SCIENTIFIC OPINION

Risk assessment of *Gibberella circinata* for the EU territory and identification and evaluation of risk management options[1]

EFSA Panel on Plant Health (PLH)[2, 3]

European Food Safety Authority (EFSA), Parma, Italy

ABSTRACT

The Panel on Plant Health was asked to provide a risk assessment for *Gibberella circinata* Nirenberg and O'Donnell, for the EU territory, and to identify and evaluate effectiveness of risk management options in reducing the risk posed by the organism. *G. circinata* is presently not listed in Council Directive 2000/29/EC. Outbreaks of the organism have been reported in EU (in Spain, Italy, France and Portugal). The risk assessment indicates that, in parts of the European Union, there is risk of pitch canker affecting the host species (pine and Douglas-fir). Entry into and spread within the European Union are considered very likely. The organism has a very high potential for establishment. The following pathways for entry have been identified: contaminated seed and other propagation material, different forms of wood material, plant material for decorative purposes, soil and growing substrates, natural means (wind, wind-blown rain, insects and other animals carrying spores) and human activities. Based on host distribution and climatic conditions, the potentially endangered areas include wide areas of central and northern Portugal, northern and eastern Spain, south and coastal areas of France, coastal areas of Italy and parts of the coastal areas of Greece. In these areas, pine forests, including plantations and native forest, cover over 10 million hectares. Host species are also widely used as ornamentals. The potential consequences of pitch canker in the endangered areas are considered massive. At present there is no single means of controlling pitch canker. Consequently, an integrated disease management approach, which combines appropriate nursery and silvicultural practices, should be used to reduce the impact of the disease. The current legislation, including the provisional emergency measures (Commission Decision 2007/433/EC), is aimed at limiting the introduction of the organism but it may have only a limited effect on its spread.

KEY WORDS

EU territory, *Fusarium circinatum*, *Gibberella circinata*, management options, *Pinus* spp. and *Pseudotsuga menziesii*, pitch canker disease, risk assessment.

---

1 On request from the European Commission, Question No EFSA-Q-2009-00678, adopted on 11 May 2010.

2 Panel members: Richard Baker, Thierry Candresse, Erzsébet Dormannsné Simon, Gianni Gilioli, Jean-Claude Grégoire, Michael John Jeger, Olia Evtimova Karadjova, Gábor Lövei, David Makowski, Charles Manceau, Maria Navajas, Angelo Porta Puglia, Trond Rafoss, Vittorio Rossi, Jan Schans, Gritta Schrader, Gregor Urek, Johan Coert van Lenteren, Irene Vloutoglou, Stephan Winter and Marina Zlotina. Correspondence: PLH@efsa.europa.eu

3 The Panel wishes to thank the members of the Working Group on *Gibberella circinata* for the preparation of this opinion: Erzsébet Dormannsné-Simon, Josep Armengol Forti, Tom Gordon, David Makowski, Angelo Porta Puglia, Trond Rafoss, Vittorio Rossi, Jan Schans, and Irene Vloutoglou. Acknowledgement is given to the external experts György Csóka and Rebecca Ganley, and EFSA"s staff members Virág Kertész, Sybren Vos and Olaf Mosbach-Schulz for the support provided to this EFSA scientific output.

Suggested citation: EFSA Panel on Plant Health (PLH): Risk assessment of *Gibberella circinata* for the EU territory and identification and evaluation of risk management options. EFSA Journal 2010; 8(6):1620. [93 pp.]. doi:10.2903/j.efsa.2010. Available online: www.efsa.europa.eu

© European Food Safety Authority, 2010

SUMMARY

Following a request from the European Commission, the Panel on Plant Health was asked to deliver a scientific opinion on the risk posed by *Gibberella circinata* Nirenberg and O'Donnell to the EU territory. It was asked to identify risk management options and to evaluate their effectiveness in reducing the risk to plant health posed by this organism.

Pitch canker disease, caused by the pathogen *G. circinata*, is among the most devastating diseases in the world to affect the pine species. *G. circinata* is presently not listed as a harmful organism in Council Directive 2000/29/EC[4]. However, a preliminary pest risk assessment carried out in 2000 by the French Plant Protection Service showed that the potential for establishment of this fungus in the EU may be considered high. In 2007, the Commission adopted provisional emergency measures to prevent the introduction into and the spread within the Community of *G. circinata* (Commission Decision 2007/433/EC[5]). Since then, outbreaks of the organism have been reported in EU.

The Panel conducted the risk assessment following the general principles of the Guidance for harmonized framework for pest risk assessment in the EU[6], and without considering the existing plant health legislation. A rating system of five levels with their respective descriptors has been developed to formulate conclusions, separately for entry, establishment, spread, impact, as well as for risk management options. CLIMEX simulations have been used to assess the establishment potential of the organism within the European Union. Risk and pest management options were identified considering all the pathways. The risk management options were then evaluated for their effectiveness, separately for entry, spread and for preventing or reducing infestation.

After consideration of the evidence, the Panel reached the following conclusions:

- In parts of the European Union, there is risk of host species (*Pinus* spp. and *Pseudotsuga menziesii*) being affected by pitch canker disease.

- The Panel considers entry into the European Union very likely. The pathways for new entry into the EU territory are contaminated propagation material (mainly seed), different forms of wood material (saw logs, timber, lumber, wood chips, dunnage, pallets, packaging material, fire wood, etc.), plant material for decorative purposes (Christmas trees, branches, cones, etc.), soil and growing substrates, natural means (wind, wind-blown rain, insects and other animals carrying spores) and human activities (including travellers, silvicultural machinery, vehicles, etc.).

  The application of regulatory measures for the import consignments which pose a risk seems to be the most effective risk management option for reducing the probability of entry.

  The provisional emergency measures (Commission Decision 2007/433/EC) include specific import requirements for plants of the genus *Pinus* and the species *Pseudotsuga menziesii*, intended for planting, including seeds and cones for propagation purposes. Taking into account the above-mentioned regulation, the probability of entry by this pathway is considered moderately likely.

  The Council Directive 2000/29/EC prohibits the introduction of the plants of *Pinus* and *Pseudotsuga* other than fruit and seed from non-European countries in all Member States. This measure may be highly effective in reducing probability of entry of *G. circinata* by means of this pathway. However, fresh Christmas trees and fresh conifer branches are imported into the European Union.

  The Council Directive 2000/29/EC requires that the isolated bark of conifers originating from non-European countries is subjected to an appropriate fumigation or has undergone an appropriate heat

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

[5] Commission Decision 2007/433/EC of 18 June 2007 on provisional emergency measures to prevent the introduction into and the spread within the Community of *Gibberella circinata* Nirenberg & O'Donnell. OJ, L.161, 22.6.2007, p.66.

[6] EFSA Panel on Plant Health (PLH), 2010. Guidance on a harmonised framework for pest risk assessment and the identification and evaluation of pest risk management options. EFSA Journal, 8(2):1495.

treatment. Council Directive 2000/29/EC also requires that all wood packaging material is debarked or undergoes phytosanitary treatments. Also Commission Decision 2006/133/EC[7] requires that wood packaging materials (and dunnage) are subjected to heat treatment or fumigation. Heat treatment of wood packaging materials and isolated bark of conifers is likely to reduce or eliminate *G. circinata*, while effectiveness of fumigation will depend on the fumigant and on the method of fumigation (no data specific for *G. circinata* are available for effectiveness of fumigation).

The Council Directive 2000/29/EC prohibits the introduction of soil and growing medium as such in all Member States. Third countries exporting to the EU are required to provide an official document stating that the growing medium is either free from soil (and organic matter), free from harmful organisms, or that it has been subjected to appropriate heat treatment or fumigation. The Directive ensures that *G. circinata* does not enter in the European Union through soil and growing media containing pine bark.

- The Panel considers the probability of establishment of *G. circinata* in the European Union as very likely based on the following evidence:
  - the pathogen has been reported at some locations in the European Union, in Spain, Italy, France and Portugal;
  - hosts are present: *Pinus* spp. are widely present in the European Union, while *Pseudotsuga menziesii* has scattered distribution only; and
  - climate conditions are suitable in parts of the European Union.

  According to the CLIMEX analysis, and considering all the areas where host plants are grown in the European Union, the endangered areas include:
  - wide areas of central and northern Portugal;
  - northern and eastern Spain;
  - south and coastal areas of France;
  - coastal areas of Italy; and
  - parts of the coastal areas of Greece.

  In these areas no limitations to establishment have been identified.

  On managed stands, cultural practices can potentially influence the ability of *G. circinata* to establish; they can modify the environment, making conditions more favourable for disease development, and/or can open wounds by handling the trees, which then serve as infection sites for the pathogen. Since there seem to be no major differences in the cultural practices used in the current area of pest distribution outside the EU compared to the ones currently applied in the European Union, their influence on establishment is comparable.

- The Panel considers spread within the European Union very likely. Wind, rain and wind-related events can create wounds on host plants and spread *G. circinata* spores in the territory of European Union. Moreover, insects have been identified as potential wounding agents, vectors and carriers of the pathogen, therefore favouring spread of the disease. In addition, there are no natural barriers to prevent propagules of the pathogen or insects carrying the pathogen to spread from an infested area to a non infested area. Commodities composed of host plant species material are widely spread and traded. Travellers, tourists, forest visitors for recreational activities are numerous. Contaminated machinery used in forests may also contribute to spread, unless properly sanitised.

  In order to reduce the probability of spread of the pathogen, the Panel considers that the establishment and proper application of requirements limiting the movement of seed, living plant

[7] Commission Decision 2006/133/EC of 13 February 2006 requiring Member States temporarely to take measures against the dissemination of *Bursaphelencus xylophilus* (Steiner et Buhrer) Nickle et al. (the pine wood nematode) as regards areas in Portugal, other than those in which it is known not to occur. OJ L 52, 23.2.2006, p. 34.

material, wood, soil, used machinery, vehicles from infested to non-infested areas within the EU is the most effective risk management option. The emergency measures (Commission Decision 2007/433/EC) define conditions for movement of all the specified plants originating in the Community (i.e. an accompanying plant passport), but do not consider the other means of spread. Though plant material for propagation purposes is the most important pathway, the other pathways should not be disregarded.

The Commission Decision 2007/433/EC imposes the delineation of demarcated areas including a buffer zone with a boundary of at least one kilometre beyond the infected zone. Appropriate measures aimed at eradicating *G. circinata* and intensive monitoring for the presence of the organism have to be considered within the demarcated areas. Based on the natural spread of the pathogen, the Panel considers this boundary insufficient. However, in order to determine this boundary precisely, more detailed studies are required. With regards to eradication, there is evidence concerning its effectiveness, though uncertainty exists because some foci are still under eradication and/or the monitoring period after eradication is too short for excluding that some infections are still latent.

Containment of the pathogen and maintenance of pest-free areas, places of production and production sites seem to be insufficient to ensure pest freedom in infested areas, as there is no practical way of preventing natural dispersal of the pathogen.

- The Panel estimates the potential impact of pitch canker in the endangered areas massive. In these areas, the pathogen can be expected to cause pitch canker epidemics mainly in nurseries and managed stands, and less frequently in native pine stands. The most important potential impacts include tree mortality, reduced growth, reduced lumber quality, reduced cone yield, seed contamination in seed orchards, and seedling mortality in nurseries. In addition, pitch canker can reduce recreational uses, tourism, and aesthetic amenity of the affected forests as well as parks and gardens. The pine plantations and forests in the endangered areas cover over 10 million hectares. Pine species and Douglas-fir are also widely used as ornamentals throughout the endangered areas.

  The uncertainty of the potential consequences is high, no precise data on impact and suitability of the environment being available in the European Union. Therefore the Panel considers very important to conduct surveillance of pitch canker in the EU territory.

  At present, no integrated disease management approach is in place for pitch canker, but combining appropriate nursery and silvicultural practices could reduce the impact of the disease. This approach is expected to be more effective in nurseries than in plantations and forests.

TABLE OF CONTENTS

BACKGROUND AS PROVIDED BY DG SANCO EUROPEAN COMMISSION

The current Community plant health regime is established by Council Directive 2000/29/EC on protective measures against the introduction into the Community of organisms harmful to plants or plant products and against their spread within the Community (OJ L 169, 10.7.2000, p.1).

The Directive lays down, amongst others, the technical phytosanitary provisions to be met by plants and plant products and the control checks to be carried out at the place of origin on plants and plant products destined for the Community or to be moved within the Community, the list of harmful organisms whose introduction into or spread within the EU is prohibited and the control measures to be carried out at the outer border of the Community on arrival of plants and plant products.

Gibberella circinata Nirenberg and O'Donnell (Kingdom: Fungi; Phylum: Ascomycota, Class: Sordariomycetes; Order: Hypocreales; Family: Nectriaceae; anamorph: *Fusarium cicinatum* Nirenberg and O''Donnell; synomym: *Fusarium subglutinans f. sp. pini*), the casual agent of pine pitch canker, is presently not listed as a harmful organism in Council Directive 2000/29/EC. However, a preliminary pest risk assessment carried out in 2000 by the French Plant Protection Service has demonstrated that it can cause significant mortality on *Pinus* spp. and tree damage on *Pseudotsuga menziesii*. Several of the described Pinus host species grow to a substantial extent in the EU and insects that could act as potential vectors are also present. The known geographic distribution of this pathogen includes ecoclimatic zones comparable with those in the EU. Therefore, the establishment potential of this fungus in the EU was considered to be high.

Consequently, the Commission adopted in 2007 provisional emergency measures to prevent the introduction into and the spread within the Community of *Gibberella circinata* Nirenberg and O'Donnell (Commission Decision 2007/433/EC of 18 June 2007). The measures provided for in this Decision apply to the introduction or the spread of this organism, the demarcation of infested areas within the Community and its control in these areas, the import, production and movement of plants of the genus *Pinus* L. and the species *Pseudotsuga menziesii*, including seeds, within the Community, and a survey for the presence or continued absence of the specified organism in the Member States. So far outbreaks of *Gibberella circinata* Nirenberg and O'Donnell have been reported from three Member States (France, Portugal and Spain).

Provisional emergency measures against a plant harmful organism adopted by the Commission are meant to be, as indicated by their name, temporary measures put in place against an imminent danger of introduction into or spread within the Community of that harmful organism. Based on the experience gained from the application of these measures over a period of time a decision will be taken whether permanent measures are needed (and what type of measures).

At the last review of the emergency measures within the meeting Standing Committee on Plant Health of March 2009 some Member States indicated that they would welcome the start of the discussions on the need to take permanent measures against *Gibberella circinata* Nirenberg and O'Donnell. For that purpose there is a need for a pest risk analysis that takes into account the latest scientific and technical knowledge of this organism as well as its present distribution in the EU territory and the experience gained from the implementation of the provisional emergency measures.

TERMS OF REFERENCE AS PROVIDED BY DG SANCO EUROPEAN COMMISSION

EFSA is requested, pursuant to Article 29(1) and Article 22(5) of Regulation (EC) No 178/2002, to provide a pest risk assessment of *Gibberella circinata* Nirenberg and O'Donnell, to identify risk management options and to evaluate their efficiency in reducing the risk to plant health posed by this organism. In dealing with the impacts it would be sufficient to describe these in biological and agronomic terms, such as yield and quality impacts, etc. The area to be covered by the requested pest risk assessment is the EU territory.

ASSESSMENT

1. Introduction

1.1. Purpose

This document presents a pest risk assessment prepared by the Panel on Plant Health for *Gibberella circinata* Nirenberg and O'Donnell, in response to a request from the European Commission. The risk assessment area is the territory of the European Union (EU 27), and the opinion includes identification and evaluation of risk management options in terms of their effectiveness in reducing the risk posed by the organism.

A preliminary pest risk analysis for *G. circinata* prepared by the French Plant Protection Service (Chandelier, 2000) has been performed covering the EU 12. Being the starting point of this risk assessment, this document has been analysed and considered, but update is required and the risk assessment area is enlarged to the EU 27.

1.2. Scope

This risk assessment covers the host species of the pathogen that are present in the European Union, namely *Pinus* spp. (detailed in section 3.1.4.) and *Pseudotsuga menziesii*.

2. Data and methodology

2.1. Data used in the risk assessment

Literature searches were performed consulting several sources such as ISI web of Knowledge database including Web of Science, Current Content Connect, CABI CAB Abstracts, Food Science and Technology Abstracts and Journal Citation Reports. Web pages specific to the pine pitch canker disease of national authorities were consulted. Other searches on the Internet were also carried out.

Among the documents that were consulted to support the risk assessment activity, peer reviewed publications and technical reports from national authorities were included.

The data used in this work concerning locations in the European Union where *G. circinata* was reported are presented in Appendix 2. The data used in the climate matching activity with CLIMEX have been retrieved from the 2007 and 2008 annual survey results for the presence of *G. circinata* or for evidence of infestation from the Member States provided by the European Commission. The results of the 2009 survey were considered in the opinion but not included in the climate matching activity, since the data were provided shortly before the end of the compilation of the opinion. The EPPO reporting services have also been consulted.

With regards to the host distribution in the EU territory, the data on dominance of tree species from the Joint Research Centre in ISPRA are compiled in a map (JRC, 2009a). Methods for mapping are detailed in JRC (2009b).

In order to analyse the probability of entry and spread of the organism in the EU, trade movements within the EU for the relevant pathways were analysed, using the EUROSTAT database. A search was performed for all categories of pine wood and pine seed to retrieve Extra EU 27 and EU 27 trade data since 1999 until 2008. These results are referenced as EUROSTAT 2008a. The database was also consulted to retrieve data of imports and exports of saw logs and veneer logs from pine species, this dataset is referenced as EUROSTAT 2008b.

2.2. Methodology

2.2.1. The Guidance document

The risk assessment has been conducted in line with the principles described in the document "Guidance on a harmonised framework for pest risk assessment and the identification and evaluation of pest risk management options" (EFSA Panel on Plant Health, 2010).

The scheme used to conduct the risk assessment is presented in the Guidance document, and has been followed in order to consider all the elements required for the pest risk assessment.

When expert judgement and/or personal communication were used, justification and evidence are provided to support the statements.

2.2.2. Conclusions of the risk assessment

The Panel conducted the risk assessment without considering the existing plant health legislation. The effectiveness of the current measures in place – specific or not to the pathogen – are evaluated under the Management Options section.

The conclusions for entry, establishment, spread and impact are presented separately.

The ratings in the conclusions are made in accordance with specific descriptors that have been developed for this opinion as described in the Appendix 1.

The risk elements have not been rated separately and no combinations of ratings have been performed.

2.2.3. Evaluation of the management options

When evaluating the effectiveness of the risk management options to reduce the level of risk, the Panel used the ratings and descriptors that were developed in this opinion for *G. circinata* as described in Appendix 1.

2.2.4. Level of uncertainty

For the risk assessment conclusions on entry, establishment, spread and impact and for the evaluation of the effectiveness of the management options, the levels of uncertainty have been rated separately in accordance with the descriptors that have been defined by the Panel in this opinion for *G. circinata*.

2.2.5. Climate matching

CLIMEX ™ (Sutherst and Maywald, 1985) has been used to assess the climatic suitability of the European Union territory for establishment of the pathogen. The "compare locations" technique of CLIMEX predicts an organism‟s potential distribution based on the climatic conditions in its current distribution, and if available, climatic responses obtained by research. A growth index, which represents the suitability of the location for growth and development, is calculated according to how close temperatures, moistures and day lengths are to the organism‟s known responses to these factors. For fungal diseases the CLIMEX annual growth index describes the potential for population growth of the host and fungus as a function of soil moisture and temperature during favourable conditions. In the unfavourable periods, a stress index is estimated according to the degree to which the climate is too wet, dry, hot, or cold. The overall suitability of the location is represented by the Ecoclimatic Index (EI), formed by the product of these two indices. The EI ranges from 0 for locations at which the species is not able to persist to 100 for locations which are optimal for the species. In the present risk assessment the classification of EI into marginal (EI = 1-5), suitable (EI = 6-25) and optimal (EI > 25) categories follows Kriticos et al. (2003a,b). The parameter values used to describe climate responses of the organism in the CLIMEX analysis are presented in Table 1.

Table 1: Parameters and values used in the CLIMEX analysis (Ganley et al., 2009)

Index	Parameter	Meaning	Parameter values	Units[a]
Temperature	DV0	Limiting low temperature	10	ºC
	DV1	Lower optimum temperature	18	ºC
	DV2	Upper optimum temperature	24	ºC
	DV3	Limiting high temperature	31	ºC
Moisture	SM0	Limiting low soil moisture	0.3	
	SM1	Lower optimum soil moisture	1	
	SM2	Upper optimum soil moisture	1.5	
	SM3	Limiting high soil moisture	2	
Cold stress	TTCS	Temperature threshold	1ºC	
	THCS	Stress accumulation rate	-0.001	week-1
	DTCS	Min. degree-day cold stress threshold	15ºC	days
	DHCS	Degree-day cold stress rate	-0.00027	week-1
Wet stress	SMWS	Wet stress threshold	2	
	HWS	Wet stress rate	0.002	week-1
Dry stress	SMDS	Dry stress threshold	0.3	
	HDS	Dry stress rate	-0.005	week-1
Hot-Wet stress	TTHW	Hot wet temperature threshold	30	ºC
	MTHW	Hot wet soil moisture threshold	1.4	
	PHW	Stress accumulation rate	0.003	week-1
Hot-Dry stress	TTHD	Hot dry temperature threshold	29	ºC
	MTHD	Hot dry soil moisture threshold	0.3	
	PHD	stress accumulation rate	0.05	week-1
Annual Heat Sum	PDD	degree-day threshold[b]	1150	ºC days

(a)Values without units are dimensionless index of a 100 mm single bucket soil moisture profile
(b)Minimum annual total number of degree-days above DV0 needed for population persistence

3. Risk assessment

3.1. Pest characterisation

3.1.1. Identity of the pest

Scientific name

Gibberella circinata Nirenberg and O'Donnell 1998 (teleomorph)
Fusarium circinatum Nirenberg and O'Donnell 1998 (anamorph)

Common name of the disease caused by the pathogen

Pine pitch canker, Pitch canker of pine

Other scientific names

Fusarium lateritium f.sp. *pini* [anamorph] Snyder et al.
Fusarium subglutinans f.sp. *pini* [anamorph] J.C. Correll et al.
Fusarium moniliforme var. *subglutinans* [anamorph] Wollenw. and Reinking
Fusarium subglutinans [anamorph] (Wollenw. and Reinking) P.E. Nelson et al.
Gibberella fujikuroi var. *subglutinans* [teleomorph] E.T. Edwards
Gibberella subglutinans [teleomorph] (E.T. Edwards) P.E. Nelson et al.
Gibberella baccata f.sp. *pini*

Taxonomic position

Fungi-Ascomycota-Hypocreales-Gibberella (teleomorph)
Fungi-Mitosporic fungi-Tuberculariales-Fusarium-section *Liseola* (anamorph)

Even if it is possible to distinguish *Fusarium circinatum* from other entities by its morphology (especially the anamorph) (Leslie et al., 2006), the identification of the pathogen using molecular characterisation is more reliable (Correll et al., 1992; Viljoen et al., 1997; Ioos et al., 2009; EPPO, 2009a; Britz et al., 2002) (see section 3.1.7).

Pine pitch canker was first reported by Hepting and Roth (1946) on *Pinus* species from North Carolina, USA and the related pathogen was identified as a *Fusarium* species (Section *Liseola*). Later it was defined as *Fusarium lateritium* (Nees) and based on host specificity designated as *F. lateritium* (Nees) emend. Snyder and Hansen f. sp. *pini* Hepting, Section Lateritium (Snyder et al, 1949). Then the pathogen was defined as *F. moniliforme* var. *subglutinans* (Section *Liseola*), based on microconidia production in culture. It was also found that the teleomorph was cross-fertile with isolates of *Gibberella fujikuroi* var. *subglutinans* (Kuhlman et al., 1978). Then *F. moniliforme* var. *subglutinans* was included into *F. subglutinans* and – based on pathogenicity studies - isolates pathogenic only to pines were designated as *F. subglutinans* f. sp. *pini* (Correll et al., 1991). Nirenberg and O'Donnell (1998) described the pine pitch canker fungus as a member of the *Gibberella fujikuroi* complex, which corresponds with the section *Liseola* of *Fusarium* (O'Donnell et al., 1998). Diversity and evolution of *Fusarium* in this complex was studied in detail by Kvas et al. (2008). Britz et al. (1999) categorised *F. subglutinans* f. sp. *pini* as mating population H in the *Gibberella fujikuroi* complex. Initially, the fungus was assigned to mating population B (Kuhlman, 1982), but crosses with B tester strains failed in later studies (Correll et al., 1992; Viljoen et al., 1994). As a next step, based on mating studies the pathogen was classified by Nirenberg and O'Donnel (1998) as *F. circinatum* (teleomorph *G. circinata*). Several molecular studies confirmed the description (Correll et al., 1992; O'Donnell et al., 1998; Viljoen et al., 1997). Detailed validation of the description and characterisation of the pathogen was later provided by Britz et al. (2002) and Ioos et al. (2009).

3.1.2. Risk assessment area

The risk assessment area is the territory of the European Union (EU 27).

3.1.3. Occurrence

3.1.3.1. In the risk assessment area

G. circinata has been reported in both nurseries and forests in several countries in the European Union. The locations of occurrence have been retrieved from the 2007 and 2008 annual survey results for the presence of *G. circinata* or for evidence of infestation of the Member States provided by the European Commission (2007, 2008) are listed in Appendix 2.

Moreover, in the European Union, *G. circinata* has been reported through other sources, namely in Spain (Landeras et al., 2005; EPPO, 2005a, 2005b, 2006a, 2007), Italy (Carlucci et al., 2007; EPPO, 2008a, 2009b), France (EPPO, 2006b, 2008b, 2009c, 2010) and Portugal (Bragança et al., 2009; EPPO, 2009d). As illustrated in Figure1, occurrence of the pathogen prevails in coastal areas.

Figure 1: Reports of occurrence of *G. circinata* in the European Union (nurseries, plantations or native forests) according to data retrieved until end 2009

3.1.3.2. Outside the risk assessment area

Presence of *G. circinata* outside the European Union is presented in Table 2.

Table 2: Presence of *G. circinata* based on an extract from CAB International (2007)

Location	Status
North America	
Mexico	present
USA	restricted distribution
Alabama	present
Arkansas	present
California	present
Florida	present
Georgia (USA)	present
Indiana	present
Louisiana	present
Massachusetts	absent, unreliable record
Mississippi	present
North Carolina	present
South Carolina	present
Tennessee	present
Texas	present
Virginia	present
Washington	absent, unreliable record

Location	Status
Central America	
Haiti	present
Honduras	absent, unreliable record
South America	
Chile	restricted distribution
Asia	
Iraq	Present
Japan	Present
Kyushu	Present
Ryukyu Archipelago	widespread
Philippines	absent, unreliable record
Africa	
South Africa	Present
Tanzania	absent, unreliable record
Oceania	
Australia	absent, unreliable record

3.1.4. Host plants

The host range of *G. circinata* is listed in CAB International (2007) and includes *Pinus elliottii* (slash pine), *Pinus palustris* (longleaf pine), *Pinus patula* (Mexican weeping pine), *Pinus radiata* (radiata pine), *Pinus taeda* (loblolly pine), *Pinus virginiana* (scrub pine), *Pinus arizonica* (arizona pine), *Pinus attenuata* (knobcode pine), *Pinus ayacahuite* (Mexican white pine), *Pinus canariensis* (Canary pine), *Pinus cembroides* (Mexican pine), *Pinus clausa* (sand pine), *Pinus contorta* (lodgepole pine), *Pinus coulteri* (big-cone pine), *Pinus densiflora* (Japanese umbrella pine), *Pinus discolor* (border Pinyon pine), *Pinus douglasiana* (Douglas pine), *Pinus durangensis* (Durango pine), *Pinus echinata* (shortleaf pine), *Pinus estevezii*, *Pinus glabra* (spruce pine), *Pinus greggii* (Gregg's pine), *Pinus halepensis* (Aleppo pine), *Pinus hartwegii* (Hartweg pine), *Pinus leiophylla* (smooth-leaved pine), *Pinus luchuensis* (luchu pine), *Pinus maximinoi* (thin-leaf pine), *Pinus michoacana* (Michoacan pine), *Pinus montezumae* (Montezuma pine), *Pinus muricata* (bishop pine), *Pinus oaxacana*, *Pinus occidentalis* (Haitian pine), *Pinus oocarpa* (ocote pine), *Pinus pinaster* (maritime pine), *Pinus pinea* (stone pine), *Pinus ponderosa* (ponderosa pine), *Pinus pringlei*, *Pinus pseudostrobus* (pseudostrobus pine), *Pinus pungens* (Tabel Mountain pine), *Pinus rigida* (pitch pine), *Pinus sabiniana* (bull pine), *Pinus serotina* (pond pine), *Pinus strobus* (eastern white pine), *Pinus sylvestris* (Scots pine), *Pinus thunbergii* (Japanese black pine), *Pinus torreyana* (Torrey pine), *Pseudotsuga menziesii* (Douglas-fir).

In the European Union, the following species of the above *taxa* can be found:

Pinus banksiana (jack pine), *Pinus brutia* (brutian pine), *Pinus contorta* (lodgepole pine), *Pinus densiflora* (Japanese umbrella pine), *Pinus halepensis* (Aleppo pine), *Pinus nigra* (black pine), *Pinus pinaster* (maritime pine), *Pinus pinea* (stone pine), *Pinus radiata* (radiata pine), *Pinus roxburghii* (chir pine), *Pinus strobus* (eastern white pine), *Pinus sylvestris* (Scots pine), *Pinus thunbergii* (Japanese black pine), *Pinus wallichiana* (blue pine), *Pinus mugo* (dwarf mountain pine), *Pinus canariensis* (Canary Island pine) and *Pseudotsuga menziesii* (Douglas-fir) (host species reports from CAB International, 2007)

The pathogen has been found on the host species and in the Member States as listed in Table 3.

Table 3: Host species and Member States where *G. circinata* has been found

Species	Member State	Reference
Pinus halepensis	Italy	Carlucci et al., 2007
Pinus nigra	Spain	Pérez-Sierra et al., 2007
Pinus pinaster	Spain Portugal	Landeras et al., 2005 Bragança et al., 2009
Pinus pinea	Spain Italy	Armengol (personal communication) Carlucci et al., 2007
Pinus radiata	Spain Portugal	Landeras et al., 2005 Bragança et al., 2009
Pinus sylvestris	Spain	Perez-Sierra et al., 2007
Pseudotsuga menziesii	France	EPPO, 2009c

Pseudotsuga menziesii is not a native species in the European Union, and is mainly found in plantations, parks and gardens, with a scattered distribution only. The surface of *Pinus* spp. in the Members States having areas endangered by *G. circinata* is shown in Table 4.

Table 4: Pine species in countries having areas endangered by G. circinata

Area (1000 hectares)	*Pinus* spp.	Source
Spain	5774	MMA, 2002.
France	2010	IFN, 2008.
Portugal	794	IFN, 2005.
Italy	2014 (all conifers)	INFC, 2005.
Greece	879	GDFNE, 1992.
Total	11471	

3.1.5. Biology and life cycle of the pitch canker pathogen

G. circinata is an ascomycete, which was originally described as an anamorphic species (*F. circinatum*). In nature *G. circinata* is known to propagate only asexually, through production of two types of mitospores: microconidia and macroconidia. Macroconidia are typically three-septate, with walls that are slightly curved, an apical cell that narrows to an inwardly (i.e. toward the ventral side) curved tip, and a foot-shaped basal cell. Microconidia are usually single-celled but may be septate, and ovoid to nearly oval in shape. Microconidia are borne in false heads on aerial polyphialides. Both spore types are borne in a viscous liquid and appear better suited to dispersal by splashing water or attachment to motile organisms than aerial dispersal. However, both can become airborne and are presumably the primary propagules recovered by air sampling in areas where pitch canker is found (Correll et al., 1991). *G. circinata* is also capable of producing perithecia, which contain meiotically derived spores (ascospores). Perithecia have not been observed in nature, but are readily produced on culture media on which they are dark purple to black in colour and ovoid to obpyriform in shape. At maturity, ascospores ooze out of the ostiole and, like mitospores, they appear unsuited to airborne dissemination. Assessments of the population structure of *G. circinata* are generally consistent with a predominance of asexual propagation (Gordon et al., 1996) but high levels of diversity in some areas may indicate a recent history of outcrossing (Wingfield et al., 2008).

Conidia of *G. circinata* germinate over a wide range of temperatures; very slowly at 5 °C and progressively faster, up to an optimum, between 20 and 25 °C. Mycelial growth is favoured by temperatures above 10 °C, with an optimum near 25 °C (Inman et al., 2008). Whereas *G. circinata* can grow on various artificial media, under natural conditions it has not been shown to colonize any substrate other than a living host (*Pinus* spp. or *Pseudotsuga menziesii*) (Gordon et al., 2006). *G. circinata* infects wounds on susceptible trees of any age (Aegerter and Gordon, 2006; Gordon et al., 2001). If a wound is not deep enough for the pathogen to reach water within host tissues, ambient moisture or very high relative humidity is required for spore germination. The pathogen has been observed to produce both microconidia and macroconidia on infected host tissues.

3.1.6. Epidemiology of pitch canker

Pitch canker results from infection of a susceptible host plant species by *G. circinata*. The disease cycle of pitch canker is illustrated in Figure 2. The infective propagules are most likely either microconidia or macroconidia. These spores may be disseminated by wind or by insects to which spores can adhere. Various pine-associated insects can acquire the pathogen by breeding in pitch canker-killed branches. Although insects tend to avoid resin-impregnated infected tissue, they can colonise dead and dying tissue distal to the girdling lesion (Storer et al., 2002a). Contact with pathogen propagules seems to occur only after insects emerge from a gallery, and a large percentage of insects reared from intact infected branches carry the pathogen (McNee et al., 2002). In areas where pitch canker occurs, *G. circinata* can be recovered from twig beetles (*Pityophthorus* spp.) and engraver beetles (*Ips* spp.) at varying frequencies, with some indications of seasonal variation (Storer et al., 2004; Erbilgin et al., 2008). A mode of transmission of the pitch canker pathogen is through feeding activities of insects that either vector the pathogen or create wounds through which the pathogen can enter the tree (Storer et al., 2004). These and other insects may also act only as wounding agents, favoring infection where fungal propagules are already present on host surfaces. For example the spittlebug, *Aphrophora canadensis*, associated with the pathogen is known to provide infection courts from its feeding activities on *Pinus radiata* (Storer et al., 1998a).

The suitability of a wound for infection may depend on how rapidly it dries out. Indeed where the foliar phase of pitch canker is a problem, infections appear to be associated with locations/seasons where atmospheric moisture is readily available and temperatures are relatively warm, such as in the south-eastern United States during summer thunderstorms (Dwinell et al., 1985). In California, the northern limit of the pitch canker infestation is in Mendocino County at approximately 39°N latitude (Gordon et al., 2001). The absence of pitch canker in stands of susceptible species north of this location is likely due to relatively cool temperatures during periods when moisture is available. This limitation is consistent with a short period of wound susceptibility and observed low rates of infection when temperatures are too low to allow spore germination and subsequent growth to occur quickly enough for the pathogen to establish itself in a wound before it ceases to be susceptible (Inman et al., 2008). Observed climatic limitations on pitch canker may not hold where insect vectors carry the pathogen deeply into host tissue. Thus, for example, the distribution of *Conophthorus radiatae*, which breeds in cones of healthy *P. radiata*, may also be an important determinant of the risk of pitch canker.

Where the aerial phase of pitch canker occurs, the first symptom is usually branch dieback (Figure 3). Dieback results from a lesion (Figure 4), usually within one or two whorls of a branch tip that girdles and kills the affected branch distal to the point of infection. In most cases, axial growth of the pathogen does not extend very far proximally, and so does no further visible damage to the tree. The disease intensifies through repeated infections that can lead to extensive dieback in the canopy (Figure 5). Infections may eventually include larger diameter branches and the main stem (trunk) of the tree; such infections are often made conspicuous by extensive production of resin (Figure 6). In some cases, diseased trees are severely weakened and may suffer top kill due to girdling of the trunk and/or attack by engraver beetles (Figure 7); cankers lower on the trunk often result in death of the entire tree (Gordon et al., 2001).

Disease progress can be rapid in susceptible pines, where conditions are conducive to infection. Generally, when pitch canker becomes established in an area, many trees become infected before the disease intensifies in severely infected trees. This pattern may reflect random branch selection by insects vectoring the pathogen (or random location of weather related injuries) which, when the incidence of pitch canker is low, is more likely to result in infection of branches on previously uninfected trees than on trees already infected. On the other hand, when the incidence of pitch canker is high, such random branch selection by insects is more likely to result in infection of branches on trees that have already sustained infections, rather than on the few remaining trees that are free of infection. Hence, disease incidence increases more rapidly than disease intensity (Storer et al., 2002b).

Spread of the disease within a stand can occur by spores carried by wind or on the bodies of insects. Longer distance spread is likely to occur mostly through human-aided movement of infested or infected plant material and also by birds and mammals. Seeds, seedlings and branches or logs cut from diseased trees can all carry the pathogen. At moderate temperatures the pathogen survives for one year or more in infected wood (Gordon et al., 2000; McNee et al., 2002; CABI International, 2007). The pitch canker pathogen does not survive well in soil, but it can persist long enough for this medium to be regarded as a vehicle for spreading the disease to new areas (Gordon et al., 2004).

In addition to its activity as a pathogen of above-ground plant parts, *G. circinata* may also infect roots (Garbelotto et al., 2007) and kill seedlings (Viljoen et al., 2004). The climatic limitations on pitch canker are less likely to apply to the seedling phase of the disease, because conditions that are conducive to root growth in soil would generally also be suitable for infection by *G. circinata*. Seedlings killed before or shortly after emergence will generally not have distinctive symptoms. Older seedlings will develop a resin-soaked lesion near the soil line, which may eventually girdle the main stem causing a uniform fading of foliage from green to yellow (Figure 8) (Gordon et al., 2001).

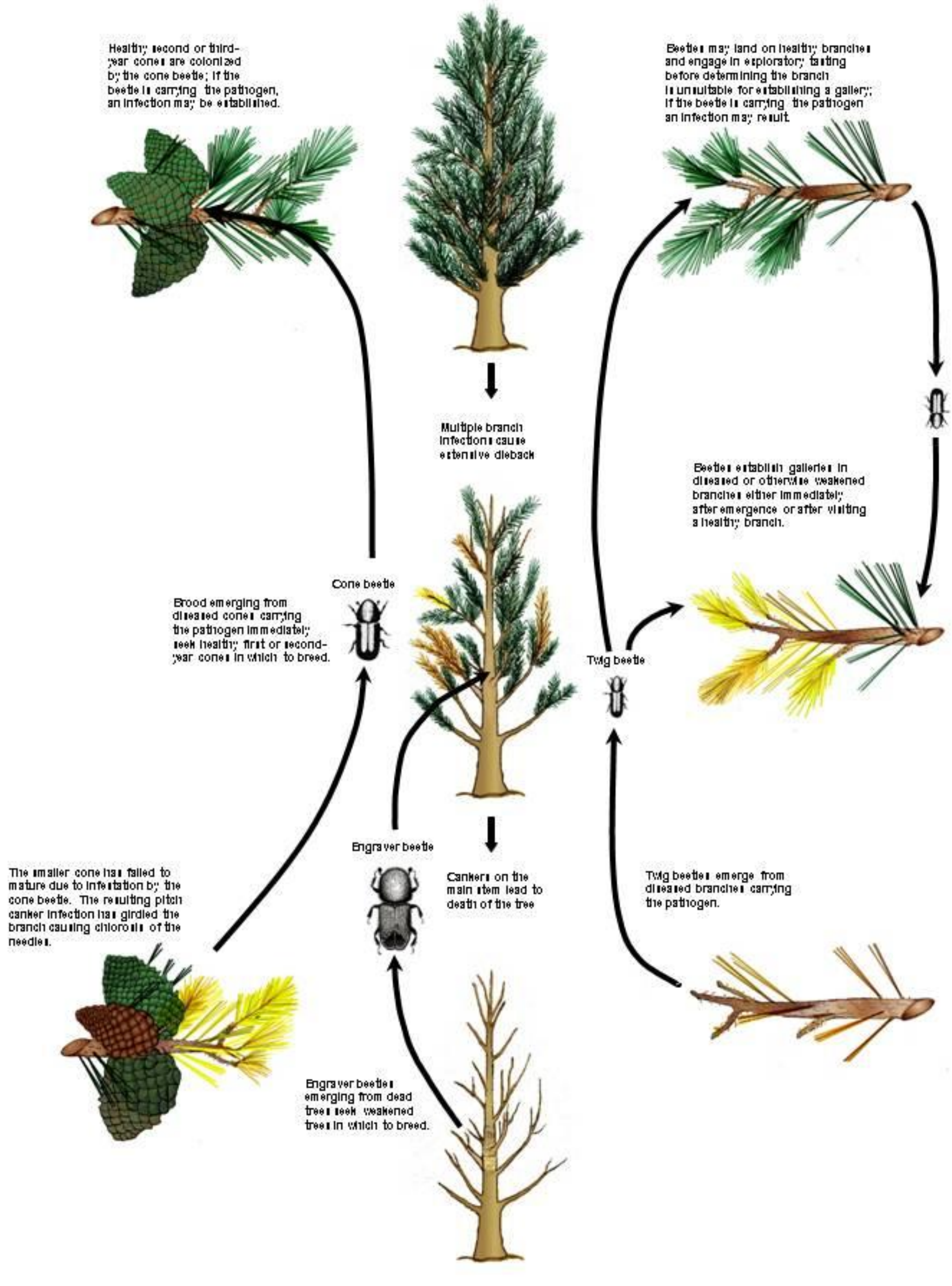

Figure 2: Disease cycle of pitch canker (Gordon et al., 2001) (by courtesy of T.R. Gordon)

Figure 3: Branch dieback due to Pitch Canker (by courtesy of T.R. Gordon)

Figure 4: Dieback results from a lesion (by courtesy of T.R. Gordon)

Figure 5: Repeated infections that can lead to extensive dieback in the canopy (by courtesy of T.R. Gordon)

Figure 6: Extensive production of resin related to infections of pitch canker (by courtesy of T.R. Gordon)

Figure 7: Top kill of diseased trees, due to girdling of the trunk and/or attack by engraver beetles (by courtesy of T.R. Gordon)

Figure 8: Uniform fading of foliage from green to yellow (by courtesy of T.R. Gordon)

3.1.7. Identification of the organism

The procedures for the identification of *G. circinata* on *Pinus* spp. and *Pseudotsuga menziesii* as discussed in the EPPO diagnostic protocol for *G. circinata* (EPPO, 2009a) involve morphological and molecular methods. Identification can be achieved by:

i) isolation of the fungus from the plant tissue on semi-selective culture media followed by morphological identification, and then by molecular identification in the case of uncertainty, or
ii) direct detection of the fungus *in planta* by molecular methods (conventional PCR, SyBr green real-time PCR or dual-labelled probe real-time PCR).

For morphological identification, two different culture media are used to grow the isolates: Potato Dextrose Agar (PDA) and Spezieller-Nährstoffarmer Agar (SNA). On PDA, the colony morphology and pigmentation, while on SNA, the formation and type of microconidia and conidiogenous cells are studied. Ten days after incubation of the PDA and SNA plates at room temperature, all isolates are examined and confirmed as *F. circinatum*[8] based on the morphological features described by Nirenberg and O'Donnell (1998) and Britz et al. (2002). On PDA, after 10 days of incubation the colony should exhibit an entire margin, white cottony or off-white aerial mycelium with a salmon tinge in the middle or with a purple or dark violet pigment in the agar. On SNA, microconidia are aggregated in false heads, with branched conidiophores, mono and polyphialidic-conidiophores, obovoid microconidia in aerial mycelium, mostly nonseptate or with occasionally one septum. Chlamydospores are absent. The sterile hyphae (coiled/not distinctively coiled) are characteristic of *F. circinatum* and are observed clearly on this medium. The epithet „circinatum" refers to these typical coiled hyphae, also called „circinate" hyphae.

For molecular identification, several methods are available. The different methods have different specificity to confirm the identity of the anamorphic stage of *G. circinata* isolated in pure culture or to detect and identify directly *G. circinata in planta* (plant tissue and seed).

i) A PCR-RFLP (Restriction Fragment Length Polymorphism) test, with primers and RFLP pattern developed by Steenkamp et al. (1999) is appropriate for identification of the anamorphic stage of *G. circinata* in pure culture only as contaminants or host material may affect the quality and numbers of PCR amplicons.
ii) SyBr green real-time PCR or conventional PCR tests with primers designed by Schweigkofler et al. (2004) can be useful for identification of the fungus in pure culture, as well as for direct detection of the pathogen in seeds. However, when carried out on plant samples DNA, verification of the nature of the PCR amplicon should be carried out by sequencing for conventional PCR, or by melting analysis for SyBr green real-time PCR. Indeed, infection by other *Fusarium* spp. is frequent and cryptic speciation was reported in the *Gibberella fujikuroi* sp. complex (Steenkamp et al., 2000). PCR cross-reaction might occur with phylogenetically close *Fusarium* spp., especially with high amounts of *Fusarium* template DNA.
iii) Method for real-time PCR with primers and a dual-labelled probe designed by Ioos et al. (2009) can be useful for identification of the fungus in pure culture, as well as for direct detection of the pathogen in plant tissue, including seeds. This method proved to be more sensitive than the conventional PCR (diagnostic sensitivities of 79.1 % and 58.6 %, respectively; Ioos et al., 2009) and its specificity is strengthened thanks to the combination of specific primers and probe.

[8] In the morphological descriptions *F. circinatum* is used since only the anamorphic form of *G. circinata* can be observed in pure culture after isolation (EPPO, 2009a).

3.1.8. Key points of the pest characterisation

i) *G. circinata* is a single taxonomic unit and can be distinguished from other entities by morphology and molecular characterisation.
ii) The pathogen is the causal agent of pine pitch canker.
iii) The pathogen is present in parts of the territory of the European Union, though not widely distributed.
iv) Host plants of the pathogen are available in the European Union.
v) The eco-climatic conditions in the European Union are similar to those of the area of the pathogen‟s original distribution.
vi) The disease caused by the pathogen has the potential for considerable impact in the European Union the same way as in the area of original distribution.

3.1.9. EU Legislation

3.1.9.1. Provisional emergency measures, specific for *G. circinata*

The pathogen is subject to Commission Decision 2007/433/EC of 18 June 2007, on provisional emergency measures to prevent the introduction into and the spread within the Community of *Gibberella circinata* Nirenberg & O‟Donnell (OJ L 161, 22.6.2007, p. 66-69):

A) Specific import requirements

The movement of specified plants[9] originating in third countries has to be accompanied by a certificate stating that the specified plants originate in a place of production which is registered and supervised by the national plant protection organisation in the country of origin, and

i) they have been grown throughout their life in countries where the specified organism is not known to occur; or
ii) they have been grown throughout their life in a pest-free area, established by the national plant protection organisation in the country of origin in accordance with relevant International Standards for Phytosanitary Measures. The name of the pest-free area shall be mentioned under the rubric „place of origin‟; or
iii) they originate in a place of production where no signs of the specified organism have been observed during official inspections within a period of two years prior to export and have been tested immediately prior to export.

B) Conditions for movement

All specified plants either originating in the Community or imported into the Community may be moved within the Community only if they are accompanied by a plant passport, and

i) they have been grown throughout their life or since their introduction into the Community in a place of production of a Member State where the organism is not known to occur, or
ii) they have been grown throughout their life or since their introduction into the Community, in a place of production in a pest-free area, established by the responsible official body in a Member State, in accordance with relevant International Standards for Phytosanitary Measures, or
iii) they originate in a place of production where no signs of the specified organism have been observed during official inspections within a period of two years prior to movement and have been tested immediately prior to movement.

[9] 'specified plants' means plants of the genus *Pinus* L. and the species *Pseudotsuga menziesii*, intended for planting, including seeds and cones for propagation purposes as defined in Commission Decision 2007/433/EC

C) Establishment of demarcated areas

The Commission Decision 2007/433/EC further requires the establishment of demarcated areas following introduction of the pathogen. The demarcated areas consist of the following parts:

i) an infected zone where the presence of the specified organism has been confirmed and which includes all specified plants showing symptoms caused by the specified organism, and
ii) a buffer zone with a boundary at least 1 km beyond the infected zone. In cases where several buffer zones overlap or are geographically close, a wider demarcated area shall be defined which includes the relevant demarcated areas and the areas between them.

The official measures to be taken in the demarcated areas have to include at least:

i) appropriate measures aimed at eradicating the specified organism;
ii) intensive monitoring (surveillance) for the presence of the specified organism through appropriate inspections.

3.1.9.2. Other legislation, not specific to *G. circinata*

G. circinata is not listed as a harmful organism for the European Community in Annex I and Annex II of the Council Directive 2000/29/EC on protective measures against the introduction into the Community of organisms harmful to plants or plant products and against their spread within the Community but important legislative measures, not specific to *G. circinata,* may concern this organism as well.

A) Legislation on host plants

The Council Directive 2000/29/EC Annex III, Part A, prohibits the introduction of the plants of *Pinus* and *Pseudotsuga* (the host plants) other than fruit and seed from non-European countries in all Member States. This regulation has been introduced because of other harmful organisms.

B) Legislation on soil and growing media

The Council Directive 2000/29/EC Annex III. Part A. 14, prohibits in all Member States the introduction of soil and growing medium as such, which consists in whole or in part of soil or solid organic substances such as parts of plants, humus including peat or bark, other than that composed entirely of peat.

The Council Directive 2000/29/EC Annex IV, Part A, Section 1. 34 (concerning import from third countries), requires an official statement that the growing medium is either free from soil (and organic matter), free from insects, harmful nematodes and from other harmful organisms, or subjected to appropriate heat treatment or fumigation to ensure freedom from harmful organisms. Similarly, appropriate measures have to be taken since planting to ensure that the growing medium has been maintained free from harmful organisms, or the plants were shaken free from the medium.

C) Legislation on wood material

The Council Directive 2000/29/EC Annex IV, Part A lays down the special requirements on conifer wood because wood of conifers is a potential pathway for entry and spread.

The Directive requires that the wood material has been subjected to heat treatment to achieve a minimum core temperature of 56 °C for at least 30 minutes or, fumigation to an approved specification or, chemical pressure impregnation with an approved product. These treatments are aimed at other pests, mainly at the pine wood nematode *Bursaphelenchus xylophilus* (Steiner and Bührer) Nickle et al. in wood packaging material. Moreover the Commission Decision 2006/133/EC requires Member States temporarily to take additional measures against the dissemination of *Bursaphelenchus xylophilus* (Steiner and Buhrer) Nickle et al. (the pine wood nematode) as regards areas in Portugal, other than those in which it is known not to occur. The measures indicate that susceptible plants (among them those that are also host plants for *G. circinata*) shall be accompanied by plant passports, subject to official inspection, or

i) susceptible wood and isolated bark, other than wood in the form of chips, particles, wood waste or scrap obtained in whole or part from these conifers, packing cases, crates or drums, pallets, box pallets or other load boards, dunnage, spacers and bearers, but including that which has not kept its natural round surface, shall be accompanied by the plant passport, after the wood or the isolated bark has undergone an appropriate heat treatment to achieve a minimum wood core temperature of 56 °C for 30 minutes, or

ii) susceptible wood, in the form of chips, particles, wood waste or scrap obtained in whole or part from these conifers shall be accompanied by the said plant passport after having undergone an appropriate fumigation treatment or susceptible wood, in the form of dunnage, spacers and bearers, including that which has not kept its natural round surface shall be stripped of its bark, be free from grub holes which are larger than 3mm across, have a moisture content expressed as a percentage of dry matter of less than 20 % achieved at time of manufacture, or

iii) susceptible wood, in the form of packing cases, boxes, crates, drums and similar packings, pallets, box pallets and other load boards, pallet collars, whether or not actually in use in the transport of objects of all kinds shall undergo either an appropriate heat treatment to achieve a minimum wood core temperature of 56 °C for 30 minutes, pressure (impregnated) treatment, or fumigation and either display an officially approved treatment marking enabling the identification of where and by whom the treatment has been carried out or be accompanied by the said plant passport attesting to the measures carried out.

The Commission Decision 2006/133/EC also requires that susceptible wood packaging material (including those made of host plants of *G. circinata*) of any origin, leaving the demarcated areas (for pine wood nematode infestation) without having been marked according to Annex II to FAO International Standard for Phytosanitary Measures No 15 (ISPM No 15) (FAO, 2007a), has to be considered by the responsible official bodies of Member States as non compliant material. Such material should be identified as free of risk for pine wood nematode infestation, when it has undergone one of the approved treatments specified in Annex I to ISPM No 15 and it has been marked according to Annex II to the said Standard.

In order to avoid disproportional disruption of trade, the Commission Decision provided a derogation for Portugal as regards the date of application of the requirements, which refer to the obligation to treat and mark in accordance with Annexes I and II to ISPM No 15 susceptible wood packaging material not originating from demarcated areas before moving it from the demarcated areas in Portugal to other areas. The reason for the derogation was that wood packaging material is required for the transport of many goods of all kinds. This Decision was in force until 31 December 2009.

The above regulation – though not meant to be specific for *G. circinata* but for the pine wood nematode – has an indirect effect on the control of *G. circinata* because of the pine pitch canker disease being present in Portugal.

In the Council Directive 2000/29/EC, the bark limitation requirement for all wood packaging materials has been implemented for all wood packaging materials on January 1, 2009 with a transitional period until July 1, 2009. According to this, the wood shall be:

i) free from bark with the exception of any number of individual pieces of bark if they are either less than 3 cm in width (regardless of the length) or, if greater than 3 cm in width, of not more than 50 cm2 in area;

ii) subject to one of the approved treatments as specified in Annex I to ISPM No 15 (Guidelines for regulating wood packaging material in international trade) (FAO, 2007a);

iii) display a mark as specified in Annex II to ISPM No 15 (FAO, 2007a), indicating that the wood has been subjected to an approved phytosanitary treatment.

The above EU regulations for wood packaging material are based on ISPM No 15 (FAO, 2007a):

i) Use of debarked wood

Irrespective of the type of treatment applied, wood packaging material must be made of debarked wood. For this standard, any number of visually separate and clearly distinct small pieces of bark may remain if they are:

- less than 3 cm in width (regardless of the length); or
- greater than 3 cm in width, with the total surface area of an individual piece of bark less than 50 square cm.

For methyl bromide treatment the removal of bark must be carried out before treatment because the presence of bark on the wood affects the efficacy of the methyl bromide treatment. For heat treatment, the removal of bark can be carried out before or after treatment.

ii) Heat treatment (treatment code for the mark: HT)

Wood packaging material must be heated in accordance with a specific time–temperature schedule that achieves a minimum temperature of 56 °C for a minimum duration of 30 continuous minutes throughout the entire profile of the wood (including at its core). Various energy sources or processes may be suitable to achieve these parameters. For example, kiln-drying, heat-enabled chemical pressure impregnation, microwave or other treatments may all be considered heat treatments provided that they meet the heat treatment parameters specified in this standard.

iii) Methyl bromide treatment (treatment code for the mark: MB)

Use of methyl bromide should be undertaken taking into account the CPM Recommendation Replacement or reduction of the use of methyl bromide as a phytosanitary measure (2008).

The wood packaging material must be fumigated with methyl bromide in accordance with a schedule that achieves the minimum concentration-time product[10] (CT) over 24 hours at the temperature and final residual concentration specified in Table 5. This CT must be achieved throughout the wood, including at its core, although the concentrations would be measured in the ambient atmosphere. The minimum temperature of the wood and its surrounding atmosphere must be not less than 10 °C and the minimum exposure time must be not less than 24 hours. Monitoring of gas concentrations must be carried out at a minimum at 2, 4 and 24 hours (in the case of longer exposure times and weaker concentrations, additional measurement should be recorded at the end of fumigation).

Table 5: Minimum concentration-time product (CT) over 24 hours for wood packaging material fumigated with methyl bromide

Temperature	CT (g·h/m^3) over 24 h	Minimum final concentration (g/m^3) after 24 h
21 °C or above	650	24
16 °C or above	800	28
10 °C or above	900	32

[10] The CT product utilized for methyl bromide treatment in this standard is the sum of the product of the concentration (g/m3) and time (h) over the duration of the treatment.

D) Legislation on forest reproductive material.

Council Directive 1999/105/EC[11] on the marketing of forest reproductive material and its implementing measures indicate the minimum requirements for marketing of forest reproductive material (seeds, parts of plants and planting stock).

3.2. Probability of entry: from infested areas outside EU to EU

3.2.1. List of pathways

The following pathways for entry from infested areas have been identified:

i) plant material for propagation purposes (seeds, seedlings and scions),
ii) wood,
iii) plant material for decorative purposes (Christmas trees, branches, cones, etc.),
iv) soil and growing substrates,
v) natural means (insects, wind, etc.),
vi) human activities (travellers, machinery, silvicultural practices, vehicles etc.)

3.2.2. Pathway 1: plant material for propagation purposes (seeds, seedlings and scions)

3.2.2.1. Association of the pathogen with the pathway at origin

There is strong evidence that *G. circinata* is associated with the seed produced in areas affected by pitch canker. The pathogen can be carried both externally and internally in pine seed, where it remains dormant until seed germination (Storer et al., 1998b). Dwinell (1999) suggested that seed contamination is largely external and it may have partially resulted from the opening and closing of mature cones with changes in temperature and humidity. However, internal location allowing survival of the fungus after surface sterilization is known to occur (Barrow-Broaddus, 1987; Storer et al., 1998b). The fungus has been isolated from the gametophyte and embryo tissues of slash and loblolly pine seed (Miller and Bramlett, 1979). The mechanisms by which *G. circinata* infests seed are unknown (Storer et al., 1998b). Hence there appear to be three types of seed infestation:

i) superficial propagules of the fungus that can be eliminated by surface treatment with sodium hypochlorite or hydrogen peroxide (Dwinell, 1999);
ii) internal infestation, not eliminated by the treatment, but detectable when the seed is plated on a selective medium (active infestation) (Storer et al., 1998b);
iii) internal infestation, not eliminated by the seed treatment and not detectable with traditional method (e.g. plating on a selective medium) (dormant infestation) (Storer et al., 1998b).

The extent of internal and/or external seed contamination seems to vary by pine species and environmental conditions (Dwinell and Fraedrich, 1999; Dwinell, 1999; Wingfield et al., 2008). According to Anderson et al. (1984), infection of *P. elliottii* seeds varied from 0 to 30 %, while selected *P. patula* seedlots showed internal contamination from 0 to 11 %. Runion and Bruck (1988) isolated the pathogen from non-disinfested (98.5 %) and surface-disinfested (84.5 %) *P. palustris* seeds. Fraedrich and Dwinell (1997) reported that *G. circinata* was isolated from an average of 61 % of the freshly extracted shortleaf pine seed (*P. echinata*), but only 1.6 % of the seeds were infected internally. Similarly, *G. circinata* seems to be associated more with the seed coat of *P. palustris,* than with the endosperm and embryos (Fraedrich and Dwinell, 1997). High percentages of infected/contaminated seed were also reported by Barrow-Broaddus (1987) (1-34 %), Pawuk (1978) (54-91 %, varying with species), Dwinell (1998) (up to 99 %), and Carey et al. (2005) (up to 88 %).

[11] Council Directive 1999/105/EC of 22 December 1999 on the marketing of forest reproductive material. OJ L 11, 15.01.2000, p. 17.

G. circinata may also be present on the surface of seed collected from apparently healthy cones (Storer et al., 1998b).

G. circinata causes pre- and post-emergence damping-off of seedlings, as well as mortality of established seedlings. Mortality of established seedlings tends to be lower than that of newly germinated seedlings (Viljoen et al., 1994). Carey et al. (2005) showed that *P. palustris* seedling mortality was linearly correlated with the percentage of infected seeds. In a greenhouse study, Dwinell and Fraedrich (1999) showed that from artificially contaminated Monterey and slash pine seed 57 % and 30 %, respectively, of the seedlings had damping-off after emergence, whereas 22 % of Monterey seedlings had damping-off prior to emergence. According to Storer et al. (1998b), seedling emergence from infested Monterey pine seed was 9 % compared with 67 % for non-infested seeds.

Infected/contaminated seed may also lead to seedling infection in nursery seedbeds (Barnard and Blakeslee, 1987; Storer et al., 1998b; Huang and Kuhlman, 1990; Wingfield et al., 2008) and these seedlings may carry the infection. Under certain conditions, contaminated seed may produce asymptomatic seedlings from which the fungus can be isolated: the pathogen was isolated from 148 Monterey pine seedlings of which 82.4 % were symptomless even after 9-15 weeks (Storer et al., 1998b). Pre- and post-emergence damping-off caused by *G. circinata* is not readily distinguishable from death due to other seedling pathogens such as *Pythium* spp.. Death of older seedlings (1-3 years of age), caused by *G. circinata* could be mistaken for *Phytophthora* root rot (CAB International, 2007).

Seed is considered among primary sources of infection. *G. circinata* is thought to have been introduced into South Africa and Chile on infected or contaminated seed (Carey et al*.,* 2005; Coutinho et al., 1997).

Scions may be used to accelerate the breeding period for certain pines (Lott et al., 2003), but they are not used for common propagation. An infected scion of *Pseudotsuga menziesii* was shipped from the United States to New Zealand, where *G. circinata* was recovered in a quarantine facility (Vogler et al., 2004).

It can be concluded that the pathogen is associated with the host plant material for propagation purposes (seeds, seedlings and scions). This material being able to carry the pathogen, the concentration of the pathogen on the pathway at origin may be high.

According to EUROSTAT (2008a), in 2008, 11,220 tonnes of pine nuts fresh or dried, whether or not shelled or peeled were imported into the 27 EU Member States, but the exact origin is not known – whether from infected places or not. The use of this high quantity of imported nuts is also unclear with regards to further processing. No data were found on the volume of import of pine nuts into EU that are officially declared as intended for sowing in nurseries. Only summarised data on "forest tree seeds for sowing" are available (445 tonnes).

Seeds and propagation material of host plants can also be mailed but quantities traded in this way are not known.

3.2.2.2. Survival of the pathogen during transport or storage

Harvested pine cones are usually stored either temporarily near collection sites or for 1-6 months in cool, dry and adequately ventilated sheds, although for storage beyond 4 months frost protection is required (Tanaka, 1982, 1984). Storing cones for some period is a common practice mainly because the processing equipment is not capable of extracting seeds from all harvested cones at once. Moreover during storage the moisture content is decreased and subsequently kiln-drying time is reduced. Also during this storage time, seeds can be artificially ripened and doing so the seed germination potential is improved (Tanaka, 1984).

Following storage and in order to facilitate extraction of seeds, cones are kiln-dried at temperatures between 32 and 43 °C and low humidity, usually lower than 30 % (Aldous, 1972). Fully dried cones usually have less than 10 % moisture content (Barnett, 1972).

Due to irregular seed production and in order to maintain supplies through years of poor production, pine seed are usually stored for several years until needed (Belcher, 1982). Storage temperature, seed moisture content and period of storage vary depending on the pine species. Based on the results of a survey (Tanaka, 1984), nurseries store pine seed at temperatures between -15 and -5 °C. At these temperatures and for a seed moisture content of 6-9 %, seeds can be stored up to 7 years. According to Barnett (1972), below 0 °C and below 10 % relative humidity, pine seed can be stored as long as 40 years.

The recommended storage conditions for seedlings would be at a temperature between 0.5 and 3.3 °C with 85-95 % relative humidity (UF, 2010).

G. circinata colonies grow most rapidly at 25 °C and progressively more slowly at 30, 20, 15 and 10 °C (Viljoen et al., 1997; Inman et al., 2008; Liao et al., 2008). Spore germination occurs most rapidly at 20 °C and is slowest at 10 °C (Inman et al., 2008), while the optimum temperatures for conidial germination are 25 and 30 °C. Agustí-Brisach et al. (2009) found that *G. circinata* is able to tolerate hot water treatments over 50 °C. The lethal temperature for *F. circinatum* mycelium and spores is 55 °C, and 52 °C respectively (Liao et al., 2008). Consequently, kiln-drying treatments probably will not severely affect the survival of spores and mycelium of *F. circinatum*. In addition, *Fusarium* cultures can be preserved for long time using different techniques including; lyophilisation, freezing of spore suspensions at -70 °C, and storage on filter paper, silica gel or soil at 4 or -20 °C (Leslie et al., 2006).

The above mentioned storage conditions of cones, seeds and seedlings are unlikely to affect the survival of the pathogen"s propagules (spores, mycelium) on the infested material. No information was found on the transport conditions of cones, seeds and seedlings of pine but it can be assumed that common transport conditions are unlikely to affect the survival of the fungus.

3.2.2.3. The pathogen surviving the existing management procedures

External contamination of pine seed may be reduced or even eliminated by seed treatments (Dwinell, 1999; Runion and Bruck, 1988). However, there is no reliable method available to eliminate the internally located mycelium of the pathogen without affecting the seed (Storer et al., 1998b; Wingfield et al., 2008). Hot water treatments of seed are effective in reducing population levels of *G. circinata* to trace levels and result in high rate of seedlings suitable for planting (Jones et al., 2002).

There is no International Seed Testing Association (ISTA) standard available for compulsory pesticide treatment of pine seed. Although an ISTA method was published in 2002 to detect *F. moniliforme* f. sp. *subglutinans* in seeds of *P. taeda* and *P. elliotii* (ISTA, 2002), the latter is not recommended anymore. In some EU Member States active ingredients propamocarb and captan are registered for treatment of pine seed to prevent damping-off diseases in pine nurseries (Ocskó et al., 2009), but no data on efficacy of these treatments against *G. circinata* was found.

Infected seed can easily remain undetected at visual inspection. In fact, infected seeds occur in cones that are misshapen, discoloured or with resinous lesions or having necrotic areas on the scales; if these abnormal cones are not culled before seed extraction, it may be difficult to later separate infected from non infected seed (Barrows-Broaddus and Dwinell, 1985a). Infected seed frequently display no symptoms until seed germination (Barrows-Broaddus and Dwinell, 1980; Storer et al., 1998b) and only show slight differences in shape compared to non infected seed (Barrows-Broaddus and Dwinell, 1985a). Furthermore, in the case of cryptic infections of seed, the pathogen remains quiescent and cannot be detected using traditional methods (Gordon et al., 2000; Storer et al., 1998b).

The organism can be easily isolated on artificial media but its exact identification is difficult. Numerous *Fusarium* species residing in the *Gibberella fujikuroi* complex, either fully described or still poorly documented, are morphologically similar and identification may not be possible just based on morphological characteristics. In particular, Steenkamp et al. (1999) report that some of the distinguishing morphological characters may be inadequate or insufficient to make a definite identification of *G. circinata* (Nirenberg and O'Donnell, 1998). For a rapid and reliable identification of the pathogen three molecular methods are currently available (Ioos et al., 2009; Schweigkofler et al., 2004; Steenkamp et al., 1999, as described in EPPO, 2009a) (see section 3.1.7).

3.2.2.4. Transfer of the pathogen to a suitable host

Evidence indicates that the pitch canker fungus has been introduced into forest tree nurseries by infected or contaminated seed (Carey et al., 2005). In South Africa and Chile the sources of the outbreaks are believed to be contaminated seed (Coutinho et al., 1996; Wingfield et al., 2002a).

Starting from infected pine seedlings the pathogen‟s propagules can be disseminated to healthy trees in plantations and native forests in the European Union by natural means, irrespective of the period of the year (see section 3.4). Therefore, infected seedlings grown in pine nurseries in the European Union may transfer the pathogen to new plantations and native forests in unaffected areas. Among pine species, many are susceptible to *G. circinata* (Dallara et al., 1995; Wikler et al, 2003b), and susceptible host species are widespread in the EU, although their density differs greatly according to the area. In most EU countries hosts are present in forests, nurseries and are widely used as ornamental plants in parks, gardens, urban and country roadsides (see section 3.3.2).

3.2.3. Pathway 2: wood from infested areas

3.2.3.1. Association of the pathogen with the pathway at origin

Wood products include roundwood that comprises all quantities of wood removed from the forest and other wooded land or other felling sites during a certain period of time. It is reported in m^3 underbark (i.e. excluding bark). Roundwood is divided into two principal categories: industrial roundwood and wood fuel. The commodities included in industrial roundwood are logs, pulpwood and other industrial wood. Logs are used for the production of sawnwood (including sleepers) and veneer sheets. Pulpwood is wood in the rough other than logs, used for the manufacture of pulp, particle board and fibreboard. Other industrial roundwood includes roundwood that will be used for poles, piling, posts, fencing, pitprops tanning, distillation and match blocks, etc. Wood fuel is wood to be used as fuel for purposes such as cooking, heating and power production (EUROSTAT, 2007). All roundwood commodities can further be divided into coniferous (generally referred to as softwood) or non-coniferous (generally referred to as broadleaves or hardwood) species. Removals of coniferous roundwood in the EU 27 Member States in 1995 totalled approximately 238.34 million m^3, in 2000, 279.96 million m^3 and in 2005, 317.02 million m^3(including all categories).

Another forest industry product is the sawnwood that has been produced either by sawing wood lengthways or by a profile-chipping process. It includes planks, beams, joists, boards, rafters, scantlings, laths, boxboards, sleepers and “lumber”, etc. Industrial wood products – like pulpwood, paper, etc. that are obtained by chemical process, cannot be taken into consideration as hosts.

By-products like bark and sawdust may be used as mulching (Harkin, 1969; Thomas and Schumann, 1993) and in this way also get into the proximity of potential hosts. The quantity of sawdust produced annually by sawmills is huge. It has been calculated that, in the United States, industry-produced air-dry wood fines may exceed one million tons per year (Harkin, 1969). The amount of bark produced as a by-product of wood industry is huge, as bark represents 13-21 % of log dry weight. It is interesting to note that Douglas fir, one of the susceptible hosts of *G. circinata*, has a very thick bark compared to other species (Harkin and Rowe, 1971).

The organism can infect the vegetative and reproductive parts of susceptible pine hosts of all ages. Shoots, branches, cones, seeds, stems and exposed roots may all become infected (Wingfield et al., 2008). *G. circinata* infects the branches of pine, causing a bark canker. The fungus invades the phloem, cambium and xylem of infected host‟s wood (CAB International, 2007). The primary root may also be deeply invaded (up to 50 cm from root collar) through root collar infection (Garbelotto et al., 2007). Therefore the pathogen can be associated with all woody parts of the plants used in trade/movement. However, because of epidemiological characteristics, most of the infectious inoculum of *G. circinata* is in the bark, borne internally (from infected wood) or externally (from the deposition of the air-born or insect-born inoculum, which occur all season long: Dwinell et al., 1985; Wingfield et al., 2008; Garbelotto et al., 2008). Bark, because of its structure (rhytidome) and as a consequence of felling logs or of the action of wind, etc., usually traps particles of soil and grits (Harkin and Rowe, 1971). The percentage of infected trees in infested areas may be high (see section 3.5.1).

The pathogen may survive for one year or more in cut wood of branches and chips (from symptomatic and asymptomatic branches) (Gordon et al., 2000; McNee et al., 2002). Insects able to carry the fungus may also survive in cut wood for many months, however, according to McNee et al. (2002) chipping reduces the emergence of *Phytophthorus* spp. by 95 %.

Based on the previous considerations, all wood products including particles, sawdust, shavings, wood waste and also chips obtained from host plants, may carry the pathogen. The wide host range within species of *Pinus* that are grown commercially, the wide geographical distribution of the pathogen and the inferior quality of timber usually used for wood packaging material indicate that *G. circinata* is likely to be in timber destined for the production of wood packaging material including pallets, dunnage, etc. (Biosecurity Australia, 2006). The volume of trade related to pallets alone is large; Molina-Murillo et al. (2005) estimated for the United States in 2003 the total number of wood-pallets for exporting activities to circa 63.6 millions. Since the pathogen is always present on an infected tree irrespectively of the time of the year, the time of felling of the trees is not relevant.

World wood trade is very intense and import of wood in the EU involves practically all the EU Member States. The EU 27 Member States imported in 2005 from extra-EU countries 27.76 million m^3 of roundwood, Finland ranging first among the importers (13.80 million m^3) followed by Italy (3.43 million m^3), Sweden (3.29 million m^3), Estonia (1.63 million m^3), Poland (1.25 million m^3), etc. The EU 27 imported in the same period 18.01 million m^3 of sawnwood, the major importing countries being Italy (5.86 million m^3), Germany (1.68 million m^3), United Kingdom (1.46 million m^3), Spain (1,27 million m^3) and the Netherlands (1.01 million m^3). It is not known if these imported forestry products originate from infested or non-infested places, and what could be their destination and end-use in the EU.

Although the statistical data include wood from all wood-producing tree species, conifers supply a large amount of wood production. For example, in 2005, the EU 27 produced 317 million m^3 of coniferous wood out of a total of 426 million m^3 and the USA 313 million m^3 out of 472 million m^3 (EUROSTAT, 2007). No disaggregated data were found for the species that are susceptible to pitch canker, pine species and Douglas fir, however the amount of wood that may be associated with the pathogen in the pathway can be considered large.

Because of the intrinsic nature of the commodity, the multitude of uses and types of wood, the movements along the pathway take place with high frequency, i.e. it is practically continuous.

3.2.3.2. Survival of the pathogen during transport or storage

As mentioned in section 3.2.2.2, the pathogen is resistant to high temperatures. Therefore, the pathogen is likely to survive under the usual conditions of transport on ships, trains, etc. Information on special storage and transport conditions of wood is not available.

Pathogen survival in wood was tested by felling infected trees in a native forest (Gordon et al., 2000). After six months on the ground under ambient conditions, three of five logs sampled were positive for *G. circinata*, whereas 18 months after felling, the pathogen was isolated from three of thirteen logs sampled. Therefore, even if the viability of the pathogen seems to decline with time, its survival in untreated wood could be expected for at least 18 months. For wood (logs, chips, packing material, etc.), in many cases, the maximum period of storage is unlikely to exceed the period of survival of the pathogen. In chipped infected *P. radiata* branch material, kept in small piles in a laboratory, the fungus was constantly re-isolated weekly for five months (Storer et al., 1997).

3.2.3.3. The pathogen surviving the existing management procedures

In general, although a variety of potential procedures for mitigating the risk of fungi, or their insect vectors, entering on imported wood are known (visual inspection, debarking, topical or diffusible biocides, fumigation, kiln-drying, thermal treatment, irradiation), the selection of mitigating measures is hampered by lack of supporting data (Morrell, 1995). This is also the case with *G. circinata*.

The pest can remain undetected at visual inspection of the wood because the pathogen may be present without showing obvious symptoms (e.g., logs from asymptomatic/pre-symptomatic branches, barks, sawdust). Latent infections are virtually impossible to detect through visual inspection. Moreover, wood shipments in general and wood packaging material in particular are difficult to inspect as access to visible surfaces is limited.

Debarking and treatment of imported wood may mitigate the risk of entry. However, the pathogen is not confined to bark (CAB International, 2007) and treatments required presently in the Council Directive 2000/29/EC are aimed at other pests and their efficacy against *G. circinata* is not known.

Effective wood treatments against *G. circinata* were tested in the United States (Gordon et al., 2000). A water-based, broad spectrum microbiocide preparate based on 2-(Thiocyanomethylthio) benzothiazole or TCMTB could effectively eliminate the pathogen on the surface of treated logs but not inside.

A fumigant based on sulfuryl fluoride – alternative to methyl bromide eliminated the pathogen also inside of the logs (barked and de-barked). Debarking of logs had no significant effect on the efficacy of any treatment (Gordon et al., 2000).

Thermal treatment of wooden packages can eliminate the pathogen. The current standard (FAO, 2007a) states that wood material should be subjected to heat treatment to achieve a minimum core temperature of 56 °C for at least 30 minutes. This treatment should be effective because the lethal temperature for *G. circinata* mycelium and spores are 55 °C, and 52 °C respectively (Liao et al., 2008).

Pine wood bark is commonly used as an amendment to soil or other plant growing media. It can be used for container growing in greenhouses, in nurseries, or simply for creating favourable conditions for some plants. It can be used as soil amendment with or even without preliminary composting (Harkin and Rowe, 1971). When used without composting, the infested bark is decomposing slowly so it could carry the pathogen. Composting of pine wood bark is a common practice of gardeners (not only professionals) which may not always be effective in eliminating fungal pathogens. The process of composting itself depends on the conditions of the bark (Harkin and Rowe, 1971). In order to eliminate the pathogen, according to Gordon et al. (2000), composting should last for at least 10 days at 50 to 55 °C. Most commercial composting operations should have no difficulty in meeting these minimum requirements.

Kiln-drying and heat or chemical treatments of wood commodities, dunnage and packaging materials either in the normal production process or as a consequence of phytosanitary requirement may affect the insect vectors of the pathogen. Chipping, which eliminates most insects (McNee et al., 2002), is unlikely to have direct effects on the pathogen‟s survival.

In the EU 27, regulation on wood packaging material in line with the provisions of the FAO International Standard for Phytosanitary Measures No 15 (FAO, 2007a) contributes to the control of potential *G. circinata* infestation in wood.

3.2.3.4. Transfer of the pathogen to a suitable host

Import of wood into the EU concerns most EU Member States (see 3.2.3.1). Even EU wood-producing countries may import wood therefore the commodity may be considered as widely distributed through the European Union.

The probability of imported infected wood to transfer the pathogen to a suitable host depends on its end-use, imported wood being used for many purposes (see 3.2.3.1). Moreover, by-products like bark, sawdust, wood-shavings, waste-chips, etc., and disposable wood material may have diverse end-uses which may also concern environments where the hosts are present. This is the case of bark or sawdust, which may be used for mulching even around susceptible hosts (Harkin, 1969; Thomas and Schumann, 1996).

As mentioned in the section 3.2.2.2, the pathogen can efficiently spread from inoculum sources to host plants by natural means, and the host species are widely distributed in the European Union.

3.2.4. Pathway 3: plant material for decorative purposes (Christmas trees, branches, cones)

3.2.4.1. Association of the pathogen with the pathway at origin

As mentioned in the previous sections, all parts of host plants can be infected by *G. circinata* (CAB International, 2007). These include trees (Christmas trees), branches and cones used for decorative purposes, which can be largely affected in the infested areas, with no seasonality in the infection pattern, and can be asymptomatic. Therefore, Christmas trees and plant parts used for decorative purposes may be a pathway for entry of the pathogen into the European Union.

According to EUROSTAT (2008a) import volume data on plant material for decorative purposes (Christmas trees, branches, cones) from third countries into the EU 27, in 2008, 104 tonnes of fresh Christmas trees and also 104 tonnes of fresh conifer branches were imported into the EU 27. It is not known whether the imported trees or branches originated from infected or non-infected areas. There are no separate data available on importation of cones from third countries for decorative purposes. In addition, dyed, bleached, impregnated or otherwise prepared branches and other material (not known whether of host plants or not) are imported into the European Union in large quantities: altogether 8,967 tonnes into EU 27 in 2008. Christmas trees, branches, cones, etc. can be purchased via Internet, and there are numerous possibilities for obtaining Christmas trees or coniferous ornamental material from third countries.

3.2.4.2. Survival of the pathogen during transport or storage

Survival of the pathogen in cones and seeds is discussed in section 3.2.2.2. Concerning Christmas trees there are no specific data, although the survival of the pathogen on the plant or in the wood during their transport and storage is very likely. However, because of the varying conditions of storage and transport, it is not known for how long the fungus can survive in the infected plant parts.

3.2.4.3. The pathogen surviving the existing management procedures

The commonly used cultural methods of control (like pruning the infected tips of branches, chipping, debarking, etc.) cannot be used for plants meant for decorative purposes. In Christmas tree farms, neither pruning nor chemical treatments are used. Removing all soil parts adhering to roots may reduce the pathogen‟s propagules on Christmas trees (CAB International, 2007).

According to Gordon et al. (2000), composting can eliminate the pathogen on small diameter branches of wood when temperatures are maintained in the range of 50 to 55 °C for at least 10 days. Most commercial composting operations should have no difficulty meeting this minimum requirement.

It is not likely that any chemical treatments could be used for branches or plant parts for decorative purposes. There are no data on the effect on the pathogen‟s spores of substances used for dying or bleaching the plant parts used for decorative purposes.

The pathogen can easily remain undetected at visual inspection because the infection may be symptomless (Gordon et al., 2001) or the symptoms may be very slight and easily missed, or the symptoms may be visible only in case of cutting through the tissues. The symptoms – even if noticed

– may easily be confused with the symptoms caused by other pine diseases: branch tip dieback caused by pitch canker is somewhat distinctive in the relatively rapid abscission of needles and the accumulation of resin at the junction of living and dead tissue (the infection site). The resulting naked branch tips, however, could be confused with symptoms caused by numerous other branch-infecting pathogens, such as *Sphaeropsis sapinea* (syn *Diplodia pinea*) and *Endocronartium harknessii* (syn. *Peridermium harknessii*).

3.2.4.4. Transfer of the pathogen to a suitable host

If plants or plant parts for decorative purposes (Christmas trees, branches, cones, etc.) are infected by the pest, the pathogen can transfer to suitable hosts in several ways, most likely when the used ornamental materials are thrown away, particularly in the vicinity of host plants (nurseries or forests) without properly processing or composting. As mentioned in section 3.2.2.2, the pathogen can efficiently spread from inoculum sources to host plants by natural means, and the host species are widely distributed in the European Union.

3.2.5. Other pathways

3.2.5.1. Soil

In a study carried out in greenhouse conditions by Gordon et al. (2004) to determine the viability of the pathogen, loam soil and sandy soil samples were inoculated by known quantities of *G. circinata* spores – both soils were tested in wet and in dry circumstances. In the loam soil, the authors found a steady decline in propagule viability, with less than 10 % survival after 12 weeks in both wet and dry soil. After 52 weeks, only one propagule per gram was detected in dry soil and none were detectable in wet soil. In sandy soil, the decline in pathogen viability was even more rapid than in loam. In dry sandy soil, the pathogen was not detectable six weeks after inoculation. In wet sandy soil, very low levels were detectable 24 weeks after inoculation, and none could be recovered after 52 weeks.

Soil in pine plantations and seed orchards is not considered as a primary source of inoculum because the pathogen is seldom recovered from these soils (Dwinell and Barrows-Broaddus, 1978).

According to Barrows-Broaddus and Kerr (1981), a reason might be that *F. circinatum* is very sensitive to *Arthrobacter* spp., common bacteria living in large quantities in the soil and strongly inhibiting the growth of *Fusarium* species. Moreover, the absence of *Fusarium* spp. from conifer forest soils may also be due in part to the presence of acids in low pH soils.

Toussoun et al. (1969) found that *Fusarium spp.* could not be isolated from soils with a heavy pine needle litter – this could concern the forests with close canopies of trees. However, other *Fusaria* (mainly *F. oxysporum* and *F. solani*) were often isolated from soil in forest nurseries (Dick and Dobbie, 2002).

These results indicate that the pitch canker pathogen does not survive well in soil, but it can persist long enough for this medium to be considered as a vehicle for spreading the disease to new areas (Gordon et al., 2004).

Entry of the organism into the European Union by the soil pathway due to human activities (forest visitors, campers, used silvicultural machines, and vehicles) is also possible. Even the low quantity of inoculum possibly getting into the EU territory (especially by inadequately cleaned vehicles) should be taken into consideration.

3.2.5.2. Natural dispersal

In addition to infected seed, *G. circinata* can also be disseminated by spores, which can be transported by a variety of agents such as wind, rain, insects, birds and other animals (section 3.4.1).

Though biological information from areas where the pathogen currently occurs clearly demonstrate that wind, rain and other weather-related events (hail, hurricanes, etc.) are effective means of dispersal of *G. circinata* spores, contribution of these events to entry of the organism into the European Union is very low, because of the large distance. The distance over which spores of *G. circinata* can be dispersed by wind or in water splash, was suggested to be at least midrange, i.e. larger than 200 m from any infected pine (Dwinell et al., 1981; Garbelotto et al., 2008).

Concerning insects, though it is well known that some insects are capable of long distance flight, especially during migrations (Greenslade et al., 1991), no data are available proving that insects mentioned among vectors of the pitch canker fungus would be able to fly overseas. However, the possibility that insects would contribute to the entry of the pathogen into the European Union, cannot be fully excluded.

Other potential carriers of the pathogen that were considered in New Zealand are possums, birds and livestock (Ganley, 2006). However, the entry of the pathogen from infested areas outside the EU into the EU territory by these means appears negligible.

3.2.5.3. Human activities

Humans (travellers, tourists, forestry workers and other forest visitors) can unintentionally spread spores of the pathogen on clothing, shoes and their equipment. This is especially important in case of direct movement of visitors from non-infested places to infested places. Forests, including pine forests, are frequently visited, not only by travellers and tourists but also by collectors of fruits, berries, mushrooms, truffles, cork, medicinal plants, firewood, plants for decorative purposes, etc. Hunting for game meat and pelts can also be considered as a human intervention and provides the possibility for spread of the disease within the EU. Special consideration should be given to visitors for recreation and especially to campers. Gadgil and Flint (1983) carried out a study of plant material and fungal spores carried in or on used tents and found that 74 % of them carried some plant debris. Potentially pathogenic fungi were present on this debris and live insects were found inside the tents. In 2005, there were more than 800 million international tourist arrivals globally, an increase of 5.5 % compared to 2004. It is estimated that the market for nature tourism is increasing at six times the rate of tourism overall (World Tourism Organization, 2006), indicating that the number of visitors in forests is high. However, information whether the visitors are coming from third countries infested by the pitch canker fungus is not available.

Machinery used in forests, either for cultivation, transport or for other purposes (e.g. trucks or tractors carrying wood or other forest products) may also carry spores of the pathogen from infested to non-infested areas. Special consideration should be given to used logging equipment imported from countries where the disease is present. According to the New Zealand Forestry Research Institute Quarantine Database records, considerable quantities of plant material and soil were found in some used logging machinery recently imported to New Zealand from the United States (Gadgil et al., 2003). Also vehicles (trucks, railway wagons, boats, etc.) or containers used in infested places, if not cleaned properly, could possibly be contaminated by soil, wood waste or any other carrier of the inoculum. Vehicles can transport and import insects, including insects carrying spores of the pathogen, unintentionally from infested areas outside the EU into the EU.

3.2.6. Conclusions on probability of entry

Rating	Description
Very likely	Based on the evidence provided the Panel reached the following conclusions: The pathogen is seed-borne, seeds of host plants are able to carry the pathogen both on their surface and in their internal tissues. Other means of propagation (seedlings and scions) are also able to carry the pathogen‟s propagules. Entry by the plant propagation material pathway is considered very likely. Different forms of wood material (saw logs, timber, lumber, wood chips, dunnage, pallets, packaging material, firewood, etc) originating from infested areas may contain and carry the pathogen into the European Union. The volume of trade of wood commodities originating from outside the European Union is considerable. The Panel considers entry by the wood pathway very likely. Plants and plant parts for decorative purposes (Christmas trees, branches, cones, etc.) may also contain and carry the inoculum. Entry by this pathway is considered very likely. Soil from infested areas and growing media containing infected pine bark can carry the inoculum. Entry by this pathway is considered likely by the Panel. Entry by natural means (wind, wind-blown rain, insects and other animals) is limited by geographical barriers (mainly by distance). Entry by this pathway is considered very unlikely. Entry by human activities (travellers, used silvicultural machinery, vehicles, etc.) in the means of soil, needles or wood debris adherent to objects of forest visitors or on used machines or vehicles or, by unintentional import of insects or animals carrying spores of the pathogen from infested places cannot be excluded. Entry into the European Union by this pathway is considered likely.

3.2.7. Uncertainties

Rating	Description
Medium	The place of origin (infested or non-infested area) and the end-use of pine nut consignments imported into the European Union are not known. The internet trade volume of host plant seeds and plant material for decorative purposes is unknown. The use of pine wood bark as a growing medium and soil conditioner is a common horticultural practice everywhere in the world. The growing media could possibly contain the pathogen but only limited data on the survival of the pathogen are available. Occasional entry by natural means (mainly by strong wind or wind blown rain, insects or birds carrying spores of the pathogen) cannot be excluded, but the quantity of the pathogen‟s propagules cannot be estimated. There is insufficient information on the survival of the organism in soil in the presence of host tissues. No disaggregated data have been found on the number of forest visitors from infested places and on the quantity of the pathogen‟s propagules adherent to objects, silvicultural machines, vehicles or unintentionally imported insects or animals.

3.3. Probability of establishment

3.3.1. Reports of *Gibberella circinata* in Europe

The pathogen has been reported in both nurseries and forests in several countries in the European Union namely Spain, France, Italy and Portugal. The locations of occurrence, retrieved from the 2007 and 2008 annual survey results provided by the European Commission for the presence of *G. circinata* or for evidence of infestation in the Member States are listed in Appendix 2 and displayed in Figure 1 of section 3.1.3.1.

3.3.2. Availability of suitable hosts in the European Union

Pathogens are primarily dependent on the presence and density of the host**.** Several of the *Pinus* species listed as hosts of *G. circinata* under the section 3.1.4 are widely present in the European Union both in the open (native forests, plantations, parks, etc) and under protected conditions (forest nurseries). The host *Pseudotsuga menziesii* is also present in the European Union but has scattered distribution only.

Data sets on the distribution or density of the main host, i.e. pine species, are not available on a European scale, but the distribution map of dominant host species (Figure 9) shows that hosts are present. The real distribution of the pine species should be wider because pines are grown everywhere in Europe as ornamentals in parks, public and private gardens, road rows, etc., or are present but not dominant in a forest.

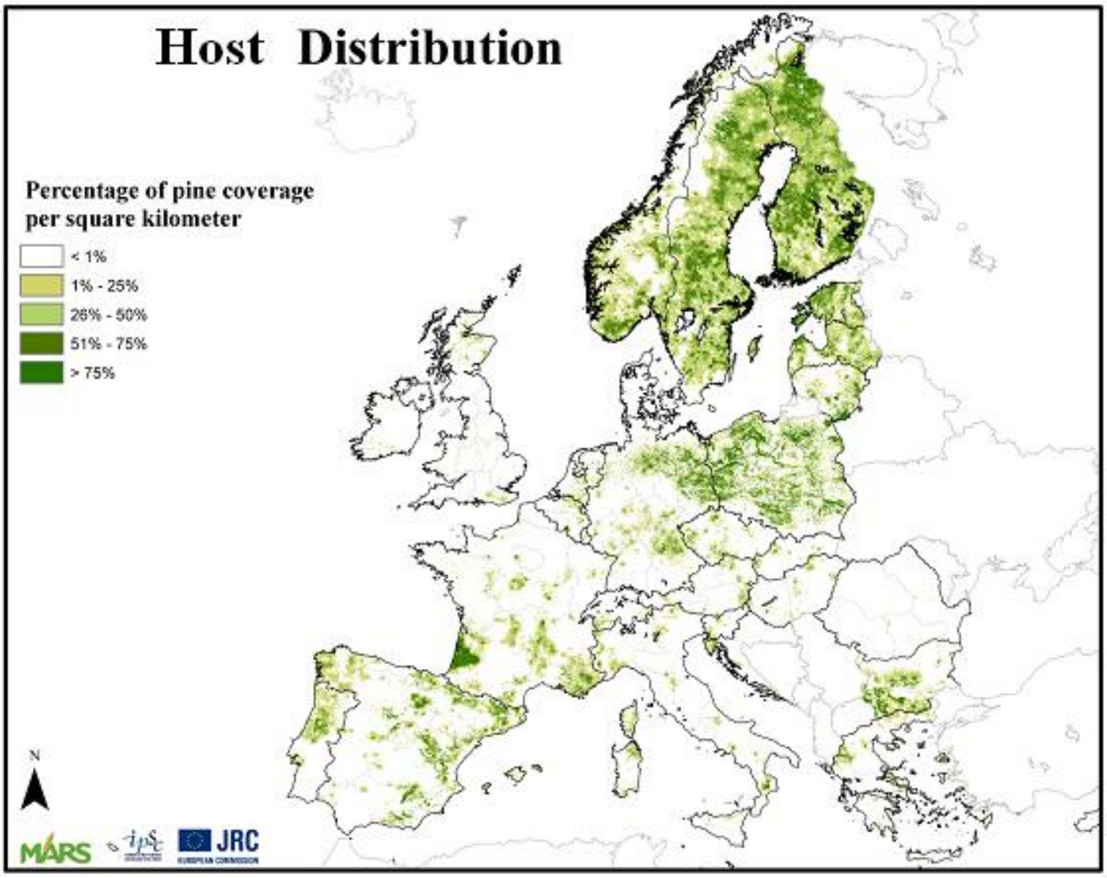

Figure 9: Geographical distribution of host species in Europe (*P. brutia, P. canariensis,P. cembra, P. contorta, P. halepensis, P. leucodermis, P. mugo, P. nigra, P. pinaster, P. pinea, P. radiata, P. strobus, P. sylvestris, P. uncinata* and *Pseudotsuga menziesii*). Map compiled by Joint Research Center – ISPRA based on JRC (2009a)

3.3.3. Suitability of environment

Prediction of environmental suitability for plant pathogens is complicated by the fact that the environment may affect not only the pathogen itself but also its host, including the host"s susceptibility to the pathogen. It is therefore inherently challenging to separate the effects of environmental factors affecting plant disease development into factors affecting the pathogen, the host and the host-pathogen interactions respectively.

Comparison of the global distribution patterns of pitch canker disease with another of the most devastating diseases of pine species, *Dothistroma* needle blight (caused by *Dothistroma* spp.) can provide information about environmental requirements for disease development. While the current world distribution of pitch canker is largely confined to Mediterranean and sub-tropical climates, with some extension into temperate climates (Ganley et al., 2009), this is in strong contrast to *Dothistroma* needle blight which has a cosmopolitan distribution that encompasses sub-arctic, continental, temperate, Mediterranean, sub-tropical and tropical climates (Watt et al., 2009). With a largely shared host range, the difference in geographical distribution of these two pathogens is an indication that these two pathogens have different environmental requirements.

In a recent risk assessment of pitch canker disease, Ganley et al. (2009) used the CLIMEX (Sutherst and Maywald, 1985) software to predict the global establishment potential of the disease as a function of climate using a global climate database (New et al. 1999). The predicted pitch canker establishment potential fitted well with the known disease distribution. For instance, CLIMEX predicted suitable to optimal establishment potential in regions known to have the disease, such as the south-east United States and Spain. However, the model predicted that the climate in California was only marginal to suitable for the disease, which fits with the observed lower frequency of natural infections and the strong association between disease incidence and insects in this area. Likewise Chile, which is known to have *G. circinata* in the nurseries but not in the plantation forests, was also predicted to have marginal to suitable conditions for disease establishment. Regions of China, Brazil, Australia, and New Zealand were predicted to have optimal conditions for pitch canker establishment. The analysis by Ganley et al. (2009) predicts that the climatic potential for establishment of pitch canker in the European Union is suitable to optimal in parts of Spain, France, Portugal, Italy and Greece (Figure 10).

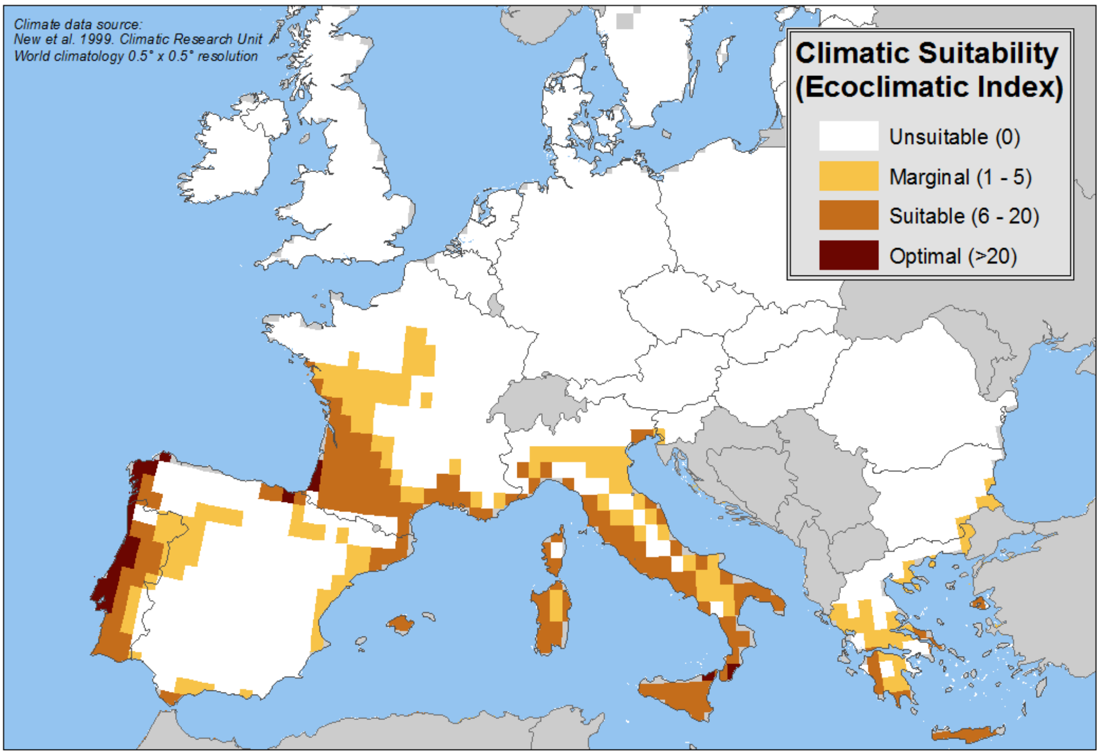

Figure 10: Map for Ecoclimatic Index reproduced after Ganley et al. (2009) for Europe; climatic dataset: 1961 – 1990; resolution: 30‟.

In order to examine the establishment potential in more detail for Europe, the CLIMEX analysis was repeated in the present risk assessment, using the parameters estimated by Ganley et al. (2009) (Table 1), with either higher resolution climate data input (New et al., 2002) (Figure 11) or more recent climate data input (JRC, 2009, European arable land climatology 1999-2007, 25 × 25 km resolution) (Figure 12).

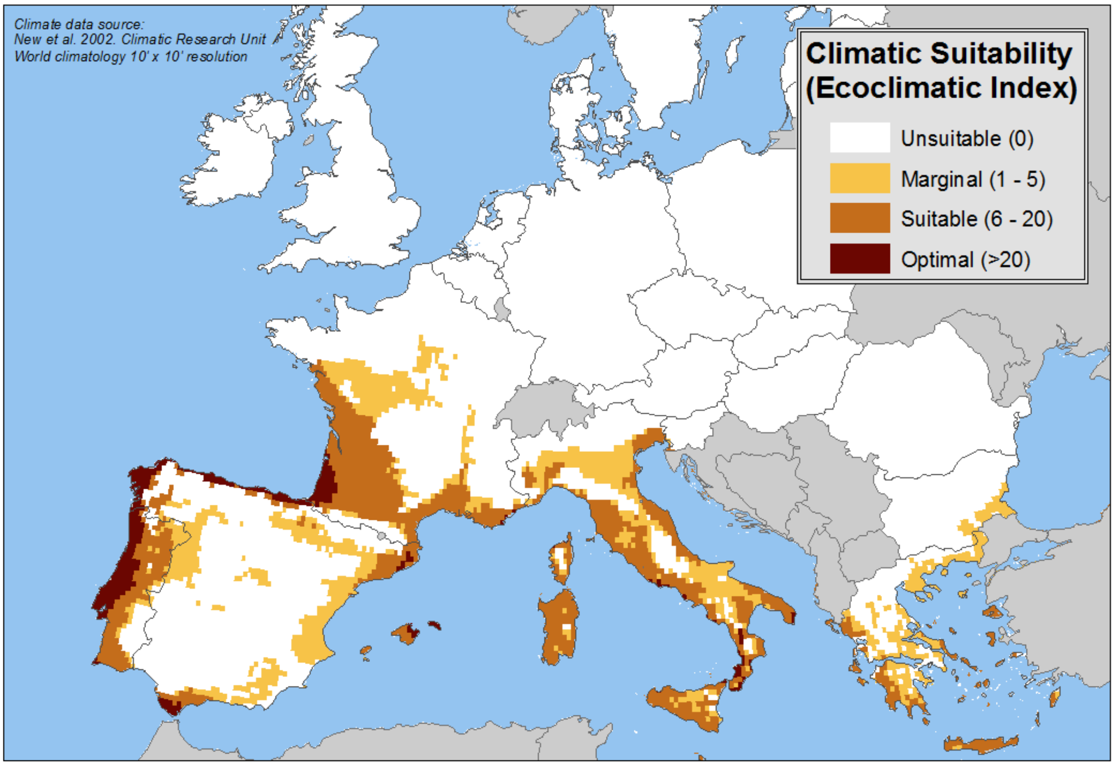

Figure 11: Map of Ecoclimatic Index generated by the CLIMEX model based on gridded climate data from: 1961 – 1990; resolution: 10‘‘

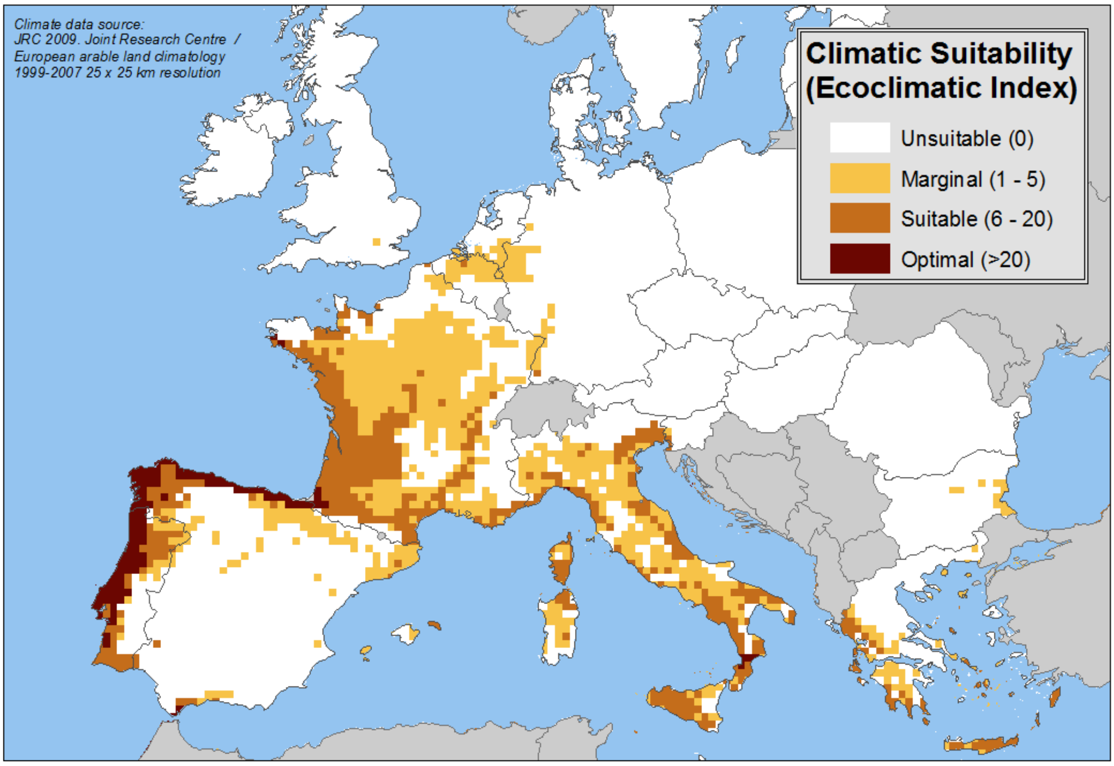

Figure 12: Map of Ecoclimatic Index generated by the CLIMEX model based on gridded climate data from: 1999 – 2007; resolution: 25 km

The higher resolution CLIMEX output (Figure 11) corresponds generally with the results in Ganley et al. (2009). However, in some regions the establishment potential is narrower and in other regions slightly broader compared to the lower resolution results (Figure 10). In general the high resolution map gives a slightly broader area which is predicted to have suitable climate conditions for the disease. This expansion is mainly coastal and specifically involves an increase of the predicted optimal areas around Portugal, Spain and France. Use of more recent data is generally desirable to reflect the current climate conditions in Europe. In collaboration with the EU Joint Research Centre, EFSA obtained climate data for Europe covering the time period 1999–2007 interpolated to a 25 kilometre grid. It should be noted that for estimation of climatic influence in general, climate conditions are commonly described over thirty year periods. This recent nine year weather average might therefore be affected by single-season deviations in weather conditions (atypical) compared to a normal thirty year climate averages. Visual comparison between the results displayed in Figures 11 and 12 mainly shows differences for the extent of the area with marginal suitability for establishment, which increases in Figure 12 by occupying new areas (especially in central and northern Europe) or areas which were considered suitable in Figure 11 (mainly in southern Spain and Italy); changes also occur in south-eastern Spain.

A summary of the results from the prediction of climatic establishment potential is provided in terms of area of land (km^2) in the European Union covered by the various categories (Table 6).

Table 6: Predicted climatic establishment potential in terms of area of land (km^2) for the three different interpolated climate databases used

Optimal (EI > 20)	1961 – 1990 (Low resolution)	1961 – 1990 (High resolution)	1999 – 2007
Portugal	17 300	21 368	26 613
Spain	8 440	20 340	25 181
France	2 944	9 432	3 515
Italy	2 614	5 152	2 051
Greece	0	0	82
EU	31 298	56 292	57 441
Suitable (EI: 6 – 20)			
Italy	110 458	120 406	81 997
France	96 274	112 023	146 378
Portugal	38 253	38 093	24 332
Spain	21 611	29 366	20 936
Greece	17 656	27 289	20 291
Germany			625
Malta		210	
EU	284 251	327 385	294 560
Marginal (EI: 1 - 5)			
France	87 306	69 066	227 914
Italy	68 190	81 779	121 531
Spain	60 548	91 372	51 299
Greece	35 720	43 437	21 465
Portugal	9 571	8 158	8 750
Bulgaria	1 251	7 898	5 403
Germany			13 125
Belgium			8 125
Netherlands			1 771
Cyprus			1 603
United Kingdom			625
EU	262 585	301709	461 611
(EI > 1)			
EU	578 135	685 387	813 612

Both the use of more recent climate data and increasing the spatial resolution in the analysis has the effect that larger areas of the European Union are predicted to have climate conditions favourable for establishment of *G. circinata* (Table 6) than when using older or lower resolution climate data.

Comparison of the locations in the European Union where *G. circinata* has been found with the predictions of climatic suitability shows that the reported locations are either within or very close to the grid cells predicted to be suitable or optimal for establishment *G. circinata*. There is one exception from this pattern; the case reported from Herrera de Pisuerga in the province of Palencia in the Castilla y León region in Spain. The case reported from Lubine in the Vosges department in Lorraine in northeastern France corresponds to an occurrence of the pathogen in a nursery. There is a similar case in the study of Ganley et al. (2009). Although it is stated by Ganley et al. (2009) that "The modeled climatic suitability for pitch canker establishment fit the known occurrences within North America well", the northeastern most occurrence of pitch canker in their map from North America falls within a cell predicted to be unsuitable. While such cases could be a sign of a shortcoming in the model, it should be pointed out that analyses performed at this regional scale, even at the 10'' resolution, will not reflect local climate conditions. As the gridded climate data represent the climate for the average altitude within the grid cell, there are climatic conditions within the grid cell which deviate from the average, resulting in either more adverse or more suitable conditions for establishment than those shown by the average Ecoclimatic Index (EI) for that grid cell. The more variable the topography, the less representative it will be, for the range of local climate conditions present within the grid cell. As illustrated in figure 13, showing the region of northern Spain with the topography added as background, the variation in altitude can be quite large at the 10'' grid cell size.

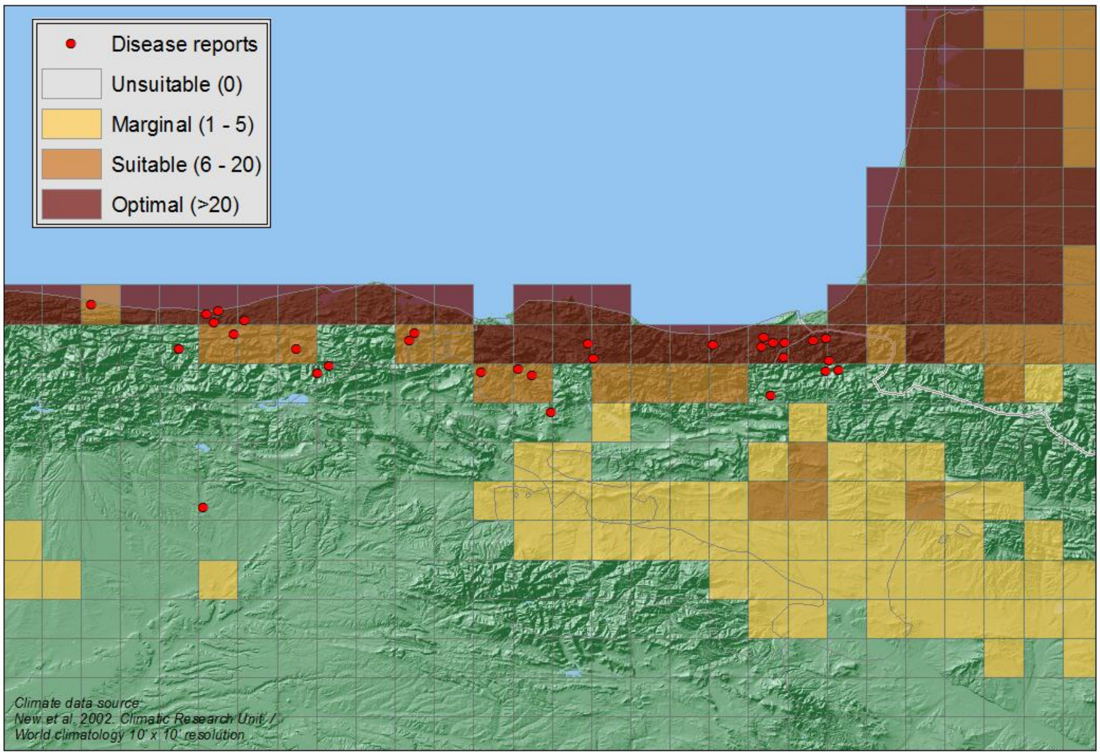

Figure 13: Detail of the map of Figure 12 showing the relationship between climatic suitability expressed as Ecoclimatic Index (EI) calculated by CLIMEX, elevation and reports on pitch canker disease

The choice of the EI thresholds for classification of the predictions of climatic establishment potential for *G. circinata* is based on Ganley et al. (2009). The interpretation of the EI classes is that in areas with "marginal" climate conditions for establishment, the variability between the years, will allow the pathogen to establish only when sufficient climate conditions are met. For the other two classes of "suitable" and "optimal", the climate conditions will in most and all seasons, respectively, be conductive to disease development.

Figures 10 to 12 clearly show that the "coloured" area is larger when the EI threshold is set to 1-5 than when it is set to 6-20 or >20; the lower the threshold, the larger the area predicted as favourable. When presence/absence data is available, the threshold value for predicting establishment could in principle be determined by receiver operating characteristic (ROC) analysis which takes account of the likelihood of misclassification in model predictions, i.e. the probability of false positive (location falsely predicted as suitable) and the probability of false negative (location falsely predicted as unsuitable). ROC analysis could be used to quantify the uncertainty in the model predictions of establishment potential. The possibility of performing this analysis was therefore explored in detail. However, the ROC analysis could not be performed appropriately due to several uncertainties and shortcomings in the data available:

i) the data set does not distinguish between establishment by infected seed or infection through other pathways;

ii) the CLIMEX analysis did not have local weather data available corresponding to the locality of pathogen observation; and

iii) the absence of an observation does not imply unsuitable climatic conditions (i.e. the pathogen may not have had a chance to establish at all locations).

In addition to climate, the current worldwide distribution of *G. circinata* is strongly affected by non-climatic factors. Host susceptibility has a key influence on the niche that the pathogen may realize (Hodge and Dvorak, 2000). Presence of suitable vectoring and wounding agents (section 3.1.6) can increase the incidence of pitch canker disease within its climatic range. Infection of the host by *G. circinata* takes place in the presence of wounds created either by insects through their feeding activity or by abiotic factors, such as weather-related injuries (wind, hail, etc.) and mechanical damage caused by silvicultural practices (e.g., pruning, cone harvesting, etc.) (Kelley and Williams, 1982; Dwinell et al., 1985; Dwinell and Barrows-Broaddus, 1982; Gordon et al., 2001). Wounds of abiotic origin are the primary points of infection in the south-east United States (Dwinell et al., 1985), while in California, insects are considered to be the main wounding agent (Correll et al., 1991). In South African pine seedling nurseries, a number of horticultural practices, such as transplanting, weeding, rough handling of seedlings during transplanting to plantations, may provide wounds which serve as infection sites (Hammerbacher et al., 2009). Cultural practices applied in pine nurseries, such as fertilisation, irrigation and tree density as well as various environmental stress factors, such as drought stress, water logging, shallow soils, air pollution, etc, have been shown to predispose trees to infection by *G. circinata* in the areas of the pathogen‟s present distribution (Blakeslee et al., 1999; Correll et al., 1991; Dwinell et al., 1985; Fisher et al., 1981; Fraedrich and Witcher, 1982; Runion and Bruck, 1986). Severe disease episodes have been observed on pines in close proximity to poultry farms, excessively fertilized pine plantations, stands fertilized and/or irrigated with nutrient laden industrial wastes (organic and inorganic), and intensively managed landscape environments such as golf courses (Barnard and Blackeslee, 1987). High levels of nutrients both in soil and foliage have been found to increase disease severity (Fisher et al., 1981; Blakeslee et al., 1999; Lopez-Zamora et al., 2007). In addition, host susceptibility to pitch canker increases during drought stress and water logging, especially when trees are planted at high densities (Dwinell et al., 1985; Runion and Bruck, 1986). High ozone concentrations have been shown to favour the development of pitch canker (Carey and Kelly, 1994). However, the extent to which environmental stress favours pitch canker epidemics is not clear, since epidemics have also occurred in the absence of stress (Dwinell et al., 1985). In the European Union, the CLIMEX analyses indicated that establishment potential were limited by cold stress in the latitude and altitude directions and by dry stress in the remaining areas predicted as unfavourable.

3.3.4. Endangered areas

To delineate the potentially endangered area within the European Union, the maps of climatic suitability (Figures 10 to 12) were compared to the geographical distribution of host plants (Figure 9). In the worst case i.e. using the marginal suitability from all maps, the endangered area for establishment of *G. circinata* will include:

i) wide areas of central and northern Portugal;
ii) northern and eastern Spain;
iii) south and coastal areas of France;
iv) coastal areas of Italy; and
v) parts of the coastal areas of Greece.

A less conservative delineation of the endangered area would be to restrict it to the areas where host plants are growing and where climate conditions are predicted to be suitable to optimal for pathogen establishment. In this area the pathogen can be expected to cause pitch canker disease on a frequent to regular basis. By this approach the endangered area will largely remain the same, except for France where the endangered area will be more constrained to the southwestern part of the country and its Mediterranean coast and in Spain where the endangered area will be restricted to areas along the northern coast only.

Because the Panel does not have access to the data behind Figure 12 (provided by JRC as a graph without spatial reference), this comparison cannot be done computationally in a GIS which would have produced a data set with the areas both having suitable climate for establishment of the pathogen and susceptible host plants.

3.3.5. Cultural practices and control measures

As described in section 3.3.3, cultural practices during production of the host are likely to have a high influence on the ability of *G. circinata* to establish in the European Union. While cultural practices altering the environment (e.g., fertilisation, irrigation and tree density) make conditions more favourable for disease development, the cultural practices altering the host itself (e.g., transplanting, weeding, pruning, cone harvesting, etc.) are even more important because such handling of plants may cause wounds which may serve as infection sites for the pathogen.

Since there seem to be no major differences in the cultural practices used in the current area of pest distribution outside the EU compared to the ones currently applied in the European Union, their influence on establishment is comparable.

3.3.6. Other characteristics of the pest affecting establishment

The effect of inoculum load on the development of the disease has been studied in both the south-east United States and California, with varying results. Storer et al. (1999) found that as few as 25 spores (microconidia) could initiate infection, although the lesions produced were smaller compared to those produced by 125 spores or more. In greenhouse studies, when Gordon et al. (1998) used 25 and 2,500 spores and Hodge and Dvorak (2000) used 50,000 and 100,000 spores for the artificial inoculation of various pine species, no consistent correlation between disease severity (lesion length) and spore load was found. Bonello et al. (2001) successfully inoculated 2-year-old trees and 4-year-old cuttings using 50-250 spores per inoculation site. Similarly, Hammerbacher et al. (2009) showed that under optimal environmental conditions, there were no significant differences in disease incidence in plants inoculated with 5, 50 or 500 spores per ml. Gordon et al. (1998) and Hodge and Dvorak (2000) showed that host resistance is not dependant on inoculum dose.

Altogether, it is likely that small populations of the pathogen may initiate infection of susceptible host trees. However, irrespective of the inoculum load present in an area, infection will not take place in the absence of wounds or other openings on the host.

3.3.7. Conclusion on probability of establishment

Rating	Description
Very likely	Based on the evidence provided the Panel reached the following conclusions: The Panel considers the probability of establishment of *G. circinata* in the European Union as very likely based on the following evidence: - the pathogen has been reported at some locations in the European Union, in Spain, Italy, France and Portugal; - hosts are present: *Pinus* spp. are widely present in the European Union, while *Pseudotsuga menziesii* has scattered distribution only; and - climate conditions are suitable in parts of the European Union. According to the CLIMEX analysis (validated for *G. circinata* at a global level by Ganley et al. in 2009), and considering all the areas where host plants are grown in the European Union, the endangered areas include: - wide areas of central and northern Portugal; - northern and eastern Spain; - south and coastal areas of France; - coastal areas of Italy; and - parts of the coastal areas of Greece. In these areas no limitations to establishment have been identified. The climate suitability tends to decrease from the coastal areas to the centre of Europe. The climatic establishment potential is limited by cold stress at high latitudes and altitudes and by dry stress in the remaining parts of the European Union predicted to have unfavourable climate conditions for the pathogen. No other obstacles to establishment seem to occur.

3.3.8. Uncertainties

Rating	Description
Medium	The pest reports do not demonstrate that the pathogen can establish in adult forests because they do not specify whether the disease originates from contaminated seed (or seedlings) or natural infection. It is therefore not possible to judge from the reports whether infection and disease development has taken place at the actual reported location. For this reason, CLIMEX output could not be validated. The present analysis operates on a regional scale. Prediction of establishment potential at a local scale would require local climate data as model input. Although all maps show that the pathogen can establish in several areas of Europe, the endangered area cannot be defined exactly: the size of the endangered area increases when the CLIMEX model is operated with increasing spatial resolution and more recent climate data. The most recent climate data used in the analysis (1999-2007 obtained from JRC)

	are computed to represent average climate conditions for the average altitude in arable areas only within the grid cells, in contrast to the two other climate data sets produced by New et al. (1999, 2002) which use the overall average altitude. This may be inappropriate for a forest pathogen, and may also introduce some bias into the CLIMEX approach which normally relies on standard meteorological conditions.

3.4. Probability of spread after establishment

3.4.1. Spread by natural means (wind, wind-blown rain, insects and other animals)

In addition to vertical dissemination through infected seed, *G. circinata* can be disseminated horizontally by spores, which can be transported by a variety of agents such as wind, rain, insects and other animals. For horizontal transmission, successful infection only occurs in the presence of wounds or openings on the trees; intact tissue is not vulnerable to invasion by the fungus (Sakamoto and Gordon, 2006; Kuhlman, 1987). In general, insects, weather or mechanical damage can cause wounds (Ganley, 2006).

Biological information from areas where the organism currently occurs clearly demonstrate that wind, rain and other weather-related events (hail, hurricanes, etc.) are effective means of dispersal of *G. circinata* spores. In the south-east of the United States, spores transferred to the wounds associated with these weather-related events are considered to be of primary importance as infection source (Dwinell et al., 1985; Kelley and Williams, 1982; Blakeslee et al., 1979; Kuhlman et al., 1982; Dwinell and Phelps, 1977).

Airborne spores of *G. circinata* are present in high densities in the infested areas (Schweigkofler et al., 2004; Kuhlman et al., 1982; Blakeslee et al., 1979; Correll et al., 1991) throughout the year, with peaks in the autumn and winter months (Kratka et al., 1979; Kuhlman et al., 1982; Garbelotto et al., 2008). Moreover, there is no evidence of diurnal patterns of dispersal (Blakeslee et al., 1979). These spores deposit on both symptomatic and asymptomatic trees (Adams 1989; Garbelotto et al., 2008) at high rates (up to 1.3×10^5 spores m^2): 52 % of wounded *P. elliottii* and *P. taeda* seedlings placed under infected trees in a seed orchard developed pitch canker because of natural infection by airborne spores of the pathogen (Kuhlman et al., 1982). The distance spores can be dispersed by wind or in water splash was suggested to be at least midrange, i.e. larger than 200 m from any infected pine (Blakeslee et al., 1979; Dwinell et al., 1981; Garbelotto et al., 2008).

The role of insects is twofold: infections can be initiated by insect-borne inoculum or by inoculum already present on the branch surface, with the insect serving as a wounding agent. In the first case the insect is truly a vector for spread, while in the second case the insect favours disease establishment. The fact that insects become contaminated with the pathogen does not prove that they serve as vectors of the disease in nature: their role may be limited to carrying spores of the pathogen or opening wounds in trees, allowing spores carried by wind or rain to enter the host (McCain et al., 1987).

Numerous insects are capable of causing wounds or carrying *G. circinata* spores (Gordon et al., 2001; Storer et al., 1997; McNee et al., 2002; Blakeslee and Foltz, 1981; Hoover et al., 1996; Fox et al., 1991), such as twig and cone beetles (*Pityophthorus* spp., *Conophthorus radiatae, Ernobius punctulatus*), tip moth (*Rhyacionia* spp.), deodar weevil (*Pissodes nemorensis*), spittlebugs (*Aphrophora canadensis*), and bark beetles (*Ips* spp.) (Correll et al., 1991; Hoover et al., 1995, 1996; Matthews, 1962; Blakeslee et al., 1978; Storer et al., 1997; Fox et al., 1990, 1991). Furthermore, many less obvious pathways involving parasites, predators, and other gallery associates of the known vectors may also serve to transfer *G. circinata* between host species (Dallara, 1997; Gordon et al., 2001). However, spread of the pathogen by these insects has not been experimentally demonstrated (Fox et al., 1990, 1991; Storer et al., 1995). Moreover according to Wingfield et al. (2008) the association of insects with pitch canker varies from region to region and is likely to reflect complex interactions between the host, insect wounding agents and/or vectors, and the environment.

Insects may also play an important role in dissemination of the pathogen, provided that cyclic outbreaks of the disease were associated with damage caused by them. The deodar weevil has been found to carry the fungus in Florida and, in laboratory studies, infection of pine seedlings has been clearly linked with the presence of artificially-contaminated weevils (Blakeslee et al., 1978). In California, twig and cone beetles (*Pityophthorus* spp., *Conophthorus radiatae, Ernobius punctulatus*) are considered to be the primary agents of the pathogen"s spread. According to Storer et al. (1997) and Fox et al. (1990; 1991), bark beetles (*Ips* spp.) may also spread the fungus. The pathogen has also been isolated from other insect pests of *P. radiata*, but dispersal by these insects has not been demonstrated (Fox et al., 1990, 1991; Storer et al., 1995).

Insect-mediated infections are a key element in the pitch canker disease cycle (Figure 2) in California (Hoover et al., 1995; 1996; Gordon et al., 2001). Four species of twig beetles (*Coleoptera: Scolytidae*) have been shown to carry *G. circinata*, with average percentage contamination of 5 to 38 % of beetles (adults or larvae) (Dallara, 1997; Hoover et al., 1995, 1996; Storer et al., 2004). Similar documentation has been obtained for the vectoring activity of the engraver beetles (*Ips* spp.) (Fox et al., 1991; Erbilgin et al., 2008): the mean percentage of insects carrying propagules was 11 to 18 % and the mean propagule load of trapped insects was over 200 (Erbilgin et al., 2008). *Pityophthorus* spp., which preferentially colonize branches, are presumed to be important in the establishment and early intensification of the disease (Gordon et al., 2001), while engraver beetles are presumed to be responsible for carrying the pathogen to larger diameter branches and tree trunks, as this is the type of material in which they normally establish galleries. Finally, the spittlebug, *Aphrophora canadensis* (*Homoptera: Cercopidae*), has been shown to act as a wounding agent capable of initiating infections in internodal regions on succulent shoots during the late winter and early spring (Storer et al., 1998b). In contrast to California, in the south-east United States insects are accorded a comparatively minor role in the epidemiology of pitch canker (Gordon et al., 2001): the disease is mainly thought to occur from weather related events and mechanical damage rather than through insects (Ganley, 2007: Wingfield et al., 2008).

In Chile where pitch canker only occurs in nurseries (Wingfield et al., 2002a; Viljoen et al., 1995) and in South Africa where after several years it has also been found in forest plantation (Coutinho et al., 2007), the low frequency of suitable insect wounding agents/vectors has been considered one of the causes for the low likelihood of infections (Ganley, 2006; Wingfield et al., 2002a). Most of the insects likely to act as vectors or wounding agents are not found in South Africa, reflecting the fact that pines are not native to this part of the world (Gordon et al., 2001). In New Zealand, 150 species of insects have been recorded on *P. radiata* but those insects closely associated with pitch canker in the United States are not present. It is possible that many of these insects may be able to carry the inoculum but, as the majority would not feed or create suitable wounds, the likelihood of disease establishment would be low unless favourable wound conditions were encountered (Ganley, 2006). In Australia, none of the insect species known to spread pine pitch canker in North America are present (Gadgil et al., 2003).

Ganley (2006) reported that in addition to insects, in New Zealand, possums, birds and livestock are considered as potential wounding agents and carriers of the pathogen. Possums are known to cause substantial damage to young plantations of *P. radiata*. Livestock running through plantations could create wounds on the roots of host plants. Birds would be unlikely to have an effect on the establishment on pitch canker infections unless they bent branches or caused considerable damage with their beaks or claws to the branches. It is unknown if possum fir and bird feathers could carry pathogen.

3.4.2. Spread by human assistance

Spread by human assistance could happen with commodities or conveyances, also by travellers or tourists, intentionally or unintentionally.

According to the Commission Decision 2007/433/EC on provisional emergency measures to prevent introduction into and spread within the Community of *G. circinata*, movement of host plants within the Member States is possible only from areas regularly surveyed and free of the pest. In spite of this regulation, new findings of pitch canker occurred in the EU (see section 3.3.1). Nothing is known about the inoculum sources for these outbreaks, but the within EU spread of the pathogen cannot be excluded.

Spread within the EU territory may occur by movements of:

i) pine seed and other propagation material (e.g., seedlings, scions, etc.);
ii) Christmas trees, branches, cones and other items for decorative purposes;
iii) mailed items;
iv) soil and growing substrates containing pine wood bark;
v) wood bark per se;
vi) wood commodities; and
vii) wooden packages.

According to EUROSTAT (2008a), within the EU 27, for 2008, the import trade volume of living Christmas trees was 35,180 tonnes, while the export trade volume was 69,275 tonnes. However, the volume of commodities that are originated from infested places is unknown. In 2006, the total import of pine saw logs and veneer logs of EU Member States was 3.919 million m^3. Export of the member states concerning pine saw logs and veneer logs in 2006 was 5.404 million m^3 (EUROSTAT, 2008b). Also in this case, the countries from which the EU Member States are importing and to which they are exporting are unknown. However, it is obvious that the volume of movement is high and spreading by these commodities cannot be excluded.

Humans (travellers, tourists, forestry workers and other forest visitors) can unintentionally spread spores of the pathogen on clothing, shoes and their equipment. This is especially important in case of direct movement of visitors from infested to non-infested places within the EU territory.

According to EUROSTAT (2007), the estimation of the average number of forest visitors in a number of European countries in mid 1990‟s was totalling 1,172 million people in Austria, Denmark, Finland, Ireland, Italy, Netherlands, Portugal, Sweden, Switzerland and United Kingdom and altogether 227.9 millions in the Czech Republic, Lithuania, Serbia and Montenegro and Turkey. Some of these countries belong to the European Union. The estimations represent numbers of visitors before the occurrence of *G. circinata* in Europe and do not provide exact information on the visitors of forests in particular countries, it shows that the number of forest visitors was high in that time and probably even higher nowadays. Moreover, at present, the European forest sector employs about 3.5 million people (UN, 2005), part of them being involved directly in silvicultural activities could spread unintentionally spores of the pathogen.

Machinery used in forests for cultivation, transport or for any other purpose may also spread the pathogen to other, non-infested parts of the forest or to other countries within Europe. From the viewpoint of spreading the spores to other host plants within Europe, the most dangerous pathway is provided by those machines and trucks that are used in the process of eradication of infected plantations or nurseries, unless properly cleaned and disinfected. Unfortunately, no data are available on the number and movement of forest cultivation machines, truck and tractors, etc.

3.4.3. Containment of the pest within the European Union

G. circinata spreads naturally by air-borne spores, which are present throughout the year in high density where the disease is present; spores can be also carried by insects and other animals (see section 3.4.1). As a consequence, there is no practical way to prevent spore dispersal by natural means.

The fungus can also spread by means of the mycelium present in infected wood parts (especially in bark), in plant debris and in soil. The spread by mycelium can be mitigated by regulations limiting the movement of these items. However, natural spread of small infected wooden particles and debris in the dust driven by wind can not be prevented.

The spread by human assistance (see section 3.4.2) cannot be fully prevented but it can be mitigated by regulations.

3.4.4. Conclusion on probability of spread

Rating	Description
Very likely	Based on the evidence provided the Panel reached the following conclusions: The probability that the pathogen can spread by natural means is considered very likely. Wind, rain and wind-related events can create wounds on host plants and spread *G. circinata* spores in the territory of European Union. Moreover, insects have been identified as potential wounding agents, vectors and carriers of the pathogen, therefore favouring spread of the disease. In addition, there are no natural barriers to prevent propagules of the pathogen or insects carrying the pathogen to spread from an infested area to a non infested area. The probability that the pathogen can spread by human assistance (by trade or humans themselves or by machines) is considered very likely. Commodities composed of host plant species material like wood, growing substrates (e.g. bark), Christmas trees, and others are widely spread and traded. Travellers, tourists, forest visitors for recreational activities or minor economic activities (gathering of mushrooms, berries, etc.) are numerous. Contaminated machinery used in forests may also contribute to spread, particularly machines and trucks used in the process of eradication of infected plantations or nurseries, unless properly sanitised.

3.4.5. Uncertainties

Rating	Description
Medium	Spread of *G. circinata* in the European Union by weather related events has not been studied, and the conclusion was made by transferring knowledge from other already infested areas outside Europe. Data from spread of the inoculum by wind and wind-blown rain were obtained by using spore traps, and those records have a certain level of inaccuracy. The evidence that insects can carry spores on their body is robust, and transmission of the disease has been demonstrated for some but not all of the insects. The role of other animals in carrying the spores is still unclear. Concerning spread by human assistance, the main sources of uncertainty are the lack of data on the internal trade for some commodities, and incomplete information on movements of forest visitors and machines.

3.5. Assessment of potential consequences

Pitch canker is a destructive disease of pines in many parts of the world where it occurs naturally or has been introduced some time ago (Hepting and Roth, 1953; McCain et al., 1987; Muramoto and Dwinell, 1990; Santos and Tovar, 1991; Viljoen et al., 1994; Dwinell et al., 2001; Wingfield et al., 2002a; Landeras et al., 2005; Carlucci et al., 2007; Coutinho et al., 2007). For its devastating nature, this disease was compared to pine blister rust and pine wood nematode, two pests that have caused substantial devastation in the United States and Asia, respectively (Wingfield et al., 1998).

In the south-east United States, the disease was first recorded in 1945 on *Pinus virginiana*, *P. echinata* and *P. rigida* (Hepting and Roth, 1946) and is currently known to occur from Florida to as far north as Virginia and westwards to Texas, primarily in stands of *P. elliottii* and *P. virginiana*.

(Dwinell et al., 1985; Ridley and Dick, 2000). In these regions, pitch canker occasionally causes epidemics (Blakeslee et al., 1979; Dwinell et al., 1985). In 1974 shoot dieback caused by the fungus reached epidemic proportions (Dwinell and Phelps, 1977; Blakeslee and Oak, 1979; Kuhlman et al., 1982; Barrows-Broaddus and Dwinell, 1983), and disease levels remained high until 1979; although the 1974-79 epidemic subsided, pitch canker continued to be a problem. In the south-east United States, the disease causes economic losses only in managed stands, such as seed orchards and it is only rarely a problem in native pine stands (Blakeslee et al., 1979). It was estimated that more than 550 million acres of slash pine were infected, with an average incidence of 13.6 % per affected stand (Dwinell et al., 1985); the volume of planted *P. elliottii* lost due to the disease was estimated to be from 385,000 to 870,000 m^3 annually. It was also estimated that 2.5 to 3.4 million logs could not be used for solid timber products because of stem malformation. In *P. elliottii* plantations, the mean annual volume increment for infected trees was 60-81 % of that of the healthy trees (Arvanitis et al., 1984).

In California, the pitch canker fungus was first recorded in 1986; the most severely affected area was in Santa Cruz County, where *G. circinata* caused branch dieback in *P. radiata*, *P. muricata*, *P. pinea* and *P. halepensis* (McCain et al., 1987). Initially, the disease appeared to be limited to landscape plantings, but by 1992, it was found to occur in native populations of *P. radiata* on the Monterey peninsula (Storer et al., 1994). Pitch canker now occurs throughout the coastal regions of California, from San Diego in the south, to Mendocino County north of San Francisco (Gordon et al., 2001). Unlike the disease distribution in the south east of the United States, pitch canker in California appears to be confined to near-coastal regions, with the exception of one site in the Sierra Nevada (Vogler et al., 2004). The severity of the disease in coastal California has been attributed to favourable biotic and abiotic conditions for infection (Gordon et al., 2001). In 1992, it was reported that 5 % of *P. radiata* Christmas trees died due to pitch canker (Storer et al., 1995).

In South Africa, *G. circinata* first appeared in a single forestry nursery in 1990, causing a root disease on *P. patula* seedlings and cuttings (Viljoen et al., 1994). Since this initial outbreak, *G. circinata* has now spread to most pine-growing forestry nurseries in South Africa, where it currently represents the most important pathogen of *Pinus* spp. in the nurseries (Britz et al., 2005). Therefore, *G. circinata* has a serious impact on pine production in South Africa (Wingfield et al., 2002b).

More recently, pitch canker has been discovered in established plantations of *P. radiata* in the Cape Peninsula (Coutinho et al., 2007). The slow establishment of pitch canker from the nurseries to plantations in South Africa is probably due to a variety of different factors including climate, low initial levels of airborne inoculum, absence of effective insect vectors and wounding agents, and the lack of associations between native biota and the plantation trees.

In 2002, the pitch canker pathogen was reported from Chile where *P. radiata* nursery seedlings and clonal hedge plants were affected (Wingfield et al., 2002a). Although symptoms typical of pitch canker have been observed on older trees in plantations in that country, those trees were probably planted from infected nursery stock. There is no evidence that pitch canker has become established as a plantation disease in Chile, but it seems likely this will eventually occur, as it has in South Africa. The risk in Chile is heightened by the fact that the highly susceptible *P. radiata* is widely planted in that country (Wingfield et al., 2002a), the planted surface and the equivalent volume totalling 1,387,041 hectares and 198.3 millions m^3 in 1996, respectively (FAO, 1998).

Hepting and Roth (1953) noted that the disease was abundant in Haiti on *P. occidentalis*. In the late 1980s, pitch canker was reported to cause trunk cankers and dieback of *P. luchuensis* on the islands of Amamiooshima and Okinawa in Japan (Kobayashi and Muramoto, 1989). In Korea, the disease was also found in pine plantations (Lee et al., 2000). Of the Korean hosts, *P. rigida* and *P. thunbergii* showed sensitivity to the organism in a pathogenicity test. In Mexico, the disease is prevalent on planted *P. radiata* and *P. halepensis* and in natural stands of *P. douglasiana*, *P. leicophylla*, *P. durangensis* and other pine species (Santos and Tovar, 1991; Guerra-Santos, 1999). Further spread of *G. circinata* is of great concern to many countries such as Australia and New Zealand, where highly susceptible *P. radiata* is grown extensively in plantations (Dick, 1998).

3.5.1. Pest effects

The impact of pitch canker involves both direct and indirect effects.

3.5.1.1. Direct pest effects

As indicated by Correll et al. (1991) direct effects of the disease include:

i) tree mortality;
ii) reduced growth;
iii) reduced lumber quality;
iv) reduced cone yield and seed contamination in seed orchards; and
v) seedling mortality in nurseries.

In general, the frequency of mortality is unclear as many trees are removed before they have died when the landowners consider they pose a safety risk or are aesthetically unpleasing (Gordon et al., 2001; Wikler et al., 2003a). However, up to 24 % of mortality from pitch canker has been reported in infected *P. elliottii* stands (Dwinell et al., 1985). Most of the *P. elliottii* infected trees remain alive, but losses in growth and quality are very serious (Dwinell and Phelps, 1977): mortality and growth suppression has been reported to cause 4.5 % (Arvanitis et al., 1984) of reduced volume growth per year and 21 % (Blakeslee and Oak, 1979) of harvest yield. Growth suppression alone has been reported to account for 60-80 % of the wood volume lost per year (Arvanitis et al., 1984; Dwinell et al., 1985). Trees with repeated infections grow proportionally less (Arvanitis et al., 1984). The above figures do not necessarily include losses from reduced lumber quality. Mortality or deformation of *P. radiata* trees in Christmas tree plantations in California has also been problematic: in 1992, 5 % of *P. radiata* Christmas trees died due to pitch canker in California, although the number rendered unusable is unknown (Storer et al., 1995). The disease was a major problem in *Pinus* spp. seed orchards where substantial losses in seed crops were incurred (Kuhlman et al., 1982; Dwinell et al., 1985); at least part of an 86 % decline in cone yield has been ascribed to pitch canker in one loblolly pine seed orchard in Mississippi (Dwinell et al., 1977). However, the impact on cone yield appears to vary from orchard to orchard and no definitive conclusion can be drawn concerning the influence of shoot dieback on cone production (Dwinell et al., 1985). For instance, 28 % reduction in cone yield in the affected orchard was attributed to pitch canker in South Carolina (Dwinell et al., 1985). In addition, 24 to 88 % of the seed produced in affected orchards were infected by *G. circinata*, these percentages being correlated with the disease in the affected orchard (Carey et al., 2005). In nurseries, losses can be extremely high from either pre- or post-emergence mortality from contaminated seed or soil, or the mortality of older seedlings from airborne inoculum (Dwinell et al., 1985; Viljoen, et al., 1994).

Trees are able to apparently recover in the absence of new infections: in stands with a long history of pitch canker, 30 % of the trees remaining in a monitoring plot had indications of disease remission (Owen and Adams, 2001), but in areas where pitch canker became established more recently, smaller percentages of trees showed signs of remission (Gordon et al., 2001). However, the proportion of trees capable of expressing disease remission may be higher than these data suggest because many trees were removed prior to their death (Gordon et al., 2001). In addition, persistence of the remission effect is not yet known (Gordon et al., 2001).

Since its initial discovery in 1945, pitch canker has become one of the most important diseases of pines in the world. There is little doubt that the disease seriously threatens plantation forestry worldwide, especially where there is a strong reliance on highly susceptible pine species. The appearance of *G. circinata* in plantations in South Africa, along with its presence in nurseries in Chile, substantially enhances this threat. The same accounts for northern Spain, where *G. circinata* has been reported as the causal agent of a severe root disease of nursery seedlings of exotic *P. radiata* and *P. pinaster* (Landeras et al., 2005; Pérez-Sierra et al., 2007). Pitch canker symptoms were also reported on *P. radiata* plantation trees. In Italy, pitch canker has recently been reported on *P. halepensis* and *P. pinea* (Carlucci et al., 2007). In spite of this, the negative effects of the pitch canker in the European Union are difficult to predict because symptom expression and disease severity are strongly correlated with host susceptibility and distribution, as well as prevailing biotic and abiotic conditions: the disease is quite dynamic and every outbreak in a particular area usually has a unique case history (Wingfield et al., 1998). As previously mentioned, the manifestation of pitch canker in the affected areas worldwide is variable (Gordon et al., 2001), and according to Devey et al. (1999) the potential impact of pine pitch canker on *P. radiata* in New Zealand is problematic, given the large number of unknowns and major differences between *P. radiata* grown in New Zealand and native and planted stands in California. In addition, losses caused by pitch canker in a new area could be higher than in an area where the disease is endemic, because the initial phases of an epidemic caused by this exotic pathogen may suffer of a nearly complete lack of resistance in the host population (Aegerter and Gordon, 2006).

Potential for pitch canker control in the European Union does not seem different of that in the already infested areas. At present, there is no single means of controlling pitch canker in nurseries and forest plantations (see section 4). Presence of resistance to pitch canker within genotypes of European pine populations has not been investigated. No effective plant protection products are available against this pathogen to be applied to large trees (Tjosvold and McCain, 1988; Runion et al., 1993); an additional problem is that maintaining a sufficiently high concentration of the active ingredient on all susceptible surfaces would be problematic (Gordon et al., 2001). Some fungicides and biocides (like sodium hypochlorite or hydrogen peroxide) have only a limited effect in nurseries (Runion and Bruck, 1988; Kuhlman and Cade, 1985; Dwinell, 1998). This is also the case for the common soil borne bacteria *Arthrobacter* spp. which has been investigated as bio control agents (Barrows-Broaddus and Dwinell, 1985b). Populations of insect acting as vectors and/or wounding agents are equally very difficult to control through insecticides. Furthermore, because the insects involved all contribute to the decomposition of wood, any large-scale effort to reduce their numbers would be difficult to justify (Gordon et al., 2001). Pruning initial branch infections, removal of heavily infected trees, and changing cultural practices for preventing and/or reducing the effects of pitch canker in pines planted in urban settings, in plantations or, more, in native stands are difficult to be changed and have a limited effectiveness (Wingfield et al., 2008). Only an integrated management approach can reduce the impact of the disease, which includes adequate phytosanitary measures, appropriate nursery and silvicultural management, and genetic selection for clones of species that are less susceptible to the pitch canker pathogen (Wingfield et al., 2008).

For evaluating the potential direct effects of pitch canker in the European Union it must be considered that:

i) pine and Douglas-fir are widespread in the European Union, not only in forests and silvicultural stands, but also in roadsides, ornamental tree plantations and gardens (see section 3.3.2.);
ii) the amount of managed stands in the European Union is considerable and these are more susceptible to pitch canker than the native pine stands;
iii) direct effects of the disease can be devastating and include tree mortality, reduced growth, reduced lumber quality, reduced cone yield and seed contamination in seed orchards, and seedling mortality in nurseries;
iv) climatic conditions are conducive for the pathogen in several areas (see section 3.3.3.);
v) the potential endangered area resulting from combining host distribution map and climate suitability map is wide (see section 3.3.4.);
vi) survival of *G. circinata* seems to be possible in infested soil and infected wood as both mycelia and conidia, under a wide range of conditions (see section 3.4.);
vii) spread by both natural vectors and soil is possible, as well as movement of infected plant materials and human activities (silviculture, camping, recreation, etc. see section 3.4.);
viii) the existing control measures will not control pitch canker in nurseries and forest plantations.

3.5.1.2. Indirect pest effects

G. circinata directly affects pine wood and seed yields and quality, but it may also have indirect, environmental side-effects. *G. circinata* was listed as a significant agent of biological disturbance in forests, which can increase the probability of fires (Ayres and Lombardero, 2000). In addition, pitch canker can reduce recreational uses, tourism, and aesthetic amenity of the affected forests (Templeton et al., 1997). This latter effect is of relevant concern (Bell et al., 2007).

3.5.2. Conclusion of the assessment of consequences

Rating	**Description for *G. circinata***
Massive	Based on the evidence provided the Panel reached the following conclusions: The pitch canker disease seriously threatens forestry plantations in areas of the world where the climatic conditions are suitable for its development. The most important potential impacts include tree mortality, reduced growth, reduced lumber quality, reduced cone yield, seed contamination in seed orchards, and seedling mortality in nurseries. The disease causes losses mainly in managed stands and is less frequently a problem in native pine stands. In addition, pitch canker can reduce recreational uses, tourism, and aesthetic amenity of the affected forests as well as parks and gardens. Cultural practices during production of the host are likely to influence the ability of *G. circinata* to establish in the European Union. Cultural practices altering the environment make conditions more favourable for disease development; cultural practices aimed at handling the trees may open wounds which serve as infection sites for the pathogen. Since there seem to be no major differences in the cultural practices used in the current area of pest distribution outside the EU compared to the ones currently applied in the European Union, their influence on establishment is comparable.

3.5.3. Uncertainties

Rating	**Description for *G. circinata***
High	Pitch canker has different relevance in the different areas of the world where the disease is present or has been introduced some time ago. In the European Union, this uncertainty strongly depends on the: i) susceptibility level of the host species present in each area, their prevalence and geographical distribution; ii) presence and abundance of the insect vector populations; iii) weather conditions; iv) stand management practices (e.g., drought management, nitrogen fertilisation, weed control, spacing between plants, etc.). Precise data on all these factors are not available in the European Union, and data on the suitability of the environment also show uncertainty.

3.5.4. Conclusion on impact in the endangered areas

Based on the analysis in section 3.3, the Panel concluded that the endangered areas in the European Union for establishment of *G. circinata* are:

i) wide areas of central and northern Portugal;
ii) northern and eastern Spain;
iii) south and coastal areas in France;

iv) coastal areas in Italy; and
v) parts of the coastal areas of Greece.

Pinus species forests in these areas cover over 10 million hectares (Table 4). Pine species and Douglas-fir are also widely used as ornamentals throughout the endangered areas. In the endangered areas the pathogen can be expected to establish and cause pitch canker epidemics.

3.6. Conclusion on risk assessment

Pitch canker disease, caused by the fungus *G. circinata*, is among the most devastating diseases of pine species in the world. The pathogen has been reported in four EU Member States, namely, Spain, Italy, France and Portugal.

After consideration of the evidence, the Panel concludes that in parts of the European Union and in the absence of regulation, there is risk of host species (*Pinus* spp. and *Pseudotsuga menziesii*) being affected by pitch canker disease.

In the absence of legislation, the Panel considers entry into the European Union very likely. The pathways for new entry into the EU territory are contaminated propagation material (mainly seed), different forms of wood material (saw logs, timber, lumber, wood chips, dunnage, pallets, packaging material, fire wood, etc.), plant material for decorative purposes (Christmas trees, branches, cones, etc.), soil and growing substrates, natural means (such as wind, wind-blown rain, insects and other animals carrying spores) and human activities (including travellers, silvicultural machinery, vehicles, etc.).

The Panel considers the establishment potential very high based on the following evidence:
i) the pathogen has been reported at some locations in the European Union, in Spain, Italy, France and Portugal,
ii) hosts are present: *Pinus* spp. are widely present in the European Union, while *Pseudotsuga menziesii* has scattered distribution only, and
iii) climate conditions are suitable in parts of the European Union.

According to the CLIMEX analysis, and considering all the areas where host plants are grown in the European Union, the endangered areas include:
i) wide areas of central and northern Portugal;
ii) northern and eastern Spain;
iii) south and coastal areas of France;
iv) coastal areas of Italy; and
v) parts of the coastal areas of Greece.

In these areas no limitations to establishment have been identified.

The Panel considers spread within the European Union very likely. *G. circinata* spores are carried by wind, rain and wind-related events, insects and other animals particularly birds. Containment of the pathogen is difficult because spores of *G. circinata* spread naturally by wind, wind-blown rain and can also be carried by insects, birds and other animals. No natural barriers are present for spores or insects to spread from an infested area. Spread can also occur by movement of contaminated wood, planting material, growing substrates and machinery or by human activity in forests.

The Panel estimates the potential impact of pitch canker in the endangered areas massive. In these areas, the pathogen can be expected to cause pitch canker epidemics mainly in nurseries and managed stands, and less frequently in native pine stands. Direct effects of the disease include tree mortality, reduced growth, reduced lumber quality, reduced cone yield and seed contamination in seed orchards, and seedling mortality in nurseries. The pine plantations and forests in the endangered areas cover over 10 million hectares. Pine species and Douglas-fir are also widely used as ornamentals throughout the endangered areas.

4. Management options

This section firstly lists all possible management options, pathway by pathway, based on the available literature (section 4.1). This list includes both risk management options and pest management options. Then, the risk management options are identified and evaluated for their effectiveness, separately for entry, spread and for preventing or reducing infestation (section 4.2). Finally, in section 4.3, conclusions are provided on these risk management options, as well as considerations on the provisional emergency measures against *G. circinata* and on the other existing phytosanitary measures**.**

4.1. Identification of management options

4.1.1. Plant material for propagation purposes (seeds, seedlings, scions)

4.1.1.1. Control of seed and living plant material imports

The control of the importation of *Pinus* spp. and *Pseudotsuga menziesii* seeds or living plant material for propagation purposes into the EU could prevent the entry of the pathogen into areas that are currently free of pitch canker and prevent the introduction of new strains of *G. circinata* in the areas where the pathogen is already present.

4.1.1.2. Control of movement of seed and living plant material for propagation purposes within the European Union

G. circinata is able to survive on infected or contaminated seed and living plant material. Regulating the movement of *Pinus* spp. and *Pseudotsuga menziesii* seeds and living plant material within the EU could be considered as a management option to exclude the pathogen from areas that are currently free of pitch canker.

4.1.1.3. Collection of seeds from pest-free areas

The use of pest-free seed is one of the most important means of preventing infection of pine seedlings in nurseries (Wingfield et al., 2008). Pine seed should be collected from seed orchards (Council Directive 1999/105/EC) in areas where the pathogen is not present.

4.1.1.4. Seed testing

G. circinata cannot be detected by visual seed inspection. Therefore, the seed should be tested in the laboratory to certify that it is free of the pathogen. *G. circinata* can be detected in infected or contaminated seed by two different methods:

i) Seeds without any surface disinfection are placed in Petri dishes with different culture media, such as PDA supplemented with 500 mg mL^{-1} of streptomycin sulphate (PDAS), *Fusarium* semi-selective culture such as Komada‟s medium or *Fusarium* selective medium (FSM) (Aegerter and Gordon, 2006). *Fusarium*-like colonies are subsequently transferred to carnation leaf agar (Fisher et al., 1982) or SNA (Nirenberg and O‟Donnell, 1998) for further growth and identification of *F. circinatum* based on morphological characteristics (Leslie et al., 2006) or by applying molecular markers (Schweigkofler et al., 2004; Ramsfield et al., 2008).

ii) Alternatively, a real-time PCR method, developed by Ioos et al. (2009), which allows the quick and reliable detection of *G. circinata* directly from seeds, can be used. This technique has proven to be more sensitive and reliable than the plating method and moreover, it allows the detection of internal or cryptic (latent) infections, which can be "underestimated" by using the plating method (Storer et al., 1998b).

The use of molecular techniques is essential for the confirmation of the presence/absence of the pathogen in seed because numerous other *Fusarium* species within the *Gibberella fujikuroi* complex, either fully described or still poorly documented and morphologically similar to *F. circinatum* may be present in *Pinus* spp. or *Pseudotsuga menziesii* seeds (Steenkamp et al., 1999). Therefore, the identification of the pathogen may not be reliable if it is based only on morphological characteristics. In particular, these authors reported that some of the distinguishing morphological characters may be inadequate or insufficient to make a definite identification of *G. circinata*.

A diagnostic protocol for *G. circinata* (EPPO, 2009a), which also includes methods for seed testing, is detailed under section 3.1.7.

4.1.1.5. Seed treatment

Fungicides and surface disinfectants can reduce or eliminate pathogenic fungi on the seed coat and improve germination (Cram, 2009). However, seed treatments applied by pine nurseries to control pre- or post-emergence damping-off of seedlings caused by fungi such as *Phytophthora* spp., *Rhizoctonia* spp., *Pythium* spp., and *Fusarium* spp., including *G. circinata*, have shown variable results (Vaartaja, 1964). In addition, some of these treatments may have phytotoxic effects, depending on the species of seed, condition of the seed coat, and application method (Vaartaja, 1964; Runion et al., 1991; Bloomberg and Trelawny, 1970; Barnett and Pesacreta, 1993).

i) Chemical treatments

Fungicides (systemic and non-systemic) applied as seed coatings are commonly used in agriculture to reduce infestation of fungi on seeds, but their effect on pine seed germination was initially unknown (Barnett and Varela, 2004). Among the fungicides tested, the non-systemic captan and thiram and the systemic benomyl, thiabendazole and thiophanate-methyl had the least detrimental effect on pine seed germination (Pawuk, 1978). Thiram was applied to conifer seeds as a bird and small mammal repellent as well as for controlling damping-off pathogens, such as *Fusarium* spp. (Barnett and Varela, 2003) *Pythium* spp. and *Rhizoctonia* spp. (Vaartaja, 1964). Thiram has been shown to increase germination of southern pine seed with 33 % or less germination (Barnett and Varela, 2003). Barnett and Varela (2003) also reported that thiram reduced the number of longleaf pine seed infested by *Fusarium* spp. from 32 to 12 % and increased seed germination from 53 to 72 %. However, thiram has also been shown to delay or reduce germination of seeds of longleaf pine, slash pine, Douglas-fir, red pine and white spruce (Runion et al., 1991; Bloomberg and Trelawny, 1970; Belcher and Carlson, 1968; Dobbs, 1971). According to Barnett and McGilvray (1997) and Barnett et al. (1999), a 10-min soak in a 2.5 % benomyl solution was equally effective as a 1-h soak in 30 % hydrogen peroxide in controlling pathogens and improving germination of longleaf pine seed. Runion and Bruck (1988) found that treatment with thiabendazole suspended in 10 % dimethyl sulfoxide significantly reduced the percentage of seed infested with the pitch canker fungus. According to Gordon and Dick (2003), treatment of *P. radiata* seeds with benomyl or a combination of benzimidazole, carboxin and thiram proved to be completely effective in the elimination of internal and external infestations of *P. radiata* seeds. No seedlings emerging from treated seed were found to be infected. However, no reliable method to eliminate the internally located mycelium of the pathogen without affecting the seed is available (Storer et al., 1998b; Wingfield et al., 2008).

ii) Disinfectants

Seed disinfectants, such as sodium hypochlorite and hydrogen peroxide, can reduce or eliminate pathogenic fungi present on conifer seed coats as contaminants (Fraedrich, 2001) and improve seed germination (Campbell and Landis, 1990; Barnett and Pesacreta, 1993). It has been shown that these two disinfectants can reduce much of the *G. circinata* inoculum present on the surface of shortleaf, longleaf and Monterey pine seed (Allen et al., 2004; Fraedrich, 1996). Storer et al. (1998b) found that sodium hypochloride was not completely effective in reducing *G. circinata* in *P. radiata* seeds due to high levels of internal infection by the pathogen. Hydrogen peroxide has been used successfully to sterilise seeds of several tree species (Trappe, 1961; Fraedrich, 2001). It has also been evaluated as a germination stimulant for western conifers and southern pine seed

(Ching and Parker, 1958; Carter and Jones, 1962). According to Barnett (1976) studies, one hour soak of longleaf pine seed in 30 % hydrogen peroxide effectively removed fungal contamination and improved germination of low-vigour seed lots that were heavily infested with fungi. Fraedrich (1996) and Dwinell and Fraedrich (1999) found that internal seed contamination by *G. circinata* could be reduced by soaking *P. radiata* seeds for 15 min in a 30 % hydrogen peroxide solution. According to Fraedrich (2001), combining this practice with the use of selective fungicides may provide effective control of pathogens present internally and externally on forest tree seeds.

iii) Physical/thermal treatments

Hot water treatment has been evaluated as a potential method to control external and internal infection of pine seed. Jones et al. (2002) indicated that preliminary tests where longleaf pine seed were immersed in hot water for two minutes at 60 ºC, followed by immersion in cold water, were effective in reducing infestations of *G. circinata* to trace levels and resulted in high levels of plantable seedlings. Agustí-Brisach et al. (2009) evaluated in vitro the sensitivity of spores and mycelium of *G. circinata* to hot-water treatment. Their studies showed that the pathogen can tolerate hot water treatment at temperatures over 50 ºC, although germination rate and mycelial growth were strongly reduced and almost completely inhibited at 52 ºC. Dumroese et al. (1988) reported that treating seed before stratification with sodium hypochloride, after stratification with hydrogen peroxide or ethanol or hot water significantly reduced seed-borne *Fusarium* spp. However, further research is needed to assess the effectiveness of hot water treatments to control *G. circinata* on pine seed. Campbell and Landis (1990) reported that cleansing the seed surface with running tap water for 48 hours is a very effective mechanical means of removal of externally located propagules of the pathogen.

4.1.1.6. Nursery quarantine

When pitch canker infected plants are found in a forest nursery, a quarantine period could be established in order to apply adequate sanitation measures, thus avoiding the spread of the pathogen. During this period, seedlings of any species grown in the nursery should not be transplanted outside the nursery. Quarantine is important in restricting the spread of exotic seed-borne tree pathogens (Burgess and Wingfield, 2002).

4.1.1.7. Nursery sanitation and eradication

Sanitation is a key factor in reducing disease problems in nurseries. Where a pathogen is already established in a nursery, sound nursery practices and the highest levels of hygiene are of great importance in preventing disease outbreaks. The use of pathogen-free irrigation water, sterile growth media and containers as well as rouging diseased plants can reduce the population of *G. circinata* within a nursery (Wingfield et al., 2008). Other general sanitation practices include cleaning borrowed machinery and restricting the movement of infected transplant stock (South and Enebak, 2006).

Gadgil et al. (2003) recommended that all seedlings, cuttings and stool bed plants of *Pinus* spp. and *Pseudotsuga menziesii* in the infested nursery and all seedlings, cuttings or stool bed plants raised from the infested seed lot in any other nursery must be uprooted with as much of the root system intact as possible. Subsequently, they must be burnt within the nursery or securely covered and transported to a site where they can be burnt.

Application of thiabendazole or benomyl in paint on pruning wounds has been shown in artificial inoculations to prevent infection of *P. radiata* by the pathogen (McCain et al., 1989). However, it has been reported that relatively high levels of resistance to benomyl, a thiabendazole derivative, exist in populations of the *G. fujikuroi* species complex (Yan and Dickman, 1993), making the use of thiabendazole and its derivatives problematic. Likewise, the use of such chemicals is strongly discouraged in many countries and they are unlikely to provide solutions for nursery infestations

(Wingfield et al., 2008). Biological control agents, such as antagonistic fungi and bacteria have been tested for their effectiveness against *G. circinata* with various results. Dumroese et al. (1988) noted that *Trichoderma* spp. applied on the conifer seed coat effectively controlled seedling diseases caused by *Fusarium* spp. However, later studies have found *Trichoderma* spp. to be ineffective against *G. circinata* (Mitchell et al., 2004). Barrows-Broaddus and Kerr (1981) reported that several *Arthrobacter* spp. (common soil borne bacteria), recovered during isolations of *G. circinata,* were effective at inhibiting the pitch canker pathogen in culture. When these bacteria were tested *in planta* on *P. elliottii* several *Arthrobacter* isolates were able to reduce the number of *G. circinata* conidia present at the wound site in comparison to the control. However, none was effective in reducing canker size or preventing infection by the pathogen (Barrows-Broaddus and Dwinell, 1985b).

The soil at most pine nurseries in southern United States is fumigated once every 4 years (two crops of pines followed by two cover crops) but hardwood seedbeds are more likely to be fumigated every year and prior to sowing (South and Enebak, 2006). The increase in seedling production associated with fumigation varies with nursery but at some nurseries, crop value increases by 6-40 % (South and Enebak, 2006). Chloropicrin is a more effective fungicide than methyl bromide and should be preferred where fungal seedling diseases cause damage (Gadgil et al., 2003; South and Enebak, 2006). Fumigation of seedbeds with chloropicrin is also recommended (Gadgil et al., 2003).

In infested containerised nurseries, containers should either be incinerated or disinfested. Potting medium should be heat-treated or fumigated to eliminate *G. circinata* (Gadgil et al., 2003).

4.1.1.8. Control of insects in nurseries

The control of insects that either carry spores of the pathogen on their body or act as wounding agents in nurseries could be considered for inclusion in a pitch canker management programme. The role of insects in the spread of *G. circinata* appears to be a critical feature of the pitch canker pathosystem in California (Gordon et al., 2001). Recent studies have also shown the potential that insect carrying spores of the pathogen could have been involved in the epidemiology of *G. circinata* in Northern Spain (Lopez-Zamora et al., 2007). However, there is no detailed information about the role of insects in nurseries. Insects, especially fungus gnats (Diptera: *Sciaridae, Mycetophlidae*), were suspected of transmitting *G. circinata* in South African nurseries (Hurley et al., 2007a, 2007b). Dipteran fauna was surveyed in four major forest nurseries between 2000 and 2001 (Hurley et al., 2007a, 2007b). Fungi were isolated from these flies and the resulting *Fusarium* species were identified. *Bradysia difformis* was the only fungus gnat species found in all nurseries. Other Dipteran families collected included *Agromyzidae*, *Cecidomyiidae*, *Chironomidae*, *Ephydridae*, *Muscidae*, *Simulidae* and *Tachinidae*. Only *F. oxysporum* and *F. stilboides* were isolated from *Chironomidae*, but these fungi were not considered important pathogens in the nurseries surveyed. Fungus gnats and other *Diptera* are widespread throughout the South African forest nurseries. Although these flies are often suspected of carrying *G. circinata* and other pathogenic fungi, studies have shown that the insects in the nurseries investigated do not play a significant role in spreading diseases to pine seedlings (Hurley et al., 2007a, 2007b). In general, for most insects, nursery managers do not apply insecticides unless an infestation has been observed (South and Enebak, 2006).

Various insecticides have been tested for their effectiveness in reducing the levels of pitch canker through the control of insects that act either as carriers of the pathogen‟s spores or wounding agents. Runion et al. (1993) reported that among the insecticides tested, carbofuran was effective at reducing both the incidence of insect damage and the number of pitch canker infections.

4.1.1.9. Removal and destruction of infected host plants and plant parts

When economically feasible, thinning of pine plantations showing low disease incidence (merchantable stands) and located in areas where there are pitch canker outbreaks could be considered as an effective control practice (Blakeslee et al., 1980). In addition, the removal and destruction of severely infected and low-vigour branches or trees reduces the availability of breeding material for beetles that have been shown to carry the pathogen. However, the decision to salvage severely diseased plantations depends on the incidence (number of infected trees) and severity (amount of infection in each tree) of the disease in the stand, the expected disease progress, and the response of infected trees (Blakeslee et al., 1980).

According to Gordon et al. (2001), pruning does not slow the spread of the disease in a highly infested area. Pruning is used to enhance the aesthetic quality of an infected tree and thereby delays its removal from the landscape. Because pine trees infected by the pathogen may recover, their removal should be delayed as long as possible and only trees that pose a hazard should be cut down.

4.1.1.10. Rotation or fallowing

Natural regeneration of native stands or use of disease resistant seed sources, once they become available, could be considered as a management practice. Because slash pines vary in their susceptibility to pitch canker, occurrence of the disease may vary according to seed source (Blakeslee et al., 1980). In many cases where pitch canker is epidemic in planted stands, the incidence of the disease is very low in natural stands or in planted stands derived from local seed sources (Blakeslee et al., 1980). When harvesting such natural stands, consider regeneration by the seed tree method to preserve and use the native seed sources, which may be more tolerant to the disease (Blakeslee et al., 1980).

Planting of resistant *Pinus* spp. (e.g., *P. canariensis, P. pinea*, etc.) can be considered as an alternative to improving the existing planting stock, which is currently utilised by commercial forestry (Wingfield et al., 2002b). Strong genetic heritability has been observed in several south-east United States pines (Rockwood et al., 1988; Kayihan et al., 2005) and a wide variation in resistance has been observed in native *P. radiata* forests (Gordon et al., 2001). Therefore, it is possible to develop resistant planting stock, which can be used for commercial forestry and for replanting of native forests (Wingfield et al., 2008).

4.1.1.11. Silvicultural practices

Diverse silvicultural practices have been indicated as useful to reduce the incidence of the disease in plantations and seed orchards.

Environmental and other abiotic stress factors increase the susceptibility of *Pinus* spp. to the pitch canker pathogen (Dwinell et al., 1985; Fraedrich and Witcher, 1982). Disease incidence and severity is higher on flat, sandy and wet sites that have a history of fire (Phelps and Chellman, 1976). Drought, early frost, high levels of fertilisation, particularly with nitrogen, and high stand density may also increase the susceptibility of host plants to pitch canker (Blakeslee et al., 1999; Fisher et al., 1981; Fraedrich and Witcher, 1982; Dwinell et al., 1985; Phelps and Chellman, 1976; Dwinell and Phelps, 1977). Planting sites, therefore, should be suited for pine production, planting density should not be inordinately high, trees should be thinned to appropriate stocking levels, the site should have adequate drainage to avoid water logging and supplemented nutrients should be carefully managed (Blakeslee et al., 1999).

During the last half of the rotation, when water demands are the greatest, the drainage system should be modified to help retain more water on the site during droughty periods, thus reducing possible moisture stress in trees (Blakeslee et al., 1980).

Pitch canker has been very damaging in some fertilised or overstocked slash pine stands (Blakeslee et al., 1980). While further research is needed to clarify any possible relationships between these factors and the incidence or severity of pitch canker, increased spacing (decreased stocking) of new plantations may result in reduced levels of competition-induced stress (Blakeslee et al., 1980).

Because *G. circinata* is a wound-infecting pathogen, wounding of trees should be avoided in summer and autumn during management practices applied to plantations and seed orchards, as any fresh wound serves as means of entry for the fungus (Dwinell et al., 1985; Blakeslee et al., 1980). Cone harvesting creates wounds during the critical infection period and can result in multiple infections throughout the crown. For this reason, manual harvest of cones should be done by clipping rather than tearing to help reduce wounding. In case of mechanical harvest, tree shakers should be adjusted and operated properly to avoid wounding the tree at the point of attachment and throughout the crown. In addition, when mowing is used, damage to the tree stem and anchor roots should be avoided. According to Hammerbacher et al. (2009), in South Africa, weeding and rough handling of seedlings during their transplanting may also provide wounds that can serve as infection sites.

In areas of south-east United States and California where the disease is established the most common practice for its control is to prune the infected branches when first detected and to remove severely infected or dying trees (Storer et al., 2002b; Gordon et al., 2001; Storer et al., 1994). Blakeslee et al. (1980) also recommend the removal of trees with bole cankers as, the further growth of the cankers will eventually kill the tree. Pruning of branch tip infections or removal of branches of infected landscape trees in California was not effective in eliminating the disease or even in reducing its incidence or severity, but this practice might delay the need to remove diseased trees (Gordon et al., 2001).

Infected or uninfected prunings (twigs, branches, etc) and infected or dead trees may become infested with insects (primarily bark-breeding beetles) that may carry the pathogen (Dallara et al., 1995). To reduce the inoculum sources and minimise the exposure of nearby stands to infection by the pathogen, this material should be either chipped and spread in a thin layer to allow rapid drying or burned in place (Blakeslee et al., 1980; Dallara et al., 1995). It is advisable to avoid establishing new plantations near diseased stands. Exposure to the fungus or to insects carrying spores of the pathogen may be reduced by avoiding close contact with infected stands (Blakeslee et al., 1980).

4.1.1.12. Forest, plantations and nursery surveys

The main purpose of the surveys will be to detect *G. circinata* and to map the spread of pine pitch canker. Surveys should be programmed according to the characteristics of the region or nurseries being surveyed and carried out by trained forestry personnel with the support of a diagnostic laboratory. Species of *Pinus* and *Pseudotsuga menziesii* should be examined for signs of dieback or damping-off in nurseries or pitch canker symptoms in plantations and forests (dieback, resin bleeding, etc.).

4.1.1.13. Sanitation of equipment and machinery used in infested areas

Equipment and machinery used in infested areas should be washed down prior to or after their use in an infested area so as to minimise the risk of spreading the fungal inoculum to non-infested sites (Gadgil et al., 2003). Similarly, pruning tools should be disinfected (e.g. by immersion in a 10 % solution of bleach) prior to and after pruning of infected trees (Anonymous, 2001).

4.1.2. Plant material for decorative purposes

4.1.2.1. Control of imports of plant material for decorative purposes

As already indicated in the section 4.1.1.1, *G. circinata* is able to survive on infected seed and/or living plant material. Thus, plants and plant parts for decorative purposes, such as Christmas trees, branches, cones, etc. may serve as means for the entry of the pathogen into the European Union. Limiting the import of this plant material into the EU could be considered as a management option.

It should be also noted that Christmas trees, branches, cones, etc. for decorative purposes can be obtained from third countries through various Internet sites (see section 3.2.4).

4.1.2.2. Control of movement of plant material for decorative purposes from infested to non-infested areas within the EU

The movement of plant material for decorative purposes could also be limited into the European Union in order to avoid the spread of *G. circinata* from infested to non-infested areas.

4.1.2.3. Destruction of host plant material for decorative purposes

Host plant material for decorative purposes, particularly used Christmas trees, should be disposed either through a local recycling program or to a local landfill that buries or composts green waste. Alternatively, it is recommended either to burn them or chip and compost them and then use them as mulch (see section 4.1.3.4 and Anonymous, 2001). The effect of these measures depends on the good quality of the composting procedure followed.

4.1.2.4. Treatment of plant material for decorative purposes

No information is available on specific treatment against the pathogen on plant material for decorative purposes.

New Zealand requires that pine/conifer wood, cones, twigs, needles, etc. should be heat-treated at a core temperature of 70 °C for 4 hours, with increased thickness of wood the exposure time must be increased (MAF, 2009).

4.1.3. Wood

4.1.3.1. Control of wood imports or wood movement from infested to non-infested areas within the EU

Great concern exists about the accidental introduction of *G. circinata* via wood products, such as wood packaging material, logs, chips, dunnage, etc. (Wingfield et al., 2008).

Macroconidia and microconidia of *G. circinata* that may be present on the wood are presumed to be the primary form of pathogen dissemination, either by wind or by insects to which spores can adhere. Bark feeding insects commonly breed in pitch canker-killed branches and a large percentage of the emergent brood carry the pathogen. These insects (including numerous species in the genera: *Pityophthorus*, *Ips* and *Conophthorus*) cannot only transport the pathogen to a new host but may also provide a wound suitable for infection (Storer et al., 1997).

The pathogen can survive in logs cut from diseased trees for more than one year (Gordon et al., 2000) and in chipped branches for up to three years (McNee et al., 2002). Chipping of infected branches reduced insect emergence by 95 % (McNee et al., 2002).

Therefore, the imports of logs, wood packaging material, chips, dunnage etc. (see section 3.2.3) from infested areas into the EU or their movement from infested to non-infested areas within the EU may also introduce or spread the pathogen, respectively, into the European Union.

Wood is used for many purposes (industrial processing for plywood, veneer, firewood, packaging material, etc.) which may have different potential in the probabilities of transfer to a suitable host. By-products like bark, sawdust, wood-shavings, waste-chips, etc., and disposable wood material may have diverse destinations/end-uses and in some cases the final destination may include environments where susceptible hosts are present. For example, by-products like bark and sawdust may be used for mulching (Harkin, 1969; Thomas and Schumann, 1993), which could place infested material in proximity to potential hosts.

It has been calculated that, in the United States, the industry-produced air-dry wood fines may exceed one million tonnes per year (Harkin, 1969). There is high uncertainty about the total amount produced presently in the EU and the percentage that may be used as mulching in proximity of pines or Douglas-fir.

Different forms of contaminated wood, originating in infested parts of the European Union, may spread the pathogen to non-infested areas. Thus, limiting the movement of wood within the EU territory could be considered as a management option to exclude the fungus from areas that are currently free of pitch canker.

4.1.3.2. De-barking wood for reducing the inoculum

The requirements for de-barking wood may mitigate the risk of entry into or spread of *G. circinata* within the European Union.

G. circinata could be transferred by the bark of infected *Pinus* spp. and *Pseudotsuga menziesii*. Spores of the pathogen are present abundantly on the margins of cankers (Hepting and Roth, 1946), which means that the bark is infested by the pathogen. On the central coast of California, where pitch canker is known to be present, a bark wash survey revealed the presence of spores on both symptomatic and asymptomatic trees (Adams, 1989). Composted pine wood bark on its own or mixed with other elements is commonly used in horticulture all over the world as an amendment for soil or other growing media. It can be used as a plant growing substrate for containers in greenhouses and nurseries, or simply for creating favourable conditions for some plants. Pine bark is also used for mulches and even for decorative purposes. It can be used as soil amendment with or even without preliminary composting (Harkin and Rowe, 1971). When used without composting, it is decomposing slowly so, if the bark was infested by *G. circinata,* it could serve to carry the pathogen. Composting of pine wood bark is a common practice applied also by amateur gardeners, which may not always be effective in eliminating the pathogen present in the bark. Studies conducted in California showed that composting for six days at the average temperature of 63 °C was sufficient to eliminate *G. circinata* in infected branches. In laboratory study, ten days at 40 °C under moist conditions completely eliminated *G. circinata* from infested wood chips. Results were more variable where wood was allowed to dry, with a low rate of survival (3 %) after 30 days at 50 °C (Gordon et al., 2000). Thus, without proper treatment, growing substrates containing bark of conifers from infected areas of the European Union may spread *G. circinata* from infected parts of the EU territory to non-infested parts. On the basis of this, growing substrates containing bark of conifers and originated in infested parts of the European Union may spread the pathogen to non-infested parts of the EU territory.

However, none of these measures are specific for *G. circinata* and, although some of them (e.g. prohibition of importation) may be effective in providing protection, other may just mitigate the risk or have no effect on the pathogen.

4.1.3.3. Wood treatment (chipping, composting, heat treatment etc.)

In New Zealand, where pitch canker is absent, all forest produce is prohibited entry into the country, unless it complies with the requirements of an import health standard that has been issued in accordance with Section 22 of the Biosecurity Act (1993)[12]. One or more of the following treatment options, according to the import health standard on sawn wood from all countries (MAF, 2003), should be applied to imported sawn wood from *Pinus* species originating from areas not considered to be free of *G. circinata*:

i) Fumigation with methyl bromide or sulphuryl fluoride of filleted or otherwise separated layers, at 80 g/m^3 for more than 24 continuous hours, and at a minimum temperature of 10 °C.
ii) Heat treatment at a minimum continuous wood core temperature of 70 °C for more than 4 hours.

[12] Biosecurity Act 1993 No 95 (as at 22 April 2010), Public Act, Date of assent 26 August 1993, into force on 01 October 1993.

iii) Chemical treatment to full sapwood penetration to a specified minimum retention rate of chemicals providing both insecticidal and fungicidal protection (boron compounds, copper + didecyldimethyl ammonium chloride, copper azole, copper chrome arsenic) or insecticidal protection only (arsenic, permethrin).

Moreover, in case the sawnwood is fumigated or heat-treated prior to export to New Zealand, the treatment must have been applied no more than 21 days before export.

Physical treatments include chipping and composting. Chipping infected wood will reduce but not eliminate insects that carry the pitch canker pathogen (USDA Forest Service, 2000). Chipping has little impact on the survival of the pathogen and may serve as a means for a more thorough distribution of the pathogen. The preferred management option for infected, chipped material is to keep it within infested areas. For chips that are not composted or otherwise treated to eliminate the pathogen, the following will greatly reduce the possibility of pathogen spread when such material is transported out of infested counties or areas:

i) the transportation route is free of pines,
ii) the material is shipped in tightly enclosed trucks,
iii) no pine forests are within a 10 mile radius of the destination area.

Composting can be an effective method for eliminating the pitch canker pathogen from infected branches (Gordon et al., 2000). Wood to be composted should be chipped and mixed with a source of nitrogen, such as grass clippings or manure. Elimination of the pathogen requires exposure to 50 °C or higher temperature for at least 10 days. As it will be necessary to turn the pile to ensure exposure of all material to the higher temperatures at the interior, the duration of the composting will necessarily be longer than 10 days. Standard commercial composting operations will ordinarily exceed the minimum time and temperature required to kill the pathogen, but if this is in doubt, temperatures should be monitored to confirm they are high enough. Note that moist conditions in a compost pile facilitate the elimination of the fungus. If dry heat is used, as by simply placing logs under plastic, higher temperatures may be required to kill the fungus.

4.1.3.4. Firewood

Some precautions could be taken for limiting the movement of firewood. No pine firewood should be transported out of infested areas, either for sale or for personal use. If camping and travelling from an infested area elsewhere, if needed, oak or cedar firewood could be transported, or else firewood could be purchased at the place of destination. In those infested areas pine firewood should be used or left behind when moving even if the firewood was brought from an uninfested area.

4.1.3.5. Log treatments

Pine logs from infested areas pose little or no threat of spreading the pathogen if they have received the following treatment:

i) heating to 71 °C at the centre of the log for 75 minutes (USDA Forest Service, 2000);
ii) fumigation with sulfuryl fluoride for five days (Gordon et al., 2000).

Pine logs from infested areas pose a reduced risk of spreading the pathogen out of the infested area if they have received one of the following treatments:

i) have been stockpiled for one year or more within the zone of infestation;
ii) have been completely debarked and all bole cankers removed (Gordon et al., 2000).

4.1.3.6. Wood destruction (burning, chipping and composting etc.)

Destruction of cut and fallen branches and trees reduces both the inoculum sources for further spread of the pathogen and the availability of breeding material for beetles which may transmit the fungus.

Infected and uninfected cut branches, prunings, and fallen trees should be chipped, debarked, or burned. Tools should be sterilized before and after contacting infected material. The movement of infected tree parts should be limited as much as possible. Fresh slash and recently cut logs or wind thrown trees are known to act as reservoirs for the pathogen and the insects associated with it. Movement of infected material, including firewood and chipped infected branches, into areas free of the pathogen greatly increases the chance of introducing it into those areas (Storer et al., 1995).

Gadgil et al. (2003) recommended that all infected trees should be felled. Merchantable logs may be sold to a processing plant within the infested area for conversion to products such as pulp or fibre board. Their use as saw logs is not allowed. Branches and other debris must be disposed of by burning or deep burial.

4.1.4. Other pathways

G. circinata spores are capable of surviving in soil, wood debris and needle litter (Wingfield et al., 2008). Thus, soil disinfestation could be recommended as a management option. The pathogen causing pitch canker does not produce chlamydospores and it is not clear how the fungus survives in the soil. *G. circinata* spores are capable of surviving in soil and wood debris, though soils in pine plantations and seed orchards have generally been eliminated as a primary source of inoculum because *G. circinata* isolates pathogenic to pine are seldom recovered from these soils (Dwinell and Barrows-Broaddus, 1978). In soil artificially infested with conidia of *G. circinata*, the pathogen was recoverable after 24 weeks in sandy soil and for up to 52 weeks in a clay-loam soil (Gordon et al., 2004).

Also humans (travellers, tourists and other forest visitors) can unintentionally spread spores of the pathogen adherent on clothing, shoes, cars and their equipment. This is especially important in case of direct movement of visitors from non-infested places to infested places. Therefore, inspection of travellers and their luggage, publicity to enhance public awareness on pest risk, fines or incentives, restriction of access of people to infested areas, as well as treatments for removing or destroying the pest can be considered as management options.

Machinery used in forests (either for cultivation or for any other purposes), used logging equipment and vehicles (trucks, railway wagons, boats, etc.) or containers used in infested places may carry the spore inoculum (usually through contaminated soil, wood waste, insects or any other carrier of the inoculum) to other, non-infested parts of the forest and also to other non-infested areas or countries (when imported or moving internationally). Cleaning or disinfection of machinery and vehicles can be then considered as a possible management option.

Fresh pine nuts, with or without shell, and pine cones containing nuts and intended for human consumption pose a low risk for the introduction of the pathogen into the EU or its spread from infested areas to non-infested areas within the EU. However, as it is not known if some of these fresh pine nuts are also used for sowing, they should be imported into or moved within the European Union with restrictions concerning the end-use.

4.2. Evaluation of risk management options

In this section, the management options described in section 4.1 are evaluated based on their effectiveness to reduce the level of risk for entry, establishment and spread of *G. circinata*, and the magnitude of impacts. Options to prevent unintentional entry on commodities (specifically, plant material for propagation and decorative purposes, wood; see section 4.2.1) are distinguished from options to prevent entry with other pathways (specifically, soil, humans, machinery and vehicles; see section 4.2.2). Options that can be implemented within the European Union are also considered (see sections 4.2.3 and 4.2.4). The evaluations are carried out irrespective of the measures which are currently in place; an analysis of these measures is provided in sections 4.3.2 and 4.3.3.

4.2.1. Risk management options for consignments (plant material for propagation and decorative purposes, wood)

According to ISPM No 5 (FAO, 2007c), a consignment is a quantity of plants, plant products and/or other articles being moved from one country to another and covered, when required, by a single phytosanitary certificate.

Risk management options for consignments (see section 4.1) include:

i) defining specific import requirements for the consignments which impose a risk for introduction of *G. circinata* in the European Union;
ii) detecting the pest in consignments;
iii) removing the pest from consignments;
iv) preventing introduction by limiting the use of the consignment; and
v) organising post-entry quarantine.

For the plant material for propagation purposes, these risk management options include:

i) control of seed and living plant material imports;
ii) seed testing;
iii) seed treatment; and
iv) nursery quarantine.

For the plant material for decorative purposes, the risk management options are:

i) control of imports of plant material for decorative purposes;
ii) inspection and testing; and
iii) destruction of host plant material for decorative purposes.

For the wood, the risk management options are:

i) control of wood imports;
ii) de-barking wood for reducing insect presence;
iii) wood treatment (chipping, composting, heat treatment, etc.); and
iv) wood destruction (burning, chipping and composting, etc.).

G. circinata cannot be reliably detected by a visual inspection of any consignment, neither at time of export, nor during transport and storage, nor at import. However, it can be detected by testing, particularly by using molecular tools. The pathogen can be also detected during post-entry quarantine, but only for the living plants or plant parts (seedlings, scions, Christmas trees). Altogether, both effectiveness and technical feasibility of detecting the pest in consignments may be evaluated as high.

G. circinata can be removed from consignments by various treatments, but the effectiveness depends on the type of consignment (seed, wood, etc.). The pathogen cannot be eliminated from certain parts of the consignments, with exception for the wood bark. Infestation cannot be prevented by handling and packaging methods. Altogether, both effectiveness and technical feasibility of removing the pest from consignments are evaluated as low to moderate.

Effectiveness of limiting the use of the various consignments to certain end-uses, certain zones in the European Union is considered moderate.

Limiting the periods of entry cannot prevent pitch canker from establishing, therefore its effectiveness is negligible. An exception may concern to limit the use of pine seed for human consumption.

4.2.2. Risk management options for other pathways of entry (soil, humans, machinery and vehicles)

These risk management options include those aimed at avoiding entry by soil, humans, machinery and vehicles. They include:

i) control of soil imports,

ii) soil disinfestations;
iii) detection of the pest in humans travellers and in their luggage through inspections;
iv) enhancement of public awareness on pest risk through publicity, fines or incentives; and
v) removal of the pest by treatments, by cleaning or disinfection of machinery and vehicles.

All these management options are described in section 4.1.

Regulation of soil imports is possible and may have high effectiveness. However, the other measures seem difficult to realise and their effectiveness may be considered very low.

4.2.3. Risk management options for prevention of pest establishment and spread

The risk management options for preventing the organism to spread within the European Union focus on:

i) defining specific conditions for the movement from infested to non-infested areas within the EU of seeds and living plant material for propagation purposes, plant material for decorative purposes, wood, soil, used machinery, and vehicles, which are all responsible for the pest spread;
ii) surveillance (i.e. an official process which collects and records data on pest occurrence or absence by survey, monitoring or other procedures);
iii) definition of demarcated areas (i.e. an infected zone where the presence of the pest has been confirmed and which includes all specified plants showing symptoms caused by the specified organism, with a buffer zone with a boundary beyond the infected zone);
iv) eradication (i.e. eliminate a pest from an area; FAO, 2007c);
v) containment of the pest (i.e. application of measures in and around an infested area to prevent the pest spread; FAO, 2007c); and
vi) establishment and maintenance of pest-free areas, places of production, and production sites (i.e., an area, place of production, or production site in which the pest does not occur; FAO, 2007c).

These management options relate to the different ways of spread of *G. circinata* within the European Union. They include:

i) control of movement of seed and living plant material for propagation purposes within the European Union;
ii) seed testing;
iii) seed treatment;
iv) removal and destruction of infected host plants and plant parts;
v) forest, plantations and nursery surveys;
vi) control of movement of plant material for decorative purposes from infested to non-infested areas within the EU;
vii) destruction of host plant material for decorative purposes;
viii) treatment of plant material for decorative purposes;
ix) control of wood movement from infested to non-infested areas within the EU;
x) de-barking wood for reducing insect presence;
xi) wood treatment (chipping, composting, heat treatment, etc.);
xii) wood destruction (burning, chipping and composting, etc.);
xiii) control of movement of soil from infested to non-infested areas within the EU;
xiv) control of soil movement from infested to non-infested areas within the EU;
xv) soil disinfestation;
xvi) detection of the pest in humans travellers and in their luggage through inspection;
xvii) enhancement of public awareness on pest risk through publicity, fines or incentives;
xviii) control of movement of used logging machinery from infested to non-infested areas within the EU;
xix) cleaning or disinfection of machinery and vehicles.

The above mentioned phytosanitary measures can be implemented for preventing *G. circinata* to spread within the European Union, preferably in a systems approach (FAO, 2007b).

Surveillance is possible for nurseries, plantations (in parks, gardens, etc.) and forests. Visual inspection of seedlings and plants for pitch canker symptoms may be further supported by testing carried out in authorised laboratories following official diagnostic methods. Due to the differences between nurseries and forests, effectiveness and technical feasibility of a surveillance plan seem to be higher for nurseries than for forests.

After the presence of the pathogen has been confirmed, the infested area can be demarcated, with an appropriate buffer zone. The boundary beyond the infected zone has to be defined based on the potential spread of the pathogen by natural means, which is at least at midrange. Eradication of the pathogen from the infested areas may involve several actions, which may be different in nurseries and forests. The presence of the pathogen not only in the affected wood but also in roots, debris and soil has to be accounted for. Effectiveness and technical feasibility of eradication seem to be high for nurseries and low for forests. Surveillance has to be maintained in the infested areas also after eradication, for at least some years.

Whenever eradication fails, a pest containment plan can be implemented in and around the infested area to prevent the spread of *G. circinata* to non-infested areas. For this purpose, all the possible means of the pathogen spread may be considered, which include seeds, living plant material, wood, soil, used machinery, vehicles, travellers and tourists, etc. The most effective measure for containment seems to be the definition of specific conditions for the movement of the above mentioned inoculum carriers from infested to non-infested areas within the EU. Advertising campaigns can also be implemented to enhance public awareness of the EU population on pest risk connected to the recreational activities in forests.

Creation and maintenance of pest-free areas, places of production, and production sites is possible.

However, there is no practical way to prevent natural spore dispersal; maintenance of pest-free areas, places of production, and production sites seems to be difficult to guarantee, at least at a midrange from infested areas considering that:

i) *G. circinata* spreads naturally by air-borne spores, which are present throughout the year in high density where the disease is present;
ii) the distance over which spores can be dispersed by wind was suggested to be at least midrange;
iii) spores can be also carried by insects and other animals;
iv) the fungus can also spread by means of the mycelium, present in infected wood parts (especially in bark), in plant debris and in the soil:
v) natural spread of small particles of wood, soil and debris in the dust driven by wind can not be prevented.

4.2.4. Risk management options for prevention or reduction of infestation in the crop

The following management options include those pest management options that the growers can implement for preventing and/or controlling pitch canker in the infested areas, at both nursery and plantation levels.

At the nursery level they include:

i) collection of seeds from pest-free areas;
ii) seed testing;
iii) seed treatment (by chemicals, disinfectants, physical/thermal treatments);
iv) nursery sanitation and eradication;
v) control of insects in nurseries;
vi) removal and destruction of infected host plantings.

At the plantation level they include:

i) rotation or fallowing;
ii) silvicultural practices;
iii) removal and destruction of infected host plants and plant parts;
iv) sanitation of equipment and machinery used in infested areas.

At present there is no single effective means of controlling pitch canker caused by *G. circinata* in nurseries and forest plantations. However, an intelligent combination of all listed methods, including the ones that are currently not yet used in the European Union, should result in a better control of *G. circinata*. The effectiveness can be considered low for plantations and forests and high for nurseries. The technical feasibility can be considered moderate for plantations and forests and high for nurseries.

The management options, even if applied within a systems approach (FAO, 2007b), are only partially effective; in addition, for some of them there are contrasting data on their effectiveness. The implementation of an integrated approach requires time and is not useful for a quick reaction against a new pest.

The certification schemes for producing healthy plants for planting (from seed collection in seed orchards to the plants ready for planting) could reliably prevent the pitch canker to spread in the European Union. Altogether, the effectiveness of the management options can be considered low for plantations and forests, high for nurseries.

4.3. Conclusion

4.3.1. Conclusion on risk management options in general

The management options developed in sections 4.1 and 4.2 and listed in Table 7 are based on the possibility of reducing the risk of entry, establishment, and spread of *G. circinata* within the European Union, and to limit impacts. The corresponding effect (i.e. level of reduction of the risk) and uncertainties are also reported.

Table 7: Effectiveness and uncertainty of the risk management options against *G. circinata*

Risk management options	Effectiveness	Uncertainty
Entry		
Import requirements for the consignment	High	Low
Inspection and sampling of the imported consignment	Very low	High
Testing of the imported consignment	High	Low
Removal of the pest from the imported consignment by treatments	Low to moderate	High
Limiting the use of the imported consignment	Moderate	Medium
Limiting the period of the imported consignment	Negligible	Low
Post-entry quarantine	High	Low
Inspection of passengers, machinery, vehicles, etc.	Very low	High
Cleaning/disinfection of passengers, machinery, vehicles, etc.	Very low	High
Establishment		
Surveillance in nurseries/plantations and native forests	High/Low	Low
Demarcated areas	Moderate	Medium
Eradication (nurseries and gardens/plantations and native forests)	High/Low	High
Spread		
Surveillance in nurseries/plantations and native forests	High/Low	Low
Requirements for the movement of seed, living plant material, wood, soil/used machinery, vehicles from infested to non-infested areas within the EU	High/Low	Low
Containment of the pest in and around infested areas	Low	High
Pest-free areas, places of production, and production sites	Low	High
Advertising campaigns to enhance public awareness of the EU population	Low	High
Impact		
Certification schemes for producing healthy plants for planting	High	Medium
Integrated Disease Management guidelines (nurseries/plantations)	High/Low	High

4.3.2. Considerations on the provisional emergency measures for *Gibberella circinata*

As reported in section 3.1.9., *G. circinata* is subject to provisional emergency measures under Commission Decision 2007/433/EC. These measures include:

i) specific import requirements for plants of the genus *Pinus* and the species *Pseudotsuga menziesii*, intended for planting, including seeds and cones for propagation purposes, originating in third countries, which consist of an accompanying certificate stating that the specified plants originate in a place of production which is registered and supervised by the national plant protection organisation in the country of origin;

ii) conditions for movement of all specified plants, either originating in the Community or imported into the Community, consisting of an accompanying plant passport or phytosanitary certificate;

iii) establishment of demarcated areas following introduction of the pest, with a buffer zone with a boundary at least 1 km beyond the infected zone. The official measures regarding the demarcated areas should include at least appropriate measures aimed at eradicating *G. circinata*, and intensive monitoring for the presence of the organism through appropriate inspections.

Despite the implementation of these provisional emergency measures, *G. circinata* established in new areas every year. Many of these new records concern nurseries, some of them concern forests. Therefore, we may conclude that:

i) The surveillance plan is essential to assess the extent of the spread of the pitch canker in the European Union. However, the Panel cannot evaluate its effectiveness because the number of possible undetected foci is unknown.

ii) The provisional emergency measures as a whole are not completely effective in preventing the introduction and/or the spread of the pathogen within the European Union. This could be explained by the fact that that these provisional emergency measures include specific import requirements only for plants of the genus *Pinus* and the species *Pseudotsuga menziesii*, intended for planting, including seeds and cones for propagation purposes, but do not consider the other pathways for entry and spread. Even if plant material for propagation purposes is the most important pathway, the others should not be disregarded.

iii) The provisional emergency measures also include the establishment of demarcated areas with a boundary of at least one kilometre. Considering that the natural spread of the pathogen is larger than 200 m from a source of inoculum (see section 3.2.5.2), the Panel considers this boundary insufficient In order to determine precisely this boundary, more detailed studies are required. Eradication is one of the official measures to be applied in the demarcated areas.

4.3.3. Considerations on other existing phytosanitary measures (against other pests)

The Council Directive 2000/29/EC Annex III, Part A, prohibits the introduction of the plants of *Pinus* and *Pseudotsuga* other than fruit and seed from non-European countries in all Member States. This measure may be highly effective in avoiding introduction of *G. circinata* with infected (also with latent infections) or contaminated seedlings, scions and plants in the European Union. However, it is necessary to mention that, according to EUROSTAT (2008a), in 2008, 740 tonnes of fresh Christmas trees and 52 tonnes of fresh conifer branches were imported into the European Union from third countries (the place of origin is not indicated).

The Council Directive 2000/29/EC Annex IV, Part A requires that the conifer wood material is subjected to heat treatment to achieve a minimum core temperature of 56 °C for at least 30 minutes, or fumigation (by methyl bromide) or chemical pressure impregnation according to an approved specification. Further requirements are included in the Commission Decision 2006/133/EC on wood package material providing certain derogation for Portugal (until 31 December 2009). The treatments laid down in the above regulations (details see in 3.1.9.2.) are aimed at other pests, mainly at the pine wood nematode *Bursaphelenchus xylophilus.* The Panel considers that heat treatment of wood packaging materials and isolated bark of conifers is likely to reduce or eliminate *G. circinata*, while efficacy of fumigation will depend on the applied fumigant and on the method of fumigation (details see in the section 3.1.9.2.). However, no data specific for *G. circinata* are available for fumigation efficacy.

The Council Directive 2000/29/EC also provides for the bark limitation requirement for all wood packaging materials in the European Community (see in 3.1.9.2.). According to this, the wood shall be:

i) free from bark with the exception of any number of individual pieces of bark if they are either less than 3 cm in width (regardless of the length) or, if greater than 3 cm in width, of not more than 50 cm^2 in area;

ii) subject to one of the approved treatments as specified in Annex I to ISPM No 15 (FAO, 2007a); and

iii) display a mark as specified in Annex II to ISPM No 15, (FAO, 2007a) indicating that the wood has been subjected to an approved phytosanitary treatment.

It is important to note that the above mentioned treatments have not been developed to control *G. circinata*, moreover no research data are available to prove their effectiveness against this organism. However, bark limitation requirements (de-barking, treatments of bark, etc.) are expected to provide an effect against this organism because a large part of the inoculum of the pathogen, infecting the bark of host plants, can be eliminated this way.

The Council Directive 2000/29/EC Annex III. Part A. 14, prohibits in all Member States the introduction of soil and growing medium as such, which consists in whole or in part of soil or solid organic substances such as parts of plants, humus including peat or bark, other than that composed entirely of peat. The Council Directive 2000/29/EC Annex IV, Part A, Section 1.,34 (concerning third countries), requires an official statement that the growing medium is either free from soil (and organic matter), free from insects, harmful nematodes and from other harmful organisms, or subjected to appropriate heat treatment or fumigation to ensure freedom from harmful organisms. Similarly, appropriate measures have to be taken when planting, to ensure that the growing medium has been maintained free from harmful organisms or, that the plants were shaken free from the growing medium. This Directive should ensure that *G. circinata* does not enter in the European Union through the soil and growing media containing pine bark, but no specific data are available for evaluating the effectiveness of the Directive against *G. circinata*.

The Council Directive 1999/105/EC provides general requirements on forestry reproductive material (e.g., quality, sources, etc.) and it underlines the importance of forests in playing a multicultural role. However, this directive does not specifically concern *G. circinata*.

4.4. Uncertainties

Rating	Description
High	Altogether, uncertainty may be considered high. Literature data on the effectiveness of management options against *G. circinata* are incomplete. In other cases, these data do not specifically concern *G. circinata*. The uncertainty of each risk management option is shown in Table 7. Evaluation of effectiveness of the provisional emergency measures was drawn from the data collected in the Member States, but these data are not always complete, there is no information about how the eradication was made and about its effectiveness (some foci are still under eradication and/or the monitoring period after eradication is too short for excluding that some infections are still latent), and it is impossible to know the number of possible undetected foci. No specific data are available on the effectiveness of the existing phytosanitary measures (against other pests) against *G. circinata*.

CONCLUSIONS

Following a request from the European Commission, the Panel on Plant Health was asked to deliver a scientific opinion on the risk posed by *Gibberella circinata* Nirenberg and O'Donnell to the EU territory. It was asked to identify risk management options and to evaluate their effectiveness in reducing the risk to plant health posed by this organism.

Pitch canker disease, caused by the pathogen *G. circinata*, is among the most devastating diseases in the world to affect the pine species. *G. circinata* is presently not listed as a harmful organism in Council Directive 2000/29/EC. However, a preliminary pest risk assessment carried out in 2000 by the French Plant Protection Service showed that the potential for establishment of this fungus in the EU may be considered high. In 2007, the Commission adopted provisional emergency measures to prevent the introduction into and the spread within the Community of *G. circinata* (Commission Decision 2007/433/EC). Since then, outbreaks of the organism have been reported in EU.

The Panel conducted the risk assessment following the general principles of the Guidance for harmonized framework for pest risk assessment in the EU, and without considering the existing plant health legislation. A rating system of five levels with their respective descriptors has been developed to formulate conclusions, separately for entry, establishment, spread, impact, as well as for risk management options. CLIMEX simulations have been used to assess the establishment potential of the organism within the European Union. Risk and pest management options were identified considering all the pathways. The risk management options were then evaluated for their effectiveness, separately for entry, spread and for preventing or reducing infestation.

After consideration of the evidence, the Panel reached the following conclusions:

- In parts of the European Union, there is risk of host species (*Pinus* spp. and *Pseudotsuga menziesii*) being affected by pitch canker disease.
- The Panel considers entry into the European Union very likely. The pathways for new entry into the EU territory are contaminated propagation material (mainly seed), different forms of wood material (saw logs, timber, lumber, wood chips, dunnage, pallets, packaging material, fire wood, etc.), plant material for decorative purposes (Christmas trees, branches, cones, etc.), soil and growing substrates, natural means (wind, wind-blown rain, insects and other animals carrying spores) and human activities (including travellers, silvicultural machinery, vehicles, etc.).

  The application of regulatory measures for the import consignments which pose a risk seems to be the most effective risk management option for reducing the probability of entry.

  The provisional emergency measures (Commission Decision 2007/433/EC) include specific import requirements for plants of the genus *Pinus* and the species *Pseudotsuga menziesii*, intended for planting, including seeds and cones for propagation purposes. Taking into account the above-mentioned regulation, the probability of entry by this pathway is considered moderately likely.

  The Council Directive 2000/29/EC prohibits the introduction of the plants of *Pinus* and *Pseudotsuga* other than fruit and seed from non-European countries in all Member States. This measure may be highly effective in reducing probability of entry of *G. circinata* by means of this pathway. However, fresh Christmas trees and fresh conifer branches are imported into the European Union.

  The Council Directive 2000/29/EC requires that the isolated bark of conifers originating from non-European countries is subjected to an appropriate fumigation or has undergone an appropriate heat treatment. Council Directive 2000/29/EC also requires that all wood packaging material is debarked or undergoes phytosanitary treatments. Also Commission Decision 2006/133/EC requires that wood packaging materials (and dunnage) are subjected to heat treatment or fumigation. Heat treatment of wood packaging materials and isolated bark of conifers is likely to reduce or eliminate *G. circinata*, while effectiveness of fumigation will depend on the fumigant and on the method of fumigation (no data specific for *G. circinata* are available for effectiveness of fumigation).

The Council Directive 2000/29/EC prohibits the introduction of soil and growing medium as such in all Member States. Third countries exporting to the EU are required to provide an official document stating that the growing medium is either free from soil (and organic matter), free from harmful organisms, or that it has been subjected to appropriate heat treatment or fumigation. The Directive ensures that *G. circinata* does not enter in the European Union through soil and growing media containing pine bark.

- The Panel considers the probability of establishment of *G. circinata* in the European Union as very likely based on the following evidence:

  - the pathogen has been reported at some locations in the European Union, in Spain, Italy, France and Portugal;
  - hosts are present: *Pinus* spp. are widely present in the European Union, while *Pseudotsuga menziesii* has scattered distribution only; and
  - climate conditions are suitable in parts of the European Union.

  According to the CLIMEX analysis, and considering all the areas where host plants are grown in the European Union, the endangered areas include:

  - wide areas of central and northern Portugal;
  - northern and eastern Spain;
  - south and coastal areas of France;
  - coastal areas of Italy; and
  - parts of the coastal areas of Greece.

  In these areas no limitations to establishment have been identified.

  On managed stands, cultural practices can potentially influence the ability of *G. circinata* to establish; they can modify the environment, making conditions more favourable for disease development, and/or can open wounds by handling the trees, which then serve as infection sites for the pathogen. Since there seem to be no major differences in the cultural practices used in the current area of pest distribution outside the EU compared to the ones currently applied in the European Union, their influence on establishment is comparable.

- The Panel considers spread within the European Union very likely. Wind, rain and wind-related events can create wounds on host plants and spread *G. circinata* spores in the territory of European Union. Moreover, insects have been identified as potential wounding agents, vectors and carriers of the pathogen, therefore favouring spread of the disease. In addition, there are no natural barriers to prevent propagules of the pathogen or insects carrying the pathogen to spread from an infested area to a non infested area. Commodities composed of host plant species material are widely spread and traded. Travellers, tourists, forest visitors for recreational activities are numerous. Contaminated machinery used in forests may also contribute to spread, unless properly sanitised.

  In order to reduce the probability of spread of the pathogen, the Panel considers that the establishment and proper application of requirements limiting the movement of seed, living plant material, wood, soil, used machinery, vehicles from infested to non-infested areas within the EU is the most effective risk management option. The emergency measures (Commission Decision 2007/433/EC) define conditions for movement of all the specified plants originating in the Community (i.e. an accompanying plant passport), but do not consider the other means of spread. Though plant material for propagation purposes is the most important pathway, the other pathways should not be disregarded.

  The Commission Decision 2007/433/EC imposes the delineation of demarcated areas including a buffer zone with a boundary of at least one kilometre beyond the infected zone. Appropriate measures aimed at eradicating *G. circinata* and intensive monitoring for the presence of the organism have to be considered within the demarcated areas. Based on the natural spread of the pathogen, the Panel considers this boundary insufficient. However, in order to determine this boundary precisely, more detailed studies are required. With regards to eradication, there is evidence concerning its effectiveness, though uncertainty exists because some foci are still under eradication and/or the monitoring period after eradication is too short for excluding that some infections are still latent.

Containment of the pathogen and maintenance of pest-free areas, places of production and production sites seem to be insufficient to ensure pest freedom in infested areas, as there is no practical way of preventing natural dispersal of the pathogen.

- The Panel estimates the potential impact of pitch canker in the endangered areas massive. In these areas, the pathogen can be expected to cause pitch canker epidemics mainly in nurseries and managed stands, and less frequently in native pine stands. The most important potential impacts include tree mortality, reduced growth, reduced lumber quality, reduced cone yield, seed contamination in seed orchards, and seedling mortality in nurseries. In addition, pitch canker can reduce recreational uses, tourism, and aesthetic amenity of the affected forests as well as parks and gardens. The pine plantations and forests in the endangered areas cover over 10 million hectares. Pine species and Douglas-fir are also widely used as ornamentals throughout the endangered areas.

  The uncertainty of the potential consequences is high, no precise data on impact and suitability of the environment being available in the European Union. Therefore the Panel considers very important to conduct surveillance of pitch canker in the EU territory.

  At present, no integrated disease management approach is in place for pitch canker, but combining appropriate nursery and silvicultural practices could reduce the impact of the disease. This approach is expected to be more effective in nurseries than in plantations and forests.

RECOMMENDATIONS

Based on these conclusions, the Panel recommends considering:

- Maintaining the current legislation for the import consignments which pose a risk. In particular:
  - the emergency measures introduced by Commission Decision 2007/433/EC, which includes specific import requirements for plants of the genus *Pinus* and the species *Pseudotsuga menziesii*, intended for planting, including seeds and cones for propagation purposes;
  - the Council Directive 2000/29/EC, which prohibits the introduction of the plants of *Pinus* and *Pseudotsuga* other than fruit and seed from non-European countries in all Member States;
  - the Council Directive 2000/29/EC, which requires that the isolated bark of conifers originating from non-European countries and wood packaging material (and dunnage) is subjected to an appropriate fumigation or has undergone an appropriate heat treatment;
  - the Council Directive 2000/29/EC, which requires that all wood packaging material is debarked or undergo phytosanitary treatments;
  - the Commission Decision 2006/133/EC, which also require that wood packaging material (and dunnage) is subjected to heat treatment or fumigation;
  - the Council Directive 2000/29/EC, which prohibits in all Member States the introduction of soil and growing medium as such; and requires third countries exporting to the EU to provide an official document stating that the growing medium is either free from soil (and organic matter), free from harmful organisms, or subjected to appropriate heat treatment or fumigation.
- Defining the requirements for the movement of seed, living plant material, wood, soil, used machinery, vehicles from infested to non-infested areas within the EU. The provisional emergency measures (Commission Decision 2007/433/EC) define conditions for movement of all the specified plants originating in the Community, but do not consider the other means of spread. Though plant material for propagation purposes is the most important pathway, the other pathways should not be disregarded.

- The application of a systems approach, which includes surveillance, delineation of demarcated areas and eradication. The Commission Decision 2007/433/EC requires the delineation of demarcated areas including a buffer zone with a boundary of at least one kilometre beyond the infected zone. Appropriate measures aimed at eradicating *G. circinata* and intensive monitoring for the presence of the organism have to be applied within the demarcated areas. Based on the natural spread of the pathogen, the Panel considers this boundary insufficient However, in order to determine precisely this boundary, more detailed studies are required.
- An integrated disease management approach, which combines appropriate nursery and silvicultural practices (e.g., stand density, irrigation, chemical control, genetic selection for resistance, cultural control), in order to reduce the impact of the disease.

DOCUMENTATION PROVIDED TO EFSA

1. Request to provide a scientific opinion on the risk to plant health of *Gibberella circinata* Nirenberg and O'Donnell for the EU territory. E1/GC/svi D(2009) 510254. 16 June 2009. Submitted by European Commission, DG SANCO Health and Consumers Directorate General.
2. Preliminary pest risk analysis for *Gibberella circinata Nirenberg and O'Donnell* prepared by the French Plant Protection Service (April 2000) (Chandelier, 2000) and EPPO pest risk assessment report.
3. Summary tables of survey for the presence of *Gibberella circinata Nirenberg and O'Donnell* in the EU for the year 2008 (tables compiled by the Food and Veterinary Office with information submitted by Member States according to Commission Decision 2007/433/EC).

REFERENCES

Adams D, 1989. Incidence of pine pitch canker in California, 1988–1989. California Department of Forestry and Fire Protection, Sacramento.

Aegerter BJ and Gordon TR, 2006. Rates of pitch canker induced seedling mortality among *Pinus radiata* families varying in levels of genetic resistance to *Gibberella circinata* (anamorph *Fusarium circinatum*). Forest Ecology and Management, 235, 14-17.

Agustí-Brisach C, Pérez-Sierra A, Berbegal M, Aguado-Ortega A, Iglesias-Sauce S, Armengol J and García-Jiménez J, 2009. Estudios preliminares sobre el control de *Fusarium circinatum* en semillas de *Pinus* spp. mediante tratamientos con agua caliente. 5° Congreso Forestal Español: Montes y sociedad: Saber qué hacer. Editors, SECF and Junta de Castilla y Leon, 10 p.

Aldous JR, 1972. Nursery practice. Her Majesty's Stationery Office, London. Forestry Commission. Bulletin 43, 184 p.

Allen TW, Enebak SA and Carey WA, 2004. Evaluation of fungicides for control of species of *Fusarium* on longleaf pine seed. Crop Protection 23, 979-982.

Anderson R, Belcher E and Miller T, 1984. Occurrence of seed funghi inside slash pine seeds produced in seed orchards in the United States. Seed Science and Technology, 12, 795-799.

Anonymous, 2001. Transport, disposal, and use of woody material infested with the pine pitch canker fungus. Pitch Canker Task Force Prevention and Management Position Paper. California Department of Forestry and Fire Protection, Department of Forest and Beach. Available online from: http://frap.cdf.ca.gov/pitch_canker/prevention_management/position_paper.html. Consulted on 15 February 2010.

Arvanitis LG, Godbee JFJ and Porta I, 1984. Pitch canker impact on volume growth: a case study in slash plantations. Southern Journal of Applied Forestry, 8 (1), 43-47.

Ayres MP and Lombardero MJ, 2000. Assessing the consequences of global change for forest disturbance from herbivores and pathogens. The science of the total environment, 262, 263-286.

Barnard EL and Blakeslee GM, 1987. Pitch canker of southern pines. Florida Department of Agriculture and Consumer Services, Division of Plant Industry. Plant Pathology Circular No. 302, 4 p December 1987 (first revision February 2006).

Barnett JP, 1972. Southern pine seed germinate after 40 years‟ storage. Journal of Forestry, 70, 629.

Barnett JP, 1976. Sterilizing southern pine seeds with hydrogen peroxide. Tree Planters‟ Notes 27(3),17–19.

Barnett JP and Pesacreta TC, 1993. Handling longleaf pine seeds for optimal nursery performance. Southern Journal of Applied Forestry 17(4), 180-186.

Barnett JP and McGilvrary JM, 1997. Practical guidelines for producing longleaf pine seedlings in containers. Gen. Tech. Rep. SRS-14. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station, 28 p. Available online from: http://www.bugwood.org/container/cultural.html. Consulted on 15 February 2010.

Barnett JP, Pickens B and Karrfalt R, 1999. Improving longleaf pine seedling establishment in the nursery by reducing seedcoat microorganisms. In: Haywood JD, editor. Proceedings tenth biennial southern silvicultural research conference. Asheville (NC): USDA Forest Service, Southern Research Station. General Technical Report SRS-30, 339–343.

Barnett JP and Varela S, 2003. Producing high-quality slash pine seeds. In: Riley LE, Dumroese R.K., Landis RD, editors. National Proceedings: Forest and Conservation Nursery Associations – 2002. Ogden, UT: USDA Forest Service, Rocky Mountain Research Station. Proceedings RMRS-P-28, 52-56.

Barnett JP and Varela S, 2004. A review of chemical treatments to improve germination of longleaf pine seeds. Nativeplants, Spring 2004.

Barrows-Broaddus J and Dwinell LD, 1980. Decay and colonization of gladiolus corms by the pine pitch canker fungus. Phytopathology, 70, 847-850.

Barrows-Broaddus J and Kerr TJ, 1981. Inhibition of *Fusarium moniliforme var. subglutinans*, the causal agent of pine pitch canker, by the soil bacterium *Arthrobacter* sp. Canadian journal of microbiology, 27, 20.

Barrows-Broaddus J and Dwinell LD, 1983. Histopathology of *Fusarium moniliforme* var. *subglutinans* in four species of southern pines. Phytopathology 73, 882-889.

Barrows-Broaddus J and Dwinell LD, 1985a. Branch dieback and cone and seed infection caused by *Fusarium moniliforme var. subglutinans* in a loblolly pine seed orchard in South Carolina. Phytopathology, 75, 1104-1108.

Barrows-Broaddus J and Dwinell LD, 1985b. Evaluation of *Arthrobacter* sp. for biological control of the pitch canker fungus *Fusarium moniliforme var. subglutinans* on slash pines. Canadian Journal of Microbiology 31, 888-892.

Barrows-Broaddus J, 1987. Pitch canker. Cone and seed diseases of north american conifers. Editors – Sutherland JR, Miller T and Quinard RS–. North American Forestry Commission Publication No. 1. Victoria, B.C. Canada, 42-49.

Belcher J, Carlson LW. 1968. Seed-treatment fungicides for control of conifer damping-off: laboratory and greenhouse tests. Canadian Plant Disease Survey, 48(2), 87-52.

Belcher EW, 1982. Storing stratified seeds for extended periods. Tree Planters‟ Notes, 24(3), 23-25.

Bell S, Tyrväinen L, Sievänen T, Pröbstl U and Simpson M, 2007. Outdoor recreation and nature tourism: a European perspective. Living Reviews. Landscape, 1, 2007, 2. Available online from: http://www.livingreviews.org/lrlr-2007-2. Consulted on15 February 2010.

Biosecurity Australia, 2006. Technical justification for Australia"s requirement for wood packaging material to be bark free. Biosecurity Australia, Canberra, Australia.

Blakeslee GM, Oak SW, Gregory W and Moses CS, 1978. Natural association of *Fusarium moniliforme var. subglutinans* with *Pissodes nemorensis*. Phytopathology News, 12, 208.

Blakeslee GM and Oak SW, 1979. Significant mortality associated with pitch canker infection of slash pine in Florida. Plant Disease Reporter, 63, 1023-1025.

Blakeslee GM, Dorset RD and Oak SW, 1979. Inoculum dispersal of the pine pitch canker fungus (*Fusarium moniliforme* var. *subglutinans*). Phytopathology, 69, 1022.

Blakeslee GM, Dwinell LD and Anderson RL, 1980. Pitch canker of southern pines: identification and management considerations. USDA Forest Service Southeast Area State and Private Forestry. Report SA-FR, 11, 15 p.

Blakeslee GM, Foltz JL and Oak SW, 1981. The deodar weevil, a vector and wounding agent associated with pitch canker of slash pine. Phytopathology, 71, 861.

Blakeslee GM, Jokela EJ, Hollis CH, Wilson DS, Lante WD and Allen JE, 1999. Pitch Canker in young Loblolly pines: influence of pre-commercial thinning and fertilization on disease incidence and severity. Southern Journal of Applied Forestry, 23, 139-143.

Bloomberg WJ and Trelawny J, 1970. Effect of thiram on germination of Douglas-fir seed. Phytopathology, 60, 1111-1116.

Bonello P, Gordon TR and Storer AJ, 2001. Systemic induced resistance in Monterey pine. Forest Pathology, 31, 99-106.

Bragança H, Diogo E, Moniz F and Amaro P, 2009. First report of pitch canker on pines caused by *Fusarium circinatum* in Portugal. Plant Disease. Instituto Nacional de Recursos Biológicos I.P., Quinta do Marquês, Edifício da exEFN, 2780 - 159 Oeiras, Portugal, 93.

Britz H, Coutinho TA, Wingfield MJ, Marasas WFO, Gordon TR and Leslie JF, 1999. *Fusarium subglutinans* f. sp. *pini* represents a distinct mating population in the *Gibberella fujikuroi* species complex. Applied and Environmental Microbiology, 65, 1198-1201.

Britz H, Coutinho TA, Wingfield MJ and Marasas WFO, 2002. Validation of the description of *Gibberella circinata* and morphological differentiation of the anamorph *Fusarium circinatum*. Sydowia, 54, 9-22.

Britz H, Coutinho TA, Wingfield BD, Marasas WFO and Wingfield MJ, 2005. Diversity and differentiation in two populations of *Gibberella circinatum* in South Africa. Plant Pathology, 54, 46-52.

Burgess T and Wingfield MJ, 2002. Quarantine is important in restricting the spread of exotic seed-borne tree pathogens in the southern hemisphere. International Forestry Review, 4, 56-65.

CAB International, 2007. Reports - *Gibberella circinata* (pitch canker) - *Pinus* -. Crop Protection Compendium. Wallingford, UK: CAB International.

Campbell SJ and Landis TD, 1990. Managing seedborne diseases in western forest nurseries. Tree Planters"Notes, 41(4), 3-7.

Carey WA and Kelley WD, 1994. First report of *Fusarium subglutinans* as a cause of late-season mortality in longleaf pine nurseries. Plant Disease, 78, 754.

Carey WA, Oak SW and Enebak SA, 2005. Pitch canker ratings of longleaf pine clones correlate with *Fusarium circinatum* infestation of seeds and seedling mortality in containers. Forest Pathology, 35, 205-212.

Carlucci A, Colatruglio L and Frisullo S, 2007. First report of pitch canker caused by *Fusarium circinatum* on *Pinus halepensis* and *P. pinea* in Apulia (Southern Italy). Plant Disease, 91, 1683-1683.

Carter MC and Jones L, 1962. The effect of hydrogen peroxide on the germination of loblolly and slash pine seed. Asheville (NC): USDA Forest Service, Southeastern Forest Experiment Station. Research Paper 141. 12 p.

Chandelier P, 2000. Preliminary pest risk analysis for *Gibberella circinata* Nirenberg and O'Donnell French Plant Protection Service (April 2000)

Ching TM and Parker MC, 1958. Hydrogen peroxide for rapid viability tests of some coniferous tree seeds. Forest Science 4, 128-134.

Correll JC, Gordon TR and McCain AH, 1992. Genetic diversity in California and Florida populations of the pitch canker fungus *Fusarium subglutinans* f. sp. *pini*. Phytopathology, 82, 415-420.

Correll JC, Gordon TR, McCain AH, Fox JW, Koehler CS, Wood DL and Schultz ME, 1991. Pitch canker disease in California: pathogenicity, distribution, and canker development on Monterey pine (*Pinus radiata*). Plant Disease, 75, 676-682.

Coutinho TA, Wingfield MJ, Viljoen A, Britz H and Marasas WFO, 1996. Pitch canker of pines: a southern African perspective. Proceedings of the ISTA Tree Seed Pathology Meeting, Opocno, Czech Republic, 9-11 October 1996, 29-35.

Coutinho TA, Steenkamp ET, Mongwaketsi K, Wilmot M and Wingfield MJ, 2007. First outbreak of pitch canker in a South African pine plantation. Australasian Plant Pathology, 36, 256-261.

Cram MM, 2009. Damping-off in tree nurseries. An online guide to plant disease control. Oregon State University Extension. Editors -Jay W. Pscheidt and Cynthia M. Ocamb, Extension Plant Pathology Specialists, Oregon State University, Corvallis, OR 97331-2903 World Wide Web site- and scripting by Eric T. Peterson and Bryan Capitano. Available online from: http://ipmnet.org/plant-disease/articles.cfm?article_id=40. Article last updated on January 1, 2009. Consulted on 15 February 2010.

Dallara PL, Storer JA, Gordon TR, and Wood DL, 1995. Current status of pitch canker disease in California. California Department of Forestry and Fire Protection. Tree Note 20. Available online from: http://www.frap.fire.ca.gov/pitch_canker/prevention_management/treenotes.html. Consulted on 15 February 2010.

Dallara PL, 1997. Studies on the distribution, interspecific relationships, host range, and chemical ecology of *Pityophthorus* spp. (Coleoptera: Scolytidae) and selected insectan associates, and their associations with *Fusarium subglutinans* f. sp. *pini* in central coastal California. Ph.D. diss. University of California, Berkeley.

Devey M, Matheson C and Gordon TR, (editors), 1999. Current and potential impacts of pitch canker in radiata pine. Proceedings of the IMPACT Monterey Workshop, Monterey, CA, USA, 30 November-3 December 1998. CSIRO Australia, 120 p.

Dick MA, 1998. Pine pitch canker-the threat to New Zealand. New Zealand Forestry, 42, 30-34.

Dick MA and Dobbie K, 2002. Species of *Fusarium* on *Pinus radiata* in New Zealand. Proceedings of the Fifty-fifth New Zealand Plant Protection, 55, 58-62.

Dobbs RC, 1971. Effect of thiram-endrin formulations on the germination of jack pine and white spruce seed in the laboratory. Tree Planters" Notes, 22(3), 16-18.

Dumroese RK, James RL, Wenny DL and Gilligan CJ, 1988. Douglas-fir seed treatments: effects on seed germination and seedborne organisms. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station: Fort Collins, CO, 155-160.

Dwinell LD and Phelps WR, 1977. Pitch canker of slash pine in Florida. Journal of Forestry, 75, 488-489.

Dwinell LD, Ryan PL and Kuhlman EG 1977. Pitch canker of loblolly pine in seed orchards. Proceedings of the fourteenth conference on Southern Forest Tree Improvement, June 1977, University of Florida, Gainesville, 130-137.

Dwinell LD and Barrows-Broaddus J, 1978. Recovery of the pine pitch canker fungus from pine plantations and seed orchard soil. Phytopathology News, 12, 207.

Dwinell LD, Kuhlman EG and Blakeslee GM, 1981. Pitch cancer of southern pines. Fusarium: Diseases, Biology and Taxonomy. Editors PE Nelson, TA Toussoun and RJ Cook. The Pennsylvania State University Press, University Park, 188-194.

Dwinell LD and Barrows-Broaddus J, 1982. Pitch canker in southern pine seed orchards. Phytopathology, 72, 979.

Dwinell LD, Barrows-Broaddus J and Kuhlman EG, 1985. Pitch canker: a disease complex of southern pines. Plant disease (USA), 69, 270-276.

Dwinell LD, 1998. Association of the pitch canker fungus with cones and seeds of pines. Current and Potential Impacts of Pitch Canker in Radiata Pine. Proceedings of the IMPACT Monterey Workshop, Monterey, CA, USA, 30 November-3 December 1998. CSIRO Australia. (editors. Devey ME, Matheson AC and Gordon TR), 35-38.

Dwinell LD, 1999. Contamination of *Pinus radiata* Seeds in California by *Fusarium circinatum*. Proceedings of Annual International Research Conference on methyl bromide alternatives and emissions reductions, 1999, November 1-4, San Diego, California.

Dwinell LD and Fraedrich SW, 1999. Contamination of pine seeds by the pitch canker fungus. National Proceedings of the Forest and Conservation Nursery Associations, 1998, USDA, Forest Service, Southern Research Station, General Technical Report SRS-25, 41-42.

Dwinell LD, Fraedrich SW and Adams D, 2001. Diseases of pines caused by the pitch canker fungus. Proceedings of Fusarium: Paul E. Nelson Memorial Symposium. Editors BA Summerell, JF Leslie, D Backhouse, WL Bryden, LW Burgess, 225-232. The American Phytopathological Society: St Paul, MN.

EFSA Panel on Plant Health (PLH), 2010. Guidance on a harmonised framework for pest risk assessment and the identification and evaluation of pest risk management options. EFSA Journal 2010, 8(2), 1495. 66 p. Available online from: http://www.efsa.europa.eu/en/efsajournal.htm

EPPO (European and Mediterranean Plant Protection Organization), 2005a. Details on quarantine pests in Spain: 2004 situation. EPPO Reporting services 2005/050, n°4. European and Mediterranean Plant Protection Organization, Paris, France.

EPPO (European and Mediterranean Plant Protection Organization), 2005b. First record of *Gibberella circinata* (pine pitch canker) in Spain. EPPO Reporting services 2005/097, n°7. European and Mediterranean Plant Protection Organization, Paris, France.

EPPO (European and Mediterranean Plant Protection Organization), 2006a. Further details on the situation of *Gibberella circinata* in Spain. EPPO Reporting services 2006/050, n°3. European and Mediterranean Plant Protection Organization, Paris, France.

EPPO (European and Mediterranean Plant Protection Organization), 2006b. First report of *Gibberella circinata* in France. EPPO Reporting services 2006/104, n°5. European and Mediterranean Plant Protection Organization, Paris, France.

EPPO (European and Mediterranean Plant Protection Organization), 2007. Details on quarantine pests in Spain: 2006 situation. EPPO Reporting services 2007/137, n°7. European and Mediterranean Plant Protection Organization, Paris, France.

EPPO (European and Mediterranean Plant Protection Organization), 2008a. First report of *Gibberella circinata* in Italy. EPPO Reporting services 2008/71, n°4. European and Mediterranean Plant Protection Organization, Paris, France.

EPPO (European and Mediterranean Plant Protection Organization), 2008b. *Gibberella circinata* eradicated in France. EPPO Reporting services 2008/103, n°5. European and Mediterranean Plant Protection Organization, Paris, France.

EPPO (European and Mediterranean Plant Protection Organization), 2009a. Diagnostic protocol on *Gibberella circinata*. EPPO standard for identification PM 7/91 (1), 2009. European and Mediterranean Plant Protection Organization. EPPO Bulletin 39, 298-309.

EPPO (European and Mediterranean Plant Protection Organization), 2009b. *Gibberella circinata* eradicated from Italy. EPPO Reporting services 2009/52, n°3. European and Mediterranean Plant Protection Organization, Paris, France.

EPPO (European and Mediterranean Plant Protection Organization), 2009c. Situation of *Gibberella circinata* in France. EPPO Reporting services 2009/93, n°5. European and Mediterranean Plant Protection Organization, Paris, France.

EPPO (European and Mediterranean Plant Protection Organization), 2009d. First report of *Gibberella circinata* in Portugal. EPPO Reporting services 2009/196, n°10. European and Mediterranean Plant Protection Organization, Paris, France.

EPPO (European and Mediterranean Plant Protection Organization), 2010. *Gibberella circinata* detected again in France. EPPO Reporting services 2010/34, n°2. European and Mediterranean Plant Protection Organization, Paris, France.

Erbilgin N, Ritokova G, Gordon TR, Wood DL and Storer AJ, 2008. Temporal variation in contamination of pine engraver beetles with *Fusarium circinatum* in native Monterey pine forests in California. Plant Pathology, 57, 1103-1108.

EUROSTAT, 2007. Forestry Statistics. Agriculture and fisheries. EUROSTAT Pocketbooks, 2007 Edition. European Commission.

EUROSTAT, 2008a. Forestry database consultation. Dataset: EU27 since 1999 CN (simulated). Intra and extra European Union (27). European Commission. Consulted on 30 November 2009 on following categories: 0602 20 90; 0602 90; 0602 90 41; 0604; 0604 91 20 ; 0604 91 40; 0604 99 ; 0604 99 10; 0604 99 90; 0802; 0802 90 50; 1209 99 10.

EUROSTAT, 2008b. Forestry database consultation. Trade by roundwood categories and species: imports and exports of sawlogs and veneer logs from pine. Consulted on 06 November 2009.

FAO (Food and Agriculture Organisation of the United Nations), 1998. Appreciation of the Chilean forest resource. In: Plantations of *Pinus radiata* and *Eucalyptus* sp. 1985–1996. Food and Agricultural Organization of the United Nations, Rome, Italy.

FAO (Food and Agriculture Organisation of the United Nations), 2007a. International Standards for Phytosanitary Measures (ISPM) 1 to 29 (2007 edition). ISPM No. 15: Guidelines for regulating wood packaging material in international trade (2002), with modifications to Annex I (2006), Rome, 194-205.

FAO (Food and Agriculture Organisation of the United Nations), 2007b. International Standards for Phytosanitary Measures (ISPM) 1 to 29 (2007 edition). ISPM No. 14: The use of integrated measures in a systems approach for pest risk management. (2002), Rome, 184-193.

FAO (Food and Agriculture Organisation of the United Nations), 2007c. International Standards for Phytosanitary Measures (ISPM) 1 to 29 (2007 edition). ISPM No. 5: Glossary of phytosanitary terms. Food and Agricultural Organization of the United Nations, Rome, 61-85.

Fisher RF, Garbett WS and Underhill EM, 1981. Effects of fertilization on healthy and pitch canker-infected pines. Southern Journal of Applied Forestry, 5, 77-79.

Fox JW, Wood DL and Koehler CS, 1990. Distribution and abundance of engraver beetles (Scolytidae: *Ips* species) on Monterey pines infected with pitch canker. The Canadian Entomologist, 122, 1157-1166.

Fox JW, Wood DL, Koehler CS and O'Keefe ST, 1991. Engraver beetles (Scolytidae: *Ips* species) as vectors of the pitch canker fungus, *Fusarium subglutinans*. The Canadian Entomologist, 123, 1355-1367.

Fraedrich BR and Witcher W, 1982. Influence of fertilization on pitch canker development on three southern pine species. Plant Disease, 66, 938-940.

Fraedrich BR and Dwinell LD, 1997. Mortality of longleaf pine seedlings caused by *Fusarium subglutinans* and an evaluation of potential inoculum sources. Proceedings of the 3rd meeting of the IUFRO working group S7.03.04, diseases and insects in forest nurseries, 29-24 May 1994. Northern Region Report 97-4. Editor R James. US Department of Agriculture, Forest Services, Forest Heath Protection, 48-54.

Fraedrich SW, 1996. Seedborne diseases of southern pines and developing strategies for their control. National Proceedings, Forest and Conservation Nursery Associations. Landis, T. D. and South, D. B. Technical Coordinators. D. B. USDA Forest Service Pacific Northwest Research Station. Portland, Oregon. General Technical Report, PNW-GTR-389, 75-81.

Fraedrich SW, 2001. Seedborne pathogens and strategies to eliminate and reduce their presence on tree seeds. Exotic Pests Workshop, Session V: An International Online Workshop to reduce movement of forest pests with a minimal impact on trade, April 16-29, 2001. Available online from: http://www.apsnet.org/online/proceedings/exoticpest/Papers/Fraedrich.htm. Consulted on 15 February 2010.

Gadgil PD and Flint TN, 1983. Assessment of the risk of introduction of exotic forest insects and diseases with imported tents. New Zealand Journal of Forestry, 28, 58-67.

Gadgil PD, Dick MA, Simpson J, Bejakovich D, Ross M, Bain J, Horgan G and Wylie R, 2003. Management plan response to an incursion of pine pitch canker in Australia or New Zealand. Commissioned and Published by the Forest Health Committee on behalf of the Forestry and Forest Products Committee, Canberra.

Ganley RJ, 2006. Pitch canker: risk of establishment in New Zealand based on a global perspective. New Zealand Journal of Forestry, 52, 26-30.

Ganley RJ, 2007. Pitch canker-risk of establishment in New Zealand based on a global perspective. New Zealand Journal of Forestry, 52, 26-30.

Ganley RJ, Watt MS, Manning L and Iturritxa E, 2009. A global climatic risk assessment of pitch canker disease. Canadian Journal of Forest Research, 39, 2246-2256.

Garbelotto M, Schweigkofler W and Shaw D, 2007. First report of *Fusarium circinatum*, causal agent of pitch canker disease, from the roots of mature Aleppo pines in California. Plant Health Progress, 1-2.

Garbelotto M, Smith T and Schweigkofler W, 2008. Variation in rates of spore deposition of *Fusarium circinatum,* the causal agent of pine pitch canker, over a 12-month-period at two locations in Northern California. Phytopathology, 98, 137-143.

GDFNE (General Directorate for the Forests and the Natural Environment), 1992. Results of the First National Forest Census. Ministry for Rural Development and Food, Athens

Gordon TR, Okamoto D, Storer AJ and Wood DL, 1998. Susceptibility of five landscape pines to pitch canker disease, caused by *Fusarium subglutinans* f. sp. *pini*. Hortscience, 33, 868-871.

Gordon TR, Wood DL and Storer AJ, 2000. Survival of *Fusarium circinatum* and its insect vectors in recently cut pitch canker infected trees. Final report to California Department of Forestry June 2000.

Gordon TR, Storer AJ and Wood DL, 2001. The pitch canker epidemic in California. Plant Disease, 85, 1128-1139.

Gordon TR and Dick MA, 2003. Fungicide treatment of *Pinus radiata* seed infected with *Fusarium circinatum*. 17 June 2003 Report to New Zealand Forest Health Research Collaborative.

Gordon TR, Wood DL and Storer AJ, 2004. Research on pitch canker at University of California: 1999-2003. Final report to California Department of Forestry and Fire Protection. August 2004.

Gordon TR, Kirkpatrick SC, Aegerter BJ, Wood DL and Storer AJ, 2006. Susceptibility of Douglas-fir (*Pseudotsuga menziesii*) to pitch canker, caused by *Gibberella circinata* (anamorph = *Fusarium circinatum*). Plant Pathology, 55, 231-237.

Greenslade P, Farrow RA and Smith JMB, 1999. Long distance migration of insects to a subantarctic island. Journal of Biogeography, 26, 1161-1167.

Guerra-Santos JJ, 1999. Pitch canker in Monterey pine in Mexico. Current and potential impacts of pitch canker in radiata pine. Proceedings of the IMPACT Monterey Workshop, Monterey, CA, USA, 30 November-3 December 1998. Editors: Devey M, Matheson C and Gordon TR. CSIRO Australia, 58-61.

Hammerbacher A, Wright LP, Wingfield BD, Wingfield MJ and Coutinho TA, 2009. Factors affecting pine pitch canker modelled on Michaelis-Menten kinetics. Botany-Botanique, 87, 36-42.

Harkin JM, 1969. Uses for sawdust, shavings, and waste chips. USDA Forest Service Research note FPL, 0208. Forest Products Laboratory, Forest Service U.S. Department of Agriculture, 45 p. Available online from: http://www.treesearch.fs.fed.us/pubs/5761. Consulted on 10 January 2010.

Harkin JM and Rowe JW, 1971. Bark and its possible uses. USDA Forest Service Research note FPL, 091. Forest Products Laboratory, Forest Service U.S. Department of Agriculture, 56 p. Available online from: http://www.treesearch.fs.fed.us/pubs/5760. Consulted on 10 January 2010.

Hepting GH and Roth ER, 1946. Pitch canker, a new disease of some southern pines. Journal of Forestry, 44, 742-744.

Hepting GH and Roth ER, 1953. Host relations and spread of the pine pitch canker disease. Phytopathology, 43, 475-475.

Hodge GR and Dvorak WS, 2000. Differential responses of Central American and Mexican pine species and *Pinus radiata* to infection by the pitch canker fungus. New Forests, 19, 241-258.

Hoover K, Wood DL, Fox JW and Bros WE, 1995. Quantitative and seasonal association of the pitch canker fungus, *Fusarium subglutinans* f. sp. *pini* with *Conophthorus radiatae* (Coleoptera*:* Scolytidae) and *Ernobius punctulatus* (Coleoptera*:* Anobiidae) which infest *Pinus radiata*. Canadian Entomologist, 127, 79-91.

Hoover K, Wood DL, Storer AJ, Fox JW and Bros WE, 1996. Transmission of the pitch canker fungus, *Fusarium subglutinans f* sp *pini*, to Monterey pine, Pinus radiata, by cone- and twig-infesting beetles. Canadian Entomologist, 128, 981-994.

Huang JW and Kuhlman EG, 1990. Fungi associated with damping-off of slash pine seedlings in Georgia. Plant Disease (USA), 74, 27-30.

Hurley BP, Govender P, Coutinho TA, Wingfield BD and Wingfield MJ, 2007a. Fungus gnats and other Diptera in South African forestry nurseries and their possible association with the pitch canker fungus. South African Journal of Science, 103, 43-46.

Hurley BP, Slippers B, Coutinho TA, Wingfield BD, Govender P and Wingfield MJ, 2007b. Molecular detection of fungi carried by *Bradysia difformis (*Sciaridae *:* Diptera) in South African forestry nurseries. Southern Hemisphere Forestry Journal, 69, 103-109.

IFN (Inventario Florestal Nacional), 2005. Resultados do IFN 2005/06. Direcção-Geral dos Recursos Florestais. Lisbon.

IFN (Inventaire Forestier National), 2008. The French forest: figures and maps. Edition 2008. France.

IFNC (Inventario Nazionale delle Foreste e dei Serbatoi di Carbonio), 2005. Dossier tematico inventario nazionale delle foreste e dei serbatoi di carbonio. Corpo Forestale dello Stato, Ispettorato Generale.

Inman AR, Kirkpatrick SC, Gordon TR and Shaw AV, 2008. Limiting effects of low temperature on growth and spore germination in *Gibberella circinata*, the cause of pitch canker in pine species. Plant Disease, 92, 542-545.

Ioos R, Fourrier C, Iancu G and Gordon TR, 2009. Sensitive detection of *Fusarium circinatum* in pine seed by combining an enrichment procedure with a real-time polymerase chain reaction using dual-labeled probe chemistry. Phytopathology, 99, 582-590.

ISTA (International Seed Testing Association), 2002. Detection of *Fusarium moniliforme* var. *subglutinans* on *Pinus taeda* and *Pinus elliottii* (Pine). International Rules for Seed Testing Annex to Chapter 7: Seed Health Testing Methods. International Seed Testing Association (ISTA), Bassersdorf, Switzerland. 7-009 (revision 2008).

Jones JP, Sun X, Eckhardt L, Weber A, Hess N, Barnett J and McGilvary J, 2002. Longleaf seedling production: some problems and their solutions. Louisiana Agriculture, 45, 4-11.

JRC (Joint Research Centre), 2009a. Forest species distribution maps. European Commission, Joint Research Centre, Institute for Environment and Sustainability. Available online from: http://forest.jrc.ec.europa.eu/download/data/climatechange/species/distribution. Consulted on 12 October 2009.

JRC (Joint Research Centre), 2009b. Tree species distribution, Rationale - Methodology - Results - Conclusion - Bibliography. European Commission, Joint Research Centre, Institute for Environment and Sustainability. Forest Data and Information Systems. Available online from: http://forest.jrc.ec.europa.eu/climate-change/species-distribution. Consulted on 01 December 2009.

Kayihan GC, Huber DA, Morse AM, White TL and Davis JM, 2005. Genetic dissection of fusiform rust and pitch canker disease traits in loblolly pine. TAG Theoretical and Applied Genetics, 110, 948-958.

Kelley WD and Williams JC, 1982. Incidence of pitch canker among clones of loblolly pine in seed orchards. Plant disease (USA), 66, 1171-1173.

Kobayashi T and Muramoto M, 1989. Pitch canker of Pinus luchuensis, a new disease in Japanese forests. Forest Pests, 38, 169-173.

Kratka SH, Blakeslee GM, Dorset RD and Oak SW, 1979. Seasonal development of sporodochia of the pitch canker fungus, *Fusarium moniliforme* var. *subglutinans*, on diseased slash pines in Florida. Phytopathology, 69(9), 1034.

Kriticos DJ, Sutherst RW, Brown JR, Adkins SA, Maywald GF, 2003a. Climate change and biotic invasions: a case history of a tropical woody vine. Biological Invasions, 5, 145–165.

Kriticos DJ, Sutherst RW, Brown JR, Adkins SA, Maywald GF, 2003b. Climate change and the potential distribution of an invasive alien plant: *Acacia nilotica* ssp. *indica* in Australia. Journal of Applied Ecology, 40, 111–124.

Kuhlman EG, Dwinell LD, Nelson PE and Booth C, 1978. Characterization of the *Fusarium* causing pitch canker of southern pines. Mycologia, 70, 1131-1143.

Kuhlman EG, 1982. Varieties of *Gibberella fujikuroi* with anamorphs in *Fusarium* section *Liseola*. Mycologia, 74, 759-768.

Kuhlman EG, Dianis SD and Smith TK, 1982. Epidemiology of pitch canker disease in a loblolly pine seed orchard in North Carolina [*Fusarium moniliforme* var. *subglutinans, Pinus taeda*]. Phytopathology, 72, 1212-1216.

Kuhlman EG and Cade SC, 1985. Pitch canker disease of loblolly and ponds pines in North Carolina plantations. Plant Disease, 69, 175-176.

Kuhlman EG, 1987. Effects of inoculation treatment with *Fusarium moniliforme var. subglutinans* on dieback of loblolly and slash pine seedlings. Plant Disease, 71, 161-162.

Kvas M, Marasas WFO, Wingfield BD, Wingfield MJ and Steenkamp ET, 2009. Diversity and evolution of *Fusarium* species in the *Gibberella fujikuroi* complex. Fungal Diversity, 34, 1-21.

Landeras E, Garcia P, Fernandez Y, Brana M, Fernandez-Alonso O, Mendez-Lodos S, Perez-Sierra A, Leon M, Abad-Campos P, Berbegal M, Beltran R, Garcia-Jimenez J and Armengol J, 2005. Outbreak of pitch canker caused by *Fusarium circinatum* on *Pinus* spp. in Northern Spain. Plant Disease, 89, 1015-1015.

Lee JK, Lee SH, Yang SI and Lee YW, 2000. First report of pitch canker disease on *Pinus rigida* in Korea. Plant Pathology Journal, 16, 52-54.

Leslie JF, Summerell BA and Bullock S, 2006. The *Fusarium* laboratory manual. Editor: Blackwell Publishing Ltd, Oxford.

Liao T, Ye J, Chen J, Han Y, Wu C and An Y, 2008. Biological characteristics of *Fusarium circinatum*. Journal of Nanjing Forestry University, Natural Sciences Edition, 32, 83-86.

Lopez-Zamora I, Bliss C, Jokela EJ, Comerford NB, Grunwald S, Barnard E and Vasquez GM, 2007. Spatial relationships between nitrogen status and pitch canker disease in slash pine planted adjacent to a poultry operation. Environmental Pollution, 147, 101-111.

Lott LH, Lott LM, Stine M, Kubisiak TL and Nelson CD, 2003. Top grafting Longleaf x Slash Pine F1 Hybrids on mature longleaf and slash pine interstocks. Proceedings of the 27th Southern Forest Tree Improvement Conference, 24-27 June, Stillwater, Okla. Southern Forest Tree Improvement Committee, Stillwater, Okla, 96-101.

MAF (Ministry of Agriculture and Forestry New Zealand), 2003. Import Health Standard for Sawn Wood from All Countries Version 1.2. Biosecurity New Zealand. Ministry of Agriculture and Forestry New Zealand 16 April 2003. 21 p.

MAF (Ministry of Agriculture and Forestry New Zealand), 2009. Approved Biosecurity Treatments BNZ-SZTD-ABTRT. Biosecurity New Zealand. Ministry of Agriculture and Forestry New Zealand 30 November 2009, 47 p.

Matthews FR, 1962. Pitch canker-tip moth damage association on slash pine seedlings. Journal of Forestry, 60, 825-826.

McCain AH, Koehler CS and Tjosvold SA, 1987. Pitch canker threatens California pines. California Agriculture, 41, 22-23.

McCain AH, Correll JC and Gordon TR, 1989. Pitch canker wound dressing. Journal of Arboriculture, 15, 241-242.

McNee WR, Wood DL, Storer AJ and Gordon TR, 2002. Incidence of the pitch canker pathogen and associated insects in intact and chipped Monterey pine branches. Canadian Entomologist, 134, 47-58.

Miller T and Bramlett DL, 1979. Damage to reproductive structures of slash pine by two seedborne pathogens: *Diplodia gossypina* and *Fusarium moniliforme* var. *subglutinans*. Proceedings: Symposium on Flowering and Seed Development in Trees, Mississippi State University. Editor: F Bonner, 347-355.

Mitchell RG, Zwolinski JJ, Jones J and Coutinho TA, 2004. The effects of applying prophylactic measures on the post-planting survival of *Pinus patula* in South Africa. Southern African Forestry Journal 200, 51-58.

MMA (Ministerio de Medio Ambiente), 2002. Plan Forestal Español, Madrid.

Molina-Murillo SA, Smith TM, Reichenbach M and Smith R, 2005. Impact of international phytosanitary standards on wood packaging material (WPM) end users: preimplementation assessment. U.S. Department of Agriculture, Forest Service, Wood Education and Resource Center and the Limestone Bluffs RC&D, Inc. Available online from: http://www.bbe.umn.edu/sites/09e1b491-15c5-4507-b6c1-72ac7cf21b53/uploads/147KBpdf.pdf. Consulted on 15 February 2010

Morrell JJ, 1995. Importation of unprocessed logs into North America: a review of pest mitigation procedures and their efficacy. Forest Products Journal, 45(9), 41–50.

Muramoto H and Dwinell LD, 1990. Pitch canker of *Pinus luchuensis* in Japan. Plant Disease, 74, 530.

New M, Hulme M and Jones PD, 1999. Representing twentieth century space-time climate variability. Part 1: development of a 1961-90 mean monthly terrestrial climatology. Journal of Climate, 12, 829-856.

New M, Lister D, Hulme M and Makin I, 2002: A high-resolution data set of surface climate over global land areas. Climate Research, 21.

Nirenberg HI and O'Donnell K, 1998. New *Fusarium* species and combinations within the *Gibberella fujikuroi* species complex. Mycologia, 90, 434-458.

Ocskó Z, Erdős G and Molnár J, 2009. Növényvédőszerek, Termésnövelő Anyagok 2009. I-II. Földművelésügyi Minisztérium.

O'Donnell K, Cigelnik E and Nirenberg HI, 1998. Molecular systematics and phylogeography of the *Gibberella fujikuroi* species complex. Mycologia, 90, 465-493.

Owen D and Adams D, 2001. Impact of pitch canker on ornamental Monterey pines in Santa Cruz County, California, US, 1987-2000. Journal of Arboriculture, 27, 298-305.

Pawuk WH, 1978. Damping-off of container grown longleaf pine seedlings by seed-borne fusaria. Plant Disease Report, 62, 82-84.

Perez-Sierra A, Landeras E, Leon M, Berbegal M, Garcia-Jimenez J and Armengol J, 2007. Characterization of *Fusarium circinatum* from *Pinus* spp. in northern Spain. Mycological Research, 111, 832-839.

Phelps WR and Chellman CW, 1976. Evaluation of "pitch canker" in Florida slash pine plantations and seed orchards . USDA Forest Service, Southeastern Area, unnumbered.

Ramsfield TD, Dobbie K, Dick MA and Ball RD, 2008. Polymerase chain reaction-based detection of *Fusarium circinatum*, the causal agent of pitch canker disease. Molecular Ecology Resources, 8, 1270-1273.

Ridley GS and Dick MA, 2000. Pine pitch canker disease: the name of the causal fungus and its distribution. Australasian Plant Pathology, 29, 263-266.

Rockwood DL, Blakeslee GM, Lowerts GA, Underhill EM and Oak SW, 1988. Genetic strategies for reducing pitch canker incidence in slash pine. Southern Journal of Applied Forestry, 12, 28-32.

Runion GB and Bruck RI, 1986. The influence of half-sib family and tree spacing on incidence of pitch canker in loblolly pine plantations in eastern North Carolina. Phytopathology, 76, 1113.

Runion GB and Bruck RI, 1988. Effects of thiabendazole-DMSO treatment of longleaf pine seed contaminated with Fusarium subglutinans on germination and seedling survival. Plant Disease (USA). 72(10), 872-874.

Runion GB, Kelley WD, Land DH, 1991. Effects of triadimefon and thiram seed treatments on emergence of southern pines. Seed Science and Technology, 19, 57-66.

Runion GB, Cade SC and Bruck RI, 1993. Effects of carbofuran and thiabendazole on incidence of pitch canker of loblolly pine. Plant disease (USA), 77, 166-169.

Sakamoto JM and Gordon TR, 2006. Factors influencing infection of mechanical wounds by *Fusarium circinatum* on Monterey pines (*Pinus radiata*). Plant Pathology, 55, 130-136.

Santos JJG and Tovar DB, 1991. Algunos aspectos sobre el cancro resinoso de los pinos. Proceedings of VI Simposio Nacional Sobre Parasitologia Forestal, (Unidad de Congresos del Colegio de Postgraduados Montecillos, Mexico), October 1991, 31.

Schweigkofler W, O'Donnell K and Garbelotto M, 2004. Detection and quantification of airborne conidia of *Fusarium circinatum*, the causal agent of pine pitch canker, from two California sites by using a real-time PCR approach combined with a simple spore trapping method. Applied and Environmental Microbiology, 70, 3512-3520.

Snyder WC, Toole ER and Hepting GH, 1949. Fusaria associated with mimosa, sumac wilt, and pine pitch canker. Journal of Agricultural Research, 78, 365-382.

South DB and Enebak SA, 2006. Integrated pest management practices in southern pine nurseries. New Forests, 31, 253-271.

Steenkamp ET, Wingfield BD, Coutinho TA, Wingfield MJ and Marasas WFO, 1999. Differentiation of *Fusarium subglutinans f.* sp *pini* by histone gene sequence data. Applied and Environmental Microbiology, 65, 3401-3406.

Steenkamp ET, Wingfield BD, Coutinho TA, Zeller KA, Wingfield MJ, Marasas WFO and Leslie JF, 2000. PCR-based identification of MAT-1 and MAT-2 in the *Gibberella fujikuroi* species complex. Applied and Environmental Microbiology, 66, 4378.

Storer AJ, Gordon TR, Dallara P and Wood D, 1994. Pitch canker kills pines, spreads to new species and regions. California Agriculture, 48, 9-13.

Storer AJ, Gordon TR, Wood DL and Dallara PL, 1995. Pitch canker in California. California Department of Forestry and Fire Protection, Sacramento. California Forestry Note N°110.

Storer AJ, Gordon TR, Wood D and Bonello P, 1997. Pitch canker disease of pines: current and future impacts. Journal of Forestry. Society of American Foresters, 95, 21-26.

Storer AJ, Wood DL, Wikler KR and Gordon TR, 1998a. Association between a native spittlebug (Homoptera : Cercopidae) on Monterey pine and an introduced tree pathogen which causes pitch canker disease. Canadian entomologist, 130,783-792.

Storer AJ, Gordon TR and Clark SL, 1998b. Association of the pitch canker fungus, *Fusarium subglutinans* f.sp. *pini*, with Monterey pine seeds and seedlings in California. Plant Pathology, 47, 649-656.

Storer AJ, Bonello P, Gordon TR and Wood DL, 1999. Evidence of resistance to the pitch canker pathogen (*Fusarium circinatum*) in native stands of monterey pine (*Pinus radiata*). Forest Science, 45, 500-505.

Storer AJ, Wood DL and Gordon TR, 2002a. Effects of pitch canker pathogen on gallery excavation and oviposition by *Ips paraconfusus* (Coleoptera : Scolytidae). Canadian entomologist, 134,519-528.

Storer AJ, Wood DL and Gordon TR, 2002b. The epidemiology of pitch canker of Monterey pine in California. Forest Science, 48, 694-700.

Storer AJ, Wood DL and Gordon TR, 2004. Twig beetles, *Pityophthorus* spp. (Coleoptera : Scolytidae), as vectors of the pitch canker pathogen in California. Canadian Entomologist, 136, 685-693.

Sutherst RW and Maywald GF, 1985. A computerised system for matching climates in ecology. Agriculture, Ecosystems and Environment, 13, 281–299.

Tanaka Y, 1982. Effect of freezing temperatures on noble fir seed during cone storage. Proceedings of the International Symposium on Forest Tree Seed Storage, September 23 1980. Petawawa National Forestry Institute. Chalk River, Ontario, 68-74.

Tanaka Y, 1984. Assuring seed quality for seedling production: cone collection and seed processing, testing, storage, and stratification. Forest nursery manual: production of bareroot seedlings 4, 27.

Templeton SR, Wood DL, Storer AJ and Gordon TR, 1997. Economic damages of pitch canker. Fremontia, 25, 10-14.

Thomas MG and Schumann DR, 1993. Income Opportunities in Special Forest Products, Self-Help Suggestions for Rural Entrepreneurs. USDA, Agriculture Information Bulletin N° 666. Available online from: http://www.fpl.fs.fed.us/research/units/tmu/tmu_pubs_topics_details.php?sort_criteria=category&groupings_id=57&unit_id=TMU&employee_id=. Consulted on 10 January 2010.

Tjosvold SA and McCain AH, 1988. Treatment of pitch canker on Monterey pine with fungisol injection. Journal of Arboriculture, 14, 135-136.

Toussoun TA, Menzinger W and Smith Jr RS, 1969. Role of conifer litter in ecology of *Fusarium*: stimulation of germination in soil. Phytopathology, 59, 1396-1399.

Trappe JM, 1961. Strong hydrogen peroxide for sterilizing coats of tree seed and stimulating germination. Journal of Forestry, 59, 828-829.

UF (University of Florida), 2010. Seedling care and handling before planting. Pine plantation management. Hillsborough County Extension Urban Forestry Website. Available online from http://urbanforestry.ifas.ufl.edu/PinePlantationMgmt.shtml. Consulted on 15 January 2010.

UN (United Nations), 2005. European Forest Sector Outlook Study 1960-2000-2020, Main Report. Geneva timber and forest study paper 20. United Nations Economic Commission for Europe (UNECE), Food and Agriculture Organization of the United Nations (FAO). Timber Branch, Geneva, Switzerland 2005.

USDA (United States Department of Agriculture) Forest Service, 2000. Background information about guidelines for handling woody material infected with the pitch canker fungus. Pitch canker Task Force, 23 January 1997, revised September 2000. Available online from: http://frap.cdf.ca.gov/pitch_canker/research/woody_guidelines.htm. Consulted on 15 January 2010.

Vaartaja O, 1964. Chemical treatment of seedbeds to control nursery diseases. Botanical Review, 30(1),1-91.

Viljoen A, Wingfield MJ and Marasas WFO, 1994. First report of *Fusarium subglutinans* f. sp. *pini* on pine seedlings in South Africa. Plant Disease (USA), 78, 309-312.

Viljoen A, Wingfield MJ, Kemp G and Marasas WFO, 1995. Susceptibility of pines in South Africa to the pitch canker fungus *Fusarium subglutinans* f.sp. *pini.* Plant Pathology, 44, 877-882.

Viljoen A, Marasas WFO, Wingfield MJ and Viljoen CD, 1997. Characterization of *Fusarium subglutinans* f. sp. *pini* causing root disease of *Pinus patula* seedlings in South Africa. Mycological Research, 101, 437-445.

Vogler DR, Gordon TR, Aegerter BJ, Kirkpatrick SC, Lunak GA, Stover P and Violett P, 2004. First report of the pitch canker fungus (*Fusarium circinatum*) in the Sierra Nevada of California. Plant Disease, 88, 772.

Watt MS, Kriticos DJ, Alcaraz S, Brown AV and Leriche A, 2009. The hosts and potential geographic range of *Dothistroma* needle blight. Forest Ecology and Management, 257, 1505-1519.

Wikler K, Storer AJ, Newman W, Gordon TR and Wood DL, 2003a. The dynamics of an introduced pathogen in a native Monterey pine (*Pinus radiata*) forest. Forest Ecology and Management, 179, 209-221.

Wikler K, Gordon TR, Storer AJ and Wood DL, 2003b. Pitch canker. Integrated pest management for home gardeners and landscape professionals.. Cooperative Extension, University of California, Placer and Nevada Counties. Pest Notes N° 74107. Available online from: http://www.ipm.ucdavis.edu/PMG/PESTNOTES/pn74107.html. Consulted on 01 December 2010.

Wingfield MJ, Jacobs A, Coutinho TA, Ahumada R, Wingfield BD, 2002a. First report of the pitch canker fungus, *Fusarium circinatum*, on pines in Chile. Plant Pathology, 51, 397.

Wingfield MJ, Coutinho TA, Roux J and Wingfield BD, 2002b. The future of exotic plantation forestry in the tropics and southern hemisphere: lessons from pitch canker. Southern African Forestry Journal, 195, 79-82.

Wingfield MJ, Hammerbacher A, Ganley RJ, Steenkamp ET, Gordon TR, Wingfield BD and Coutinho TA, 2008. Pitch canker caused by *Fusarium circinatum* - a growing threat to pine plantations and forests worldwide. Australasian Plant Pathology, 37, 319-334.

World Tourism Organization, 2006. Tourism Highlights (2006 Edition). World Tourism Organization, Madrid. Available online from: http://www.world-tourism.org/facts/eng/pdf/highlights/highlights 06 eng lr.pdf. Consulted on 7 November 2009.

Yan K and Dickman MB, 1993. Sensitivity of field strains of *Gibberella fujikuroi* (*Fusarium* section *Liseola*) to benomyl and hygromycin B. Mycologia 85, 206-213.

A. APPENDIX 1: RATINGS AND DESCRIPTORS

In order to follow the principle of transparency as described under section 3.1 of the Guidance document on the harmonised framework for risk assessment (EFSA Panel on Plant Health, 2010) – *"…Transparency requires that the scoring system to be used is described in advance. This includes the number of ratings, the description of each rating…. the Panel recognises the need for further development…"*– the Plant Health Panel has developed for this opinion rating descriptors to provide clear justification when a rating is given.

1. Ratings used in the conclusion of the pest risk assessment

In this opinion of EFSA"s Panel on Plant Health, concerning the risk assessment of *G. circinata*, a rating system of five levels with their respective descriptors has been developed to formulate separately the conclusions on entry, establishment, spread and impact as described in the following tables:

1.1. Rating of probability of entry

Ratings	Descriptors
Very unlikely	The likelihood of entry would be very low because the pest: i) is not or only occasionally associated with the pathway at the origin; ii) may not survive during transport or storage; iii) cannot survive the current pest management procedures existing in the risk assessment area; and/or iv) may not transfer to a suitable host in the risk assessment area.
Unlikely	The likelihood of entry would be low because the pest: i) is rarely associated with the pathway at the origin; ii) survives at very low rate during transport or storage; iii) is strongly affected by the current pest management procedures existing in the risk assessment area; and/or iv) has considerable limitations for transfer to a suitable host in the risk assessment area.
Moderately likely	The likelihood of entry would be moderate because the pest: i) is frequently associated with the pathway at the origin; ii) survive at low rate during transport or storage; iii) is affected by the current pest management procedures existing in the risk assessment area; and/or iv) has some limitations for transfer to a suitable host in the risk assessment area.
Likely	The likelihood of entry would be high because the pest i) is regularly associated with the pathway at the origin; ii) mostly survive during transport or storage; iii) is partially affected by the current pest management procedures existing in the risk assessment area; and/or iv) has very few limitations for transfer to a suitable host in the risk assessment area.
Very likely	The likelihood of entry would be very high because the pest i) is usually associated with the pathway at the origin; ii) survive during transport or storage; iii) is not affected by the current pest management procedures existing in the

	risk assessment area; and/or iv) has no limitations for transfer to a suitable host in the risk assessment area.

1.2. Rating of probability of establishment

Ratings	**Descriptors**
Very unlikely	The likelihood of establishment would be very low because: i) even though the host plants are present in the risk assessment area; ii) the environmental conditions are unsuitable; and/or iii) the host is susceptible for a very short time during the year; iv) other considerable obstacles to establishment occur.
Unlikely	The likelihood of establishment would be low because: i) even though the host plants are present in the risk assessment area; ii) the environmental conditions are mostly unsuitable; and/or iii) the host is susceptible for a very short time during the year; iv) other obstacles to establishment occur.
Moderately likely	The likelihood of establishment would be moderate because: i) even though the host plants are present in the risk assessment area; ii) the environmental conditions are frequently unsuitable and/or iii) the host is susceptible for short time; iv) other obstacles to establishment may occur.
Likely	The likelihood of establishment would be high because: i) the host plants are present in the risk assessment area; ii) they are susceptible for long time during the year; iii) and the environmental conditions are frequently suitable; iv) no other obstacles to establishment occur.
Very likely	The likelihood of establishment would be very high because: i) the host plants are present in the risk assessment area; ii) they are susceptible for long time during the year; iii) and the environmental conditions are suitable for most of the host growing season; iv) no other obstacles to establishment occur. Alternatively, the pest has already been established in the risk assessment area.

1.3. Rating of probability of spread

Ratings	**Descriptors**
Very unlikely	The likelihood of spread would be very low because the pest has only one specific way to spread (e.g. a specific vector) which is not present in the risk assessment area, and/or highly effective barriers to spread exist.
Unlikely	The likelihood of spread would be low because the pest has one to few specific ways to spread (e.g. specific vectors), their presence in the risk assessment area is occasional, and/or effective barriers to spread exist.
Moderately likely	The likelihood of spread would be moderate because the pest has few and specific ways to spread (e.g. specific vectors), their presence in the risk assessment area is

	limited, and/or effective barriers to spread exist.
Likely	The likelihood of spread would be high because the pest has some unspecific ways to spread, which are present in the risk assessment area; no effective barriers to spread exist.
Very likely	The likelihood of spread would be very high because the pest has multiple unspecific ways to spread, which are all present in the risk assessment area; no effective barriers to spread exist.

1.4. Rating of magnitude of the potential consequences

Ratings	**Descriptors**
Minimal	Not distinguishable from normal variation in the parameter examined.
Minor	Distinguishable from normal variation in the parameter examined but with reversible effects.
Moderate	Not expected to threaten viability of the hosts (in forest, nurseries, gardens, parks, etc.) but causing a decrease in production and/or in environmental resources. Effects are reversible.
Major	May threaten viability by increasing mortality or reducing vigour of the hosts. Decrease in production and/or in environmental resources. Effects may not be reversible.
Massive	Threaten viability by increasing mortality or reducing vigour of the hosts. Severe decrease in production and/or in environmental resources. Effects are irreversible.

2. Ratings used for the evaluation of the management options

The Panel developed the following ratings with their corresponding descriptors for evaluating the effectiveness and the technical feasibility of the risk management options to reduce the level of risk.

2.1. Rating of the effectiveness of risk management options

Rating	**Descriptors**
Negligible	The management has no practical effect in reducing the probability of entry or establishment or spread, or the potential consequences.
Very low	The management options make it possible to reduce the probability of entry or establishment or spread, or the potential consequences, to a moderate level.
Low	The management options make it possible to reduce the probability of entry or establishment or spread, or the potential consequences, to a low level.
Moderate	The management options make it possible to reduce the probability of entry or establishment or spread, or the potential consequences, to a very low level.
High	The management options make it possible to reduce the probability of entry or establishment or spread, or the potential consequences, to a negligible level.

2.2. Rating of the technical feasibility of risk management options

Rating	Descriptors
Negligible	The management options are not in use in the risk assessment area, and the many technical difficulties they have (e.g., changing or abandoning the current practices, implement new practices and or measures) make their implementation into the practice impossible.
Very low	The management options are not in use in the risk assessment area, and the many technical difficulties they have (e.g., changing or abandoning the current practices, implement new practices and or measures) make their implementation into the practice very difficult or nearly impossible.
Low	The management options are not in use in the risk assessment area, and they can be implemented (e.g., changing or abandoning the current practices, implement new practices and or measures) with several technical difficulties.
Moderate	The management options are not in use in the risk assessment area, but they can be implemented into the practice (e.g., changing or abandoning the current practices, implement new practices and or measures) with some technical difficulties.
High	The management options are already in use in the risk assessment area as a part of the current crop management actions and/or of the existing phytosanitary measures. If the management options are not in use, they can be easily implemented in the practice.

3. Ratings used for describing the level of uncertainty

For the risk assessment chapter – entry, establishment, spread and impact – as well as for the evaluation of the effectiveness of the management options, the level of uncertainties has been rated separately in coherence with the descriptors that have been defined specifically by the Panel in this opinion for *G. circinata*.

Rating	Descriptors
Low	No or few information or data are missing, incomplete, inconsistent or conflicting. No subjective judgement is introduced. No unpublished data are used. Where models are used: i) input data are clearly described and contain only minor measurement errors; ii) model assumptions, structure, methods, algorithms, and limitations are clearly described; iii) output is clearly described with sensitivity and uncertainty analysis.
Medium	Some information or data are missing, incomplete, inconsistent or conflicting. Subjective judgement is introduced with supporting evidence. Unpublished data are sometimes used. Whether models are used: i) input data are not clearly described and/or contain measurement errors; ii) model assumptions, structure, methods, algorithms, and limitations are not clearly described; iii) output is not clearly described and neither sensitivity nor uncertainty analysis is available.
High	Most part of information or data are missing, incomplete, inconsistent or conflicting. Subjective judgement may be introduced without supporting evidence. Unpublished data are frequently used. Whether models are used:

	i) input data are not described and/or contain measurement errors; ii) model assumptions, structure, methods, algorithms, and limitations are not described; iii) output is not described and neither sensitivity nor uncertainty analysis is available.

B. APPENDIX 2: LOCATIONS OF *GIBBERELLA CIRCINATA* IN NURSERIES, GARDENS AND FORESTS IN EUROPE

Year	Country / Province	Type of site	Location name	Area (ha)	Latitude	Longitude
2006	Spain / Asturias / Asturias	Forest	Llanes	1.88	43.4189	-4.7886
2006	Spain / Cantabria / Cantabria	Forest	San Pedro Romeral	113.8	43.1242	-3.8278
2006	Spain / Cantabria / Cantabria	Forest	Vega de Pas	n/a	43.1556	-3.7789
2006	Spain / Cantabria / Cantabria	Forest	Rionansa	17.19	43.2289	-4.4164
2006	Spain / Cantabria / Cantabria	Forest	Comillas	70.72	43.3783	-4.3000
2006	Spain / Cantabria / Cantabria	Forest	Udías	n/a	43.3397	-4.2669
2006	Spain / Cantabria / Cantabria	Forest	Ruiloba	n/a	43.3908	-4.2503
2006	Spain / Cantabria / Cantabria	Forest	Santiurde Toranzo	12.49	43.2272	-3.9178
2006	Spain / Cantabria / Cantabria	Forest	Ramasales (A Ramales de la Victoria)	29.62	43.2633	-3.4394
2006	Spain / Cantabria / Cantabria	Forest	Rasines	n/a	43.2975	-3.4167
2007	Spain / País Vasco / Guipúzcoa	Forest	Aia-Orio	8.31	43.2450	-2.1522
2007	Spain / País Vasco / Guipúzcoa	Forest	Hernani	7.85	43.2386	-1.9442
2007	Spain / País Vasco / Guipúzcoa	Forest	Oiartzun	4.17	43.2542	-1.8472
2007	Spain / País Vasco / Álava	Forest	Artziniega	n/a	43.1303	-3.1317
2007	Spain / País Vasco / Álava	Forest	Orondo	n/a	43.1167	-2.9167
2007	Spain / País Vasco / Álava	Forest	Llodio	n/a	43.1439	-2.9739
2007	Spain / País Vasco / Álava	Forest	Zuia	n/a	42.9603	-2.8378
2008	Spain / Galicia / Pontevedra	Forest	Moraña	314	42.5828	-8.5747
2008	Spain / Galicia / La Coruña	Forest	Boiro	314	42.6519	-8.8781
2008	Spain / Galicia / La Coruña	Forest	Vimianzo	357	43.1136	-9.0233
2008	Spain / Castilla y León / Palencia	Forest	Herrera de Pisuerga	402	42.5553	-4.3122
2008	Spain / Cantabria / Cantabria	Forest	Mazcuerras	1 750	43.2900	-4.1800
2008	Spain / Cantabria / Cantabria	Forest	Riocin	n/a	43.3483	-4.1364
2008	Spain / Cantabria / Cantabria	Forest	Rionansa	n/a	43.2289	-4.4164
2008	Spain / País Vasco / Guipúzcoa	Forest	Astigarraga	1 300	43.2797	-1.9333
2008	Spain / País Vasco / Guipúzcoa	Forest	Errentería	n/a	43.2553	-1.8928
2008	Spain / País Vasco / Vizcaya	Forest	Iurreta	1 293.66	43.1900	-2.6553
2008	Spain / País Vasco / Vizcaya	Forest	Muxica	n/a	43.2486	-2.6783
2008	Spain / Navarra / Navarra	Forest	Sumbilla	n/a	43.1811	-1.6553
2008	Spain / Navarra / Navarra	Forest	Bera de Bidasoa	n/a	43.2739	-1.6700

2008	Spain / Navarra / Navarra	Forest	Goizueta	n/a	43.1947	-1.8492
2008	Spain / Navarra / Navarra	Forest	Bertirraza	n/a	43.1389	-1.6183
2008	Spain / Navarra / Navarra	Forest	Santisteban	n/a	43.1350	-1.6703
2008	Spain / Navarra / Navarra	Forest	Lesaca	n/a	43.2622	-1.7261
2008	Spain / Navarra / Navarra	Forest	Errazkin	n/a	43.0314	-1.9017
2005	Italy / Apulia	Garden	Foggia	n/a	41.4593	15.5405
2005	France / Languedoc-Roussillon	Garden	Perpignan	n/a	42.7013	2.8948
2008	France / Vosges	Nursery	Lubine	n/a	48.3167	7.15
2009	France / Pays de la Loire / Vendée	Nursery	Thorigny	n/a	46.6167	-1.25
2007	Portugal	Nursery	Anadia	n/a	40.4333	-8.4333
2007	Spain /Cantabria / Cantabria	Nursery		n/a	n/a	n/a
2007	Spain / Galicia / Lugo	Nursery		n/a	n/a	n/a
2007	Spain / Galicia / Pontevedra	Nursery		n/a	n/a	n/a
2007	Spain/ Navarra / Navarra	Nursery		n/a	n/a	n/a
2007	Spain / Asturias /Asturias	Nursery		n/a	n/a	n/a
2008	Spain / Galicia / Lugo	Nursery		n/a	n/a	n/a
2008	Spain / Castilla y León / León	Nursery	Chozas de Abajo	n/a	n/a	n/a
2008	Spain / Castilla y León / Valladolid	Nursery	Cabezón de Pisuerga	n/a	n/a	n/a
2008	Spain / Asturias /Asturias	Nursery		n/a	n/a	n/a

Source: Annual survey results for the presence of *Gibberella circinata* or for evidence of infestation of the Member States provided by the European Commission for 2007 and 2008.

n/a: not available