have been distinguished on geographical, ecological and molecular criteria (Hamelin et al., 1996, 2000; Anon, 2009): the North American, European and Asian races. The North American race mainly infects *Pinus* spp. The Asian race has mainly been found infecting *Abies sachalinensis* in Japan (Yokota et al., 1974). The European race mainly infects *Pinus* spp. but can also infect other conifers. Three different biotypes can be further distinguished within the European race:

1) The Scandinavian biotype, also referred to as the small tree type (STT), northern or B type, is mainly found infecting *Pinus sylvestris*, *Pinus contorta* and *Picea abies* at high altitudes in Northern Europe (Uotila, 1983; Hellgren and Högberg, 1995; Hamelin et al., 1996).

2) The Alpine biotype is found on *Pinus cembra*, *Pinus mugo*, *Pinus sylvestris* and *Larix lyallii* at high altitudes in the European Alps (Hamelin et al., 1996).

3) The third biotype within the European race, known as the large tree type (LTT) or A type, is widespread in Europe (Hamelin et al., 1996). This biotype was introduced to North America, assumed to be on infected seedlings during 1950–1960 (See: Hamelin et al., 2000). The genetic difference between the LTT biotype found in Europe and in North America could be due to a founder effect with introduction (Hamelin et al., 1998).

It has been suggested that the different races should be regarded as different species (Hantula and Müller, 1997; Dusabenyagasani et al., 2002; Laflamme, 2010). In addition, some of the biotypes within the European race, i.e. the Scandinavian and the European biotypes do not cross readily in the field (Uotila et al., 2000; Hantula and Tuomivirta, 2003), although they may generate low-fitness hybrids when paired artificially (Hantula and Tuomivirta, 2003). There are also studies indicating that there is limited gene flow between subgroups within the European A type where isolates from North America, Iceland and Italy have been found to be different from isolates originating from Scandinavia and Finland (Hantula and Müller, 1997) and where Spanish isolates were found to be different from Finnish and Russian isolates (Botella et al., 2010). The latter has also been suggested to be a fourth biotype within the European race (Santamaria et al., 2005).

3.1.4. Detection and identification of the pest

Are detection and identification methods available for the pest? Yes

*G. abietina* can be identified based on the species morphological structures following the EPPO diagnostic protocol PM 7/92(1): *Gremmeniella abietina* (Anon, 2009). There are also molecular methods available to identify the species in infected material or isolated in culture (Hellgren and Högberg, 1995; Hamelin et al., 1996, 1998, 2000; Hantula and Müller, 1997; Zeng et al., 2005; Børja et al., 2006).

The different varieties, races and biotypes of *G. abietina* can be identified and separated based on DNA methods (Hellgren and Högberg, 1995; Hamelin et al., 1996, 1998, 2000; Hantula and Müller, 1997; Zeng et al., 2005; Børja et al., 2006) and by some other methods reviewed in Appendix 1 of the EPPO diagnostic protocol PM 7/92(1): *Gremmeniella abietina* (Anon, 2009).

3.2. Pest distribution

*G. abietina* is reported from North America, Europe and Asia (EPPO Global Database) (Figure 1).
3.2.1. Pest distribution outside the EU

In North America, the pathogen is found in large parts of Canada (Alberta, British Columbia, Manitoba, New Brunswick, Newfoundland, Nova Scotia, Ontario and Quebec) and in north-eastern states of USA (Maine, Michigan, Minnesota, New Hampshire, New York, Vermont, Wisconsin) (EPPO, 2017).

In Asia, the pathogen has been reported from Japan (EPPO, 2017) and Korea (La et al., 2007).

In non-EU Europe, the fungus has been reported from Belarus, Georgia, Iceland, Montenegro, Norway, Russia, Serbia and Switzerland (EPPO, 2017).

3.2.2. Pest distribution in the EU

G. abietina is present in the EU and has been reported from 19 EU MS (Table 2). These countries range from the Mediterranean (Italy and Spain) to the Scandinavian (Finland and Sweden) parts of Europe. Within countries, the reported distribution varies from ‘restricted’ to ‘widespread’.

The pathogen is listed as ‘Absent, confirmed by survey’ in both Ireland (information from NPPO, 1993; EPPO Global Database) and in the United Kingdom, Northern Ireland (official survey in 2009; EPPO Global Database), which are the countries for which the PZ status applies according to Council Directive 2000/29/EC (Table 3).

There is some uncertainty on the distribution of G. abietina in the EU, both for MS having reported it (it is uncertain how widespread the pathogen is there) and for the PZ (it is uncertain whether the pathogen is really absent there). Results on PZ annual surveys which report negative findings are not available to the Panel.
3.3. Regulatory status

3.3.1. Council Directive 2000/29/EC

_G. abietina_ is listed in Council Directive 2000/29/EC. Details are presented in Tables 3 and 4.

Table 2: Current distribution of _Gremmeniella abietina_ in the 28 EU MS based on information from the EPPO Global Database. No other sources of information were used

| Country              | EPPO Global Database Last update: 30/9/2016 Date accessed: 8/6/2017 |
|----------------------|-------------------------------------------------------------------------|
| Austria              | Present, no details                                                     |
| Belgium              | Present, no details                                                     |
| Bulgaria             | Present, widespread                                                    |
| Croatia              | –                                                                       |
| Cyprus               | –                                                                       |
| Czech Republic       | Present, restricted distribution                                        |
| Denmark              | Present, widespread                                                    |
| Estonia              | Present, no details                                                     |
| Finland              | Present, widespread                                                    |
| France               | Present, restricted distribution                                        |
| Germany              | Present, restricted distribution                                        |
| Greece               | Present, no details                                                     |
| Hungary              | –                                                                       |
| Ireland              | Absent, confirmed by survey                                            |
| Italy                | Present, restricted distribution                                        |
| Latvia               | –                                                                       |
| Lithuania            | Present, no details                                                     |
| Luxembourg           | –                                                                       |
| Malta                | –                                                                       |
| Poland               | Present, restricted distribution                                        |
| Portugal             | –                                                                       |
| Romania              | Present, no details                                                     |
| Slovak Republic      | Present, widespread                                                    |
| Slovenia             | –                                                                       |
| Spain                | Present, restricted distribution                                        |
| Sweden               | Present, widespread                                                    |
| The Netherlands       | Present, no details                                                     |
| United Kingdom       | Present, restricted distribution in England and Scotland Absent, confirmed by survey in Northern Ireland |

Table 3: _G. abietina_ in Council Directive 2000/29/EC

| Annex II, Part B | Harmful organisms whose introduction into, and whose spread within, certain protected zones shall be banned if they are present on certain plants or plant products |
|------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| (c) Fungi        | Subject of contamination                                                                                                                                                |
| 2.               | Protected Zones                                                                                                                                                         |
| _Gremmeniella abietina_ (Lag.) Morelet | Plants of _Abies_ Mill., _Larix_ Mill., _Picea_ A. Dietr., _Pinus_ L. and _Pseudotsuga_ Carr., intended for planting, other than seeds | IRL, UK (Northern Ireland) |
3.3.2. Legislation addressing plants and plant parts on which G. abietina is regulated

Table 4: Regulated hosts and commodities that may involve G. abietina in Annexes III and V of Council Directive 2000/29/EC

| Annex III, Part A | Description | Country of origin |
|-------------------|-------------|-------------------|
| 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 | Non-European countries |

| Annex IV, Part B | Special requirements which shall be laid down by all member states for the introduction and movement of plants, plant products and other objects into and within certain protected zones |
|-------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Section II | Plants, plant products and other objects originating in the community |
| 6. | Plants of Pinus L., Picea A. Dietr., Larix Mill., Abies Mill. and Pseudotsuga Carr., intended for planting, other than seeds | Without prejudice to the provisions applicable to the plants listed in Annex III(A)(1), Annex IV(A)(I)(8.1), (8.2), (9), Annex IV(A)(II)(4) and Annex IV(B)(7), (8), (9), (10), (11), (12), (13), (15), where appropriate, official statement that the plants have been produced in nurseries and that the place of production is free from Gremmeniella abietina (Lag.) Morelet Protected Zones: IRL, UK (Northern Ireland) |

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 which are potential carriers of harmful organisms of relevance for certain protected zones, and which must be accompanied by a plant passport valid for the appropriate zone when introduced into or moved within that zone

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

G. abietina infects various conifer species belonging to the following genera: Pinus, Abies, Picea, Larix and Pseudotsuga.

The main hosts reported are Pinus sylvestris, Pinus contorta, Abies sachalinensis and Picea abies (CABI, 2015).

However, the following hosts have also been reported: Larix leptolepis, Picea glauca, Picea rubens, Pinus mariana, Pinus banksiana, Pinus cembra, Pinus densiflora, Pinus flexilis, Pinus griffithii, Pinus monticola, Pinus mugo, Pinus nigra var. austriaca, Pinus nigra var. corsicana, Pinus nigra var. maritima, Pinus pinaster, Pinus pinea, Pinus ponderosa, Pinus radiata, Pinus resinosa, Pinus rigida, Pinus sabiniana, Pinus strobos, Pinus thunbergii, Pinus wallichiana, Pseudotsuga menziesii (EPPO, 1997) and Pinus halepensis (Botella et al., 2010).

The above-named hosts are regulated. However, Cedrus libani (on which G. abietina is not regulated) has recently been reported to be a host of G. abietina on the basis of field inoculations (Doğmuş-Lehtijärvi et al., 2012, 2016).
3.4.2. Entry

Is the pest able to enter into the Protected Zone Areas of the EU territory?

Yes, the pest has been reported from 19 EU MS and could enter the EU PZ.

G. abietina is already present in the EU and the European race is believed to originate from Europe. The main pathways of entry into the PZ are:

- Plants for planting are considered to be a host commodity providing a pathway for entry (EPPO, 2017). For plants for planting of Abies, Larix, Picea, Pinus and Pseudotsuga spp. produced in the EU and moved to the PZ, there must be an official statement that the plants have been produced in nurseries and that the place of production is free from G. abietina (Annex IV B).
- Christmas trees of Pinus sylvestris were shown to harbour the pathogen and potentially provide a means of transport (Magasi and Manley, 1974).
- Natural spread from other EU MS (see Section 3.4.4 on Spread).

In the ISEFOR database of plants for planting (Eschen et al., 2017), there are no records of Pinus plants for planting imported by the PZ (Ireland and Northern Ireland) from the countries (both within and outside the EU) with reports of G. abietina.

In principle, wood with bark could provide a pathway of entry (but see Section 3.4.4).

According to EUROSTAT, between 2011 and 2015, about 130 tonnes of Pinus spp. wood in the rough were imported into the EU from the USA and Canada.

As of May 2017, there are no records of interception of G. abietina in the Europhyt database.

3.4.3. Establishment

Is the pest able to become established in the Protected Zone Areas of the EU territory?

Yes, the pest is already established in 19 EU MS, some of which have a climate similar to the one found in the PZ (Ireland and Northern Ireland).

3.4.3.1. EU distribution of main host plants

G. abietina is already established in most of the EU territory (see Table 2). The two main European host species Pinus sylvestris and Picea abies are widely distributed in central and northern Europe (Figures 2 and 3). The former species is also present, although with a more fragmented distribution, in Scotland, in southern France, in the Iberian and Balkan Peninsulas. The latter species is present in central Europe mostly in mountain areas. Also as genera, Pinus and Picea are widely present in EU forests (Figures 4a and 5a). The trustability in relation to the probability of the presence (see Appendix A) of both genera is low in the PZ (Figures 4b and 5b).

However, while the natural distribution areas of the main host species do not extend into the PZ (Ireland and Northern Ireland), based on the Irish National Forest Inventory (2007) P. sylvestris and P. abies have been frequently planted in the Republic of Ireland, with 0.5% and 2.8% of the total number of trees, respectively. Among the exotic host species, P. contorta has been widely planted in Ireland, representing about 10% of the total stocked forest area (National Forest Inventory of the Republic of Ireland, 2007).
Figure 2: Native range of *Pinus sylvestris* in Europe (map prepared by Euforgen in 2009). Blue dots represent isolated occurrences of the species.

Figure 3: Native range of *Picea abies* in Europe (map prepared by Euforgen in 2009).
Figure 4: **Left-hand panel:** Relative probability of presence (RPP) of the genus *Pinus* (based on data from the species: *P. sylvestris*, *P. pinaster*, *P. halepensis*, *P. nigra*, *P. pinea*, *P. contorta*, *P. cembra*, *P. mugo*, *P. radiata*, *P. canariensis*, *P. strobus*, *P. brutia*, *P. banksiana*, *P. ponderosa*, *P. heldreichii*, *P. leucodermis*, *P. wallichiana*) in Europe, mapped at 100 km² 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 A (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 the 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).
3.4.3.2. Climatic conditions affecting establishment

Given that *G. abietina* has been reported from EU regions with a wide variety of climatic and ecological conditions (e.g. from Greece to Lithuania and from Scotland to Spain), there are no obvious ecoclimatic factors limiting its establishment. The climatic conditions that are most conducive for establishment and outbreak are long periods of cool, moist weather during the spring and summer (Uotila and Petaisto, 2007; Thomsen, 2009). These conditions are likely to frequently occur in Ireland and Northern Ireland.

3.4.4. Spread

In natural conditions, the spread of the pathogen may occur by means of both ascospores and conidia. It was previously thought that the European race of *G. abietina* var. *abietina* mostly disperses through rain-splashed conidia (EPPO, 1997). However, dispersal by means of airborne ascospores is known to occur, which may have implications for the spread of the disease (Section 3.1.2). If conidia are involved, infection usually occurs in early summer, whereas ascospores infect later during the growing period and late in autumn (Skilling, 1972; Gibbs, 1984; Laflamme and Archambault, 1990; Hellgren and Barklund, 1992).

The pathogen can also spread through the movement of infected plants for planting and Christmas trees. As the fungus can survive in an endophytic stage for an undetermined period of time (Petrini et al., 1990), it can be moved over long distances in infected but asymptomatic plants (Hamelin et al., 1998).

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**Figure 5:** Left-hand panel: Relative probability of presence (RPP) of the genus *Picea* (based on data from the species: *P. abies, P. sitchensis, P. glauca, P. engelmannii, P. pungens, P. omorika, P. orientalis, P. leucodermis*) in Europe, mapped at 100 km² 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 A (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 A)

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

**Yes**, via conidia mostly disseminated through rain splash, wind-dispersed ascospores, and through infected plants for planting.

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 only one of the means of spread.
In the ISEFOR database of plants for planting, there are no records of *Pinus* plants for planting imported by the PZ (Ireland and Northern Ireland) from the countries (both within and outside the EU) with reports of *G. abietina*.

The opportunity for dispersal through movement of infected wood is limited because: first, most fruiting bodies are produced on shoots and branches which are left on the ground when harvesting; second, if there are fruiting bodies on the trunk (an infrequent occurrence), because of their small size, young infected trees are not commercialised; or for bigger trees, the cankers will make the logs unsuitable for harvesting and be classified as waste or at least as portions with defects (Gaston Laflamme, Canadian Forest Service, personal communication, 19 June 2017). It is uncertain whether use of such waste as wood chips in landscaping could contribute to the dispersal of the pathogen.

### 3.5. Impacts

**Would the pest introduction have an economic or environmental impact on the Protected Zones of the EU?**

**Yes.** Given that *G. abietina* is most damaging to species that are grown towards the limit of their range, and given that the EU PZ are outside of the native range of the main hosts of the pathogen, impact can be expected in the PZ, should the pathogen be introduced.

Outside of the EU, *G. abietina* is present in North America and Asia, where the main hosts are *Pinus contorta* and *Abies sachalinensis*, respectively. In that context, the disease may kill young trees as well as reduce growth and cause distortion of older trees. It can also cause serious nursery losses. Under severe conditions, all the foliage of the host may be affected and die (Figure 6). Severe outbreaks have been reported in Quebec, where the pathogen was found in 163 plantations, primarily on *Pinus resinosa* and occasionally on *Pinus sylvestris*, during a survey of more than 1,000 pine plantations (Laflamme and Lachance, 1987).

*G. abietina* is present in Europe, where the main hosts are *Pinus sylvestris* and *Picea abies*. However, destructive epidemics have also been reported on other pine species, including some exotic pines (e.g. the North American *Pinus contorta*). In general, the pathogen is most damaging to species that are grown towards the limit of their range (CABI, 2015).

While the disease is characterised by death of the growing point and the apical needles, under severe conditions, the pathogen can kill the trees. In Sweden, an epidemic starting in 2001 covered more than 450,000 ha of mainly 30- to 50-year-old and some 70- to 80-year-old *Pinus sylvestris* stands (Wulff et al., 2006). About 50,000 ha were sanitorily thinned or clear cut (Wulff et al., 2006). That epidemic seriously influenced the forest industry regionally. The net losses due to the disease were estimated to reach 250 million Euro (Hansson et al., 2004). Concerning this epidemic, recent

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**Figure 6:** Damage due to *Gremmeniella abietina* on *Pinus resinosa* in the USA, with kind permission of USDA Forest Service, North Central Research Station (available online at https://www.invasive.org/browse/detail.cfm?imgnum=1406101)
analyses of volume dynamics in some stands indicated a decade-long negative effect of pathogen infections (Wang et al., 2017). Over the years 2000–2012, the difference between projected (assuming no infection) and observed volume growth ranged between 10% and 62%. Height growth of *Pinus sylvestris* in affected stands was reduced by 64–85%. The average reduction in basal area increment in affected areas countrywide, accumulated over 2000–2006, was about 21% for *Pinus sylvestris* and 4% for *Picea abies* (Wang et al., 2017).

In Finland, volume growth in moderately infested *Pinus sylvestris* stands decreased by 22–42%, depending on disease severity (Riihinen and Uotila, 1992).

In a study in the Swiss Alps, a total of about 60% of *Pinus cembra* and about 45% of *Pinus mugo* trees were killed by *G. abietina* during the first 20 years after planting in subalpine stands (Senn, 1999). In another study performed in Switzerland, only 5% of all *Pinus cembra* trees survived to *G. abietina* and *Phacidium infestans* attacks 30 years after planting in two sites at the tree line (Barbeito et al., 2013).

In Sweden, *Pinus contorta* logs with occluded cankers caused by *G. abietina* gave pulp with poor paper properties (Ahlqvist et al., 1996). Thus, wood damaged by *G. abietina* should be separated and classed as low-grade raw material.

### 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 Protected Zones such that the risk becomes mitigated? |
|---|
| **Yes.** Please see section 3.6.3. |

| Is it possible to eradicate the pest in a restricted area within 24 months after the presence of the pest was confirmed in the PZ? |
|---|
| **No.** There is no evidence that eradication can be achieved. |

Hudler and Neal (1990) demonstrated that postharvest treatments (hot water treatment and sodium hypochlorite treatment) led to complete eradication of the pathogen from seedlings.

Bernhold et al. (2006) found that slash removal and piling of infected material were not enough to eradicate infection sources and concluded that burning or complete removal of slash would be needed to reduce inoculum sources further.

Once established in a plantation, the impossibility of control has been stated (EPPO, 1997), although the evidence used in support of this statement is not provided.

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

The pathogen can survive in an endophytic stage for an undetermined period of time (Petrini et al., 1990). Therefore, despite the uncertainty, it might be moved over long distances in infected but asymptomatic plants.

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

- The indeterminate endophytic phase (see above) hinders the ability to promptly identify the presence of the pest on the source material.
- The widespread distribution of the pathogen may lead to infection from conidia or ascospores entering the nursery site of production from surrounding areas.
- Chemical control in nurseries may mask the symptoms, thus resulting in infected asymptomatic plants for planting carrying the pathogen over long distances.

#### 3.6.3. Control methods

- Selection of disease-free planting material.
- Selection of planting sites at some distance from infested plantations.
- Selection of sites suitable for the grown tree species, so as to avoid stress (Nevalainen, 1999; Witzell and Karlman, 2000).
Growing plants for planting in sites characterised by climatic conditions unsuitable or non-conducive for dissemination and infection (e.g. sites not characterised by cool and wet springs and/or by risk of frost damages).

Selection of host provenances with low susceptibility to the pathogen and suitable for the sites and regions where they are grown (Hansson, 1998; Romeralo et al., 2016).

As attacks are favoured by shaded conditions, by dense, badly aerated plantations in which humidity is high, appropriate spacing between plants and thinnings may reduce the risk of infection.

Pruning of the lower half of the crown whorls is recommended in infected plantations less than 20 years old (CABI, 2015 based on Laflamme, 1999).

Delaying pine plantation until after two growing seasons following harvesting of diseased pine trees is recommended (Laflamme and Rioux, 2015).

Slash burning or complete removal of the infected slash is needed to minimise the infection risk (Bernhold et al., 2006).

Treatment with fungicides at the nursery stage (for instance with chlorothalonil, propiconazole and azoxystrobin) applied from May to mid-August (Nef and Perrin, 1999; CABI, 2015).

3.7. Uncertainty

There is uncertainty on the outcome of revising the taxonomic status of the species, given its current intraspecific diversity.

There is some uncertainty on the distribution of G. abietina in the EU, both for MS having reported it (it is uncertain how widespread the pathogen is there) and for the PZ (it is uncertain whether the pathogen is really absent there). Results on PZ annual surveys which report negative findings are not available to the Panel.

There is uncertainty over the host status of hosts not currently regulated, e.g. Cedrus libani.

There is considerable uncertainty on the length of the endophytic stage of the pathogen in host plants, which makes it difficult to reduce the presence of the pest on plants for planting.

It is also unclear whether infected wood with bark could be an effective means of spread of the pathogen, whether disposal of infected rootless Christmas trees could carry the pathogen and whether wood products such as wood chips could provide a means of spread.

4. Conclusions

G. abietina meets the criteria assessed by EFSA for consideration as a potential PZ quarantine pest for the territory of the PZ (Ireland and Northern Ireland) (Table 5).

Table 5: 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 protected zone quarantine pest (articles 32–35) | Panel’s conclusions against criterion in Regulation (EU) 2016/2031 regarding Union regulated non-quarantine pest | Key uncertainties |
|---------------------------------|-------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------|-------------------|
| Absence/presence of the pest in the EU territory (Section 3.2) | *G. abietina* is present in the EU and has been reported from 19 MS The pathogen is listed as 'Absent, confirmed by survey' in both PZ (Ireland and in Northern Ireland) | *G. abietina* is present in the EU and has been reported from 19 MS The pathogen is listed as 'Absent, confirmed by survey' in both PZ (Ireland and in Northern Ireland) | There is some uncertainty on the distribution of *G. abietina* in the EU, including the PZ. This is because the official reports documenting absence go back to 1993 and 2009 |
| Regulatory status (Section 3.3) | *G. abietina* is regulated by Council Directive 2000/29/EC on plants of *Abies, Larix, Picea, Pinus* and *Pseudotsuga*, intended for planting, other than seeds, for Protected Zones (Annex II, Part B) (Ireland and the UK (Northern Ireland)) | *G. abietina* is regulated by Council Directive 2000/29/EC on plants of *Abies, Larix, Picea, Pinus* and *Pseudotsuga*, intended for planting, other than seeds, for Protected Zones (Annex II, Part B) (Ireland and the UK (Northern Ireland)) | None |
| Pest potential for entry, establishment and spread in the EU territory (Section 3.4) | Entry: the pest has been reported from 19 EU MS and could enter the EU PZ Establishment: the pest is already established in 19 EU MS, some of which (e.g. the UK) have a climate similar to the one found in the PZ (Ireland and Northern Ireland) Spread: the pest would be able to spread within the PZ of the EU following establishment, via airborne ascospores, rain-splashed conidia, infected plants for planting, Christmas trees and, possibly, wood with bark | The pathogen can be spread by plants for planting, but also via airborne ascospores and rain-splashed conidia | There is uncertainty over: the host status of hosts not currently regulated, e.g. *Cedrus libani* whether infected wood with bark could be an effective means of spread of the pathogen whether disposal of infected rootless Christmas trees could carry the pathogen and whether wood products such as wood chips could provide a means of spread |
| Potential for consequences in the EU territory (Section 3.5) | Given that *G. abietina* is most damaging to species that are grown towards the limit of their range, and given that the PZ are outside of the native range of the main hosts of the pathogen (*Picea abies* and *Pinus sylvestris*), which are nonetheless planted in the PZ, impact can be expected in the PZ, if the pathogen is introduced there | *G. abietina* could be of economic importance on the use of plants for planting in the EU MS where it is reported because of the requirement for nurseries producing for the PZ to be certified as pest-free | Differential responses of the different hosts to the different biotypes of *G. abietina* |
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| Criterion of pest categorisation | Panel’s conclusions against criterion in Regulation (EU) 2016/2031 regarding protected zone quarantine pest (articles 32–35) | Panel’s conclusions against criterion in Regulation (EU) 2016/2031 regarding Union regulated non-quarantine pest | Key uncertainties |
|----------------------------------|-------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------|------------------|
| Available measures (Section 3.6) | Selection of disease-free planting material, selection of planting sites at some distance from infested plantations, appropriate spacing between plants and thinning may reduce the risk of infection | Nursery inspections to ensure plantations or landscape plantings are not made with infected stock | The indeterminate endophytic stage makes the effectiveness of the available measures uncertain |
| Conclusion on pest categorisation (Section 4) | The criteria assessed by the Panel for consideration as potential PZ quarantine pest are met | The criterion on plants for planting as main pathway for spread is not met, as plants for planting are only one of the means of spread of the pathogen | |
| Aspects of assessment to focus on/ scenarios to address in future if appropriate | Intraspecific variation and distribution of the different biotypes, with regard to the potential introduction of the North American and/or Asian race and the movement of biotypes of the European race within the EU | | |
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**Abbreviations**

- CLC: Corine Land Cover
- EPPO: European and Mediterranean Plant Protection Organization
- EU MS: European Union Member State
- EUGFIS: 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
- LTT: large tree type
- PLH: EFSA Panel on Plant Health
- PZ: protected zone
- RA: risk assessment
- RNQP: regulated non-quarantine pest
- RPP: relative probability of presence
- RRO: risk reduction option
- SMFA: spatial multiscale frequency analysis
- STT: small tree type
Appendix A – Methodological notes on Figures 4 and 5

The relative probability of presence (RPP) reported here for Pinus spp. and Picea spp. in Figures 4 and 5 and in the European Atlas of Forest Tree Species (De Rigo et al., 2016; San-Miguel-Ayanz et al., 2016) is the probability of those genera 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).

A.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 as activity 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/).

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 ~375,000 sample points with a spatial resolution of 1 km²/pixel, covering 21 European countries (de Rigo et al., 2014, 2016, 2017).

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. 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.

A.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.

A.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 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.

4 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.
A.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 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 (1 km²) and filtered to a study area that comprises 36 countries in the European continent. The density of field observations varies greatly throughout the study area and large areas are poorly covered by the plot databases. A low density of field plots is particularly problematic in heterogeneous landscapes, such as mountainous regions and areas with many different land use and cover types, where a plot in one location is not representative of many nearby locations (de Rigo et al., 2014). To account for the spatial variation in plot density, the model used here (C-SMFA) considers multiple spatial scales when estimating RPP. Furthermore, statistical resampling is systematically applied to mitigate the cumulated data-driven uncertainty.

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

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

The probability to find a single species (e.g. a particular coniferous tree species) in a 1 km² grid cell cannot be higher than the probability of presence of all the coniferous species combined. The same logical constraints applied to the case of single broadleaved species with respect to the probability of presence of all the broadleaved species combined. Thus, to improve the accuracy of the maps, the preliminary RPP values were constrained so as 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 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, 2017).

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.