# SCIENTIFIC OPINION

# Pest categorisation of *Guignardia laricina*

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

## Abstract

Following a request from the European Commission, the EFSA Panel on Plant Health performed a pest categorisation of *Guignardia laricina*, a well-defined and distinguishable fungal species of the family Phyllostictaceae. The pathogen is regulated in Council Directive 2000/29/EC (Annex IAI) as a harmful organism whose introduction into the EU is banned. *G. laricina* is native to East Asia and causes a shoot blight disease of *Larix* spp. Major hosts of *G. laricina* are European larch (*Larix decidua*) and two North American larch species (*Larix laricina* (tamarack) and *Larix occidentalis* (Western larch)). *Larix kaempferi* (Japanese larch) is reported as susceptible. The only other host in nature is Douglas fir (*Pseudotsuga menziesii*), which is reported as an incidental host, but various other conifers have been reported as susceptible following artificial inoculation, including *Picea abies*. The fungus is not known to occur in the EU but could enter via plants for planting (including artificially dwarfed plants) and cut branches of *Larix* spp. It could establish in the EU, as hosts are present and climatic conditions are favourable. The pathogen would be able to spread following establishment by natural dissemination of ascospores and pycnospores and by human movement of infected plants for planting. Should the pathogen be introduced in the EU, impacts can be expected in larch forests, plantations and nurseries, leading to reduced tree growth and ecosystem service provision. The key uncertainties concern the current distribution and level of impacts in the native range of the pathogen. The criteria assessed by the Panel for consideration as a potential quarantine pest are met. As the pest is not present in the EU, not all criteria for consideration as a regulated non-quarantine pest are met.

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

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# 1.    Introduction

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

### 1.1.1.    Background

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

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

### 1.1.2.    Terms of reference

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

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

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

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

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

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

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

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

### 1.1.2.1. Terms of Reference: Appendix 1

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

#### *Annex IIAI*

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

*Aleurocantus* spp.

*Anthonomus bisignifer* (Schenkling)

*Anthonomus signatus* (Say)

*Aschistonyx eppoi* Inouye

*Carposina niponensis* Walsingham

*Enarmonia packardi* (Zeller)

*Enarmonia prunivora* Walsh

*Grapholita inopinata* Heinrich

*Hishomonus phycitis*

*Leucaspis japonica* Ckll.

*Listronotus bonariensis* (Kuschel)

*Numonia pyrivorella* (Matsumura)

*Oligonychus perditus* Pritchard and Baker

*Pissodes* spp. (non-EU)

*Scirtothrips aurantii* Faure

*Scirtothrips* citri (Moultex)

*Scolytidae* spp. (non-EU)

*Scrobipalpopsis solanivora* Povolny

*Tachypterellus quadrigibbus* Say

*Toxoptera citricida* Kirk.

*Unaspis citri* Comstock

#### (b) Bacteria

Citrus variegated chlorosis

*Erwinia stewartii* (Smith) Dye

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

#### (c) Fungi

*Alternaria alternata* (Fr.) Keissler (non-EU pathogenic isolates)

*Anisogramma anomala* (Peck) E. Müller

*Apiosporina morbosa* (Schwein.) v. Arx

*Ceratocystis virescens* (Davidson) Moreau

*Cercoseptoria pini-densiflorae* (Hori and Nambu) Deighton

*Cercospora angolensis* Carv. and Mendes

*Elsinoe* spp. Bitanc. and Jenk. Mendes

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

*Guignardia piricola* (Nosa) Yamamoto

*Puccinia pittieriana* Hennings

*Stegophora ulmea* (Schweinitz: Fries) Sydow & Sydow

*Venturia nashicola* Tanaka and Yamamoto

#### (d) Virus and virus-like organisms

Beet curly top virus (non-EU isolates)

Black raspberry latent virus

Blight and blight-like

Cadang-Cadang viroid

Citrus tristeza virus (non-EU isolates)

Leprosis

Little cherry pathogen (non- EU isolates)

Naturally spreading psorosis

Palm lethal yellowing mycoplasm

Satsuma dwarf virus

Tatter leaf virus

Witches' broom (MLO)

#### *Annex IIB*

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

*Anthonomus grandis* (Boh.)

*Cephalcia lariciphila* (Klug)

*Dendroctonus micans* Kugelan

*Gilphinia hercyniae* (Hartig)

*Gonipterus scutellatus* Gyll.

*Ips amitinus* Eichhof

*Ips cembrae* Heer

*Ips duplicatus* Sahlberg

*Ips sexdentatus* Börner

*Ips typographus* Heer

*Sternochetus mangiferae* Fabricius

**(b) Bacteria**

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

**(c) Fungi**

*Glomerella gossypii* Edgerton

*Gremmeniella abietina* (Lag.) Morelet

*Hypoxylon mammatum* (Wahl.) J. Miller

### 1.1.2.2. Terms of Reference: Appendix 2

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

#### *Annex IAI*

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

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

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

Group of Tephritidae (non-EU) such as:

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

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

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

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

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

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

<u>*Annex IIAI*</u>

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

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

1) *Margarodes vitis* (Phillipi)

2) *Margarodes vredendalensis* de Klerk

3) *Margarodes prieskaensis* Jakubski

### 1.1.2.3. Terms of Reference: Appendix 3

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

<u>*Annex IAI*</u>

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

*Acleris* spp. (non-EU)

*Amauromyza maculosa* (Malloch)

*Anomala orientalis* Waterhouse

*Arrhenodes minutus* Drury

*Choristoneura* spp. (non-EU)

*Conotrachelus nenuphar* (Herbst)

*Dendrolimus sibiricus* Tschetverikov

*Diabrotica barberi* Smith and Lawrence

*Diabrotica undecimpunctata howardi* Barber

*Diabrotica undecimpunctata undecimpunctata* Mannerheim

*Diabrotica virgifera zeae* Krysan & Smith

*Diaphorina citri* Kuway

*Heliothis zea* (Boddie)

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

*Liriomyza sativae* Blanchard

*Longidorus diadecturus* Eveleigh and Allen

*Monochamus* spp. (non-EU)

*Myndus crudus* Van Duzee

*Nacobbus aberrans* (Thorne) Thorne and Allen

*Naupactus leucoloma* Boheman

*Premnotrypes* spp. (non-EU)

*Pseudopityophthorus minutissimus* (Zimmermann)

*Pseudopityophthorus pruinosus* (Eichhoff)

*Scaphoideus luteolus* (Van Duzee)

*Spodoptera eridania* (Cramer)

*Spodoptera frugiperda* (Smith)

*Spodoptera litura* (Fabricus)

*Thrips palmi* Karny

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

*Xiphinema californicum* Lamberti and Bleve-Zacheo

## (b) Fungi

*Ceratocystis fagacearum* (Bretz) Hunt

*Chrysomyxa arctostaphyli* Dietel

*Cronartium* spp. (non-EU)

*Endocronartium* spp. (non-EU)

*Guignardia laricina* (Saw.) Yamamoto and Ito

*Gymnosporangium* spp. (non-EU)

*Inonotus weirii* (Murril) Kotlaba and Pouzar

*Melampsora farlowii* (Arthur) Davis

*Mycosphaerella larici-leptolepis* Ito et al.

*Mycosphaerella populorum* G. E. Thompson

*Phoma andina* Turkensteen

*Phyllosticta solitaria* Ell. and Ev.

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

*Thecaphora solani* Barrus

*Trechispora brinkmannii* (Bresad.) Rogers

## (c) Viruses and virus-like organisms

Tobacco ringspot virus

Tomato ringspot virus

Bean golden mosaic virus

Cowpea mild mottle virus

Lettuce infectious yellows virus

Pepper mild tigré virus

Squash leaf curl virus

Euphorbia mosaic virus

Florida tomato virus

**(d) Parasitic plants**

*Arceuthobium* spp. (non-EU)

*Annex IAII*

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

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

**(b) Bacteria**

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

**(c) Fungi**

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

*Annex I B*

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

| | |
|---|---|
| *Leptinotarsa decemlineata* Say | *Liriomyza bryoniae* (Kaltenbach) |

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

Beet necrotic yellow vein virus

## 1.2. Interpretation of the Terms of Reference

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

## 2. Data and methodologies

### 2.1. Data

#### 2.1.1. Literature search

A literature search on *G. laricina* was conducted at the beginning of the categorisation in the ISI Web of Science bibliographic database, using the scientific name of the pest as well as its synonyms as search terms. Relevant papers were reviewed, and further references and information were obtained from experts, from citations within the references and grey literature.

#### 2.1.2. Database search

Pest information, on host(s) and distribution, was retrieved from the EPPO Global Database (EPPO, 2018).

Data about the import of commodity types that could potentially provide a pathway for the pest to enter the EU and about the area of hosts grown in the EU were obtained from EUROSTAT.

Information on EU Member States (MS) imports of *Larix* plants for planting from Asia was sought in the ISEFOR database (Eschen et al., 2017). This database of imported plants for planting is not comprehensive of all EU MS and the time series data for participating MS are of differing periods.

The Europhyt database was consulted for pest-specific notifications on interceptions and outbreaks. Europhyt is a web-based network run by the Directorate General for Health and Food Safety (DG SANTE) of the European Commission, and is a subproject of PHYSAN (Phyto-Sanitary Controls) specifically concerned with plant health information. The Europhyt database manages notifications of interceptions of plants or plant products that do not comply with EU legislation, as well as notifications of plant pests detected in the territory of the MS and the phytosanitary measures taken to eradicate or avoid their spread.

## 2.2.    Methodologies

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

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

Table 1 presents the Regulation (EU) 2016/2031 pest categorisation criteria on which the Panel bases its conclusions. All relevant criteria have to be met for the pest to potentially qualify either as a quarantine pest or as a regulated non-quarantine pest. If one of the criteria is not met, the pest will not qualify. A pest that does not qualify as a quarantine pest may still qualify as a regulated non-quarantine pest which needs to be addressed in the opinion. For the pests regulated in the protected zones only, the scope of the categorisation is the territory of the protected zone, thus the criteria refer to the protected zone instead of the EU territory.

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

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

| Criterion of pest categorisation | Criterion in Regulation (EU) 2016/2031 regarding Union quarantine pest | Criterion in Regulation (EU) 2016/2031 regarding protected zone quarantine pest (articles 32–35) | Criterion in Regulation (EU) 2016/2031 regarding Union regulated non-quarantine pest |
|---|---|---|---|
| **Identity of the pest (Section 3.1)** | Is the identity of the pest established, or has it been shown to produce consistent symptoms and to be transmissible? | Is the identity of the pest established, or has it been shown to produce consistent symptoms and to be transmissible? | Is the identity of the pest established, or has it been shown to produce consistent symptoms and to be transmissible? |
| **Absence/ presence of the pest in the EU territory (Section 3.2)** | Is the pest present in the EU territory? If present, is the pest widely distributed within the EU? Describe the pest distribution briefly! | Is the pest present in the EU territory? If not, it cannot be a protected zone quarantine organism | Is the pest present in the EU territory? If not, it cannot be a regulated non-quarantine pest. (A regulated non-quarantine pest must be present in the risk assessment area) |
| **Regulatory status (Section 3.3)** | If the pest is present in the EU but not widely distributed in the risk assessment area, it should be under official control or expected to be under official control in the near future. | The protected zone system aligns with the pest free area system under the International Plant Protection Convention (IPPC) The pest satisfies the IPPC definition of a quarantine pest that is not present in the risk assessment area (i.e. protected zone) | Is the pest regulated as a quarantine pest? If currently regulated as a quarantine pest, are there grounds to consider its status could be revoked? |

| Criterion of pest categorisation | Criterion in Regulation (EU) 2016/2031 regarding Union quarantine pest | Criterion in Regulation (EU) 2016/2031 regarding protected zone quarantine pest (articles 32–35) | Criterion in Regulation (EU) 2016/2031 regarding Union regulated non-quarantine pest |
|---|---|---|---|
| **Pest potential for entry, establishment and spread in the EU territory (Section 3.4)** | Is the pest able to enter into, become established in, and spread within, the EU territory? If yes, briefly list the pathways! | Is the pest able to enter into, become established in, and spread within, the protected zone areas? Is entry by natural spread from EU areas where the pest is present possible? | Is spread mainly via specific plants for planting, rather than via natural spread or via movement of plant products or other objects? Clearly state if plants for planting is the main pathway! |
| **Potential for consequences in the EU territory (Section 3.5)** | Would the pests' introduction have an economic or environmental impact on the EU territory? | Would the pests' introduction have an economic or environmental impact on the protected zone areas? | Does the presence of the pest on plants for planting have an economic impact, as regards the intended use of those plants for planting? |
| **Available measures (Section 3.6)** | Are there measures available to prevent the entry into, establishment within or spread of the pest within the EU such that the risk becomes mitigated? | Are there measures available to prevent the entry into, establishment within or spread of the pest within the protected zone areas such that the risk becomes mitigated? Is it possible to eradicate the pest in a restricted area within 24 months (or a period longer than 24 months where the biology of the organism so justifies) after the presence of the pest was confirmed in the protected zone? | Are there measures available to prevent pest presence on plants for planting such that the risk becomes mitigated? |
| **Conclusion of pest categorisation (Section 4)** | A statement as to whether (1) all criteria assessed by EFSA above for consideration as a potential quarantine pest were met and (2) if not, which one(s) were not met | A statement as to whether (1) all criteria assessed by EFSA above for consideration as potential protected zone quarantine pest were met, and (2) if not, which one(s) were not met | A statement as to whether (1) all criteria assessed by EFSA above for consideration as a potential regulated non-quarantine pest were met, and (2) if not, which one(s) were not met |

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

## 3. Pest categorisation

### 3.1. Identity and biology of the pest

### 3.1.1. Identity and taxonomy

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

**Yes**

*Guignardia laricina* (Sawada) W. Yamam. & Kaz. Itô is a fungus of the family Phyllostictaceae.

Species synonyms are *Botryosphaeria laricina*, *Physalospora laricina* (Index Fungorum, http://www.indexfungorum.org/names/names.asp) and *Phyllosticta laricis* (EPPO, 2018). Previous reports referred to a *Fusicoccum* species as a probable anamorph (EPPO, 1997).

### 3.1.2. Biology of the pest

*G. laricina* causes a shoot blight disease of *Larix* spp. (Yokota, 1966). An anamorphic stage of the fungus appears in abundance on the underside of needles and on young shoots between July and November. In Japan, pycnidia are most abundant in August and September, and they are rarely found on over-wintered infected shoots and leaves (Yokota, 1966). Pycnospores are exuded from pycnidia forming small, white or pale milk-white masses, but they are discharged abundantly only at relative humidity (RH) 98–100% and temperature between 10°C and 35°C (25°C optimum) (Yokota, 1966). Pycnospores are responsible for secondary infection of the host and their dispersal occurs mainly with the splash of rain (Yokota, 1966). A few pycnospores in the pycnidia can overwinter until the following April (EPPO, 1997). A spermogonial stage may also be found from late July on infected shoots (Yokota, 1966).

The teleomorph produces black pseudothecia on infected current season's shoots starting from October (Yokota, 1966). The pseudothecia increase in number the following year in May–June. Discharge of ascospores takes place from June to October, most abundantly in August and September, under condition of 100% RH or over-saturated condition and temperature in the range from 5°C to 30°C, with the optimum above 20°C (Yokota, 1966). Ascospores are disseminated by wind (Yokota, 1966) and optimum temperature for infection is 20°C with free water (EPPO, 1997). Wounds do not appear necessary for penetration. Disease symptoms appear about 2 weeks after infection. Some ascospores may overwinter in the pseudothecia (EPPO, 1997).

Because the pycnospores of *G. laricina* are disseminated mainly with the splash of rain, it was suggested that the distance of potential dispersal must be shorter than that of ascospores (Yokota, 1966). Therefore, it seems that ascospores contribute mainly to propagate the disease from one stand (tree) to the other, and pycnospores play the role of increasing the degree of the damage on infected trees (Yokota, 1966).

The disease is associated with discoloration, wilting and death of the current season's growth. Old twigs remain unaffected. Early attack, visible between June and September, causes hanging of the top of shoots, accompanied by a yellowing and browning of leaves which may fall. The leaves at the tops of shoots turn brown and often remain on the tree during winter. Dark, sunken lesions, abundant in sporulating bodies, and exuding resin appear on the stems of affected seedlings and on shoots, and usually girdle these parts. The resin hardens into whitish drops. Late infections do not show the characteristic hanging, owing to the lignified nature of the twigs. On needles, symptoms appear as brown spots with chlorotic haloes, which subsequently coalesce. Repeated infections result in stunted, bushy trees with many dead shoots (EPPO, 1997).

### 3.1.3. Intraspecific diversity

No information was found on the intraspecific diversity of *G. laricina*.

### 3.1.4. Detection and identification of the pest

*Are detection and identification methods available for the pest?*

**Yes**

A description of *G. laricina* useful for the identification of the species is available (EPPO, 1997 and references therein). The fungus can be either observed directly on infected plant tissues or isolated in pure culture on a specific medium (Ito, 1963). Molecular detection methods based on the analysis of the internal transcribed spacer region have been published (Xiu and Feng, 2009).

### 3.2. Pest distribution

*G. laricina* is reported from East Asia, i.e. eastern China, eastern Russia, Japan, North Korea and South Korea (EPPO, 2018) (Figure 1).

Distribution                                     Last updated: 2017-09-12
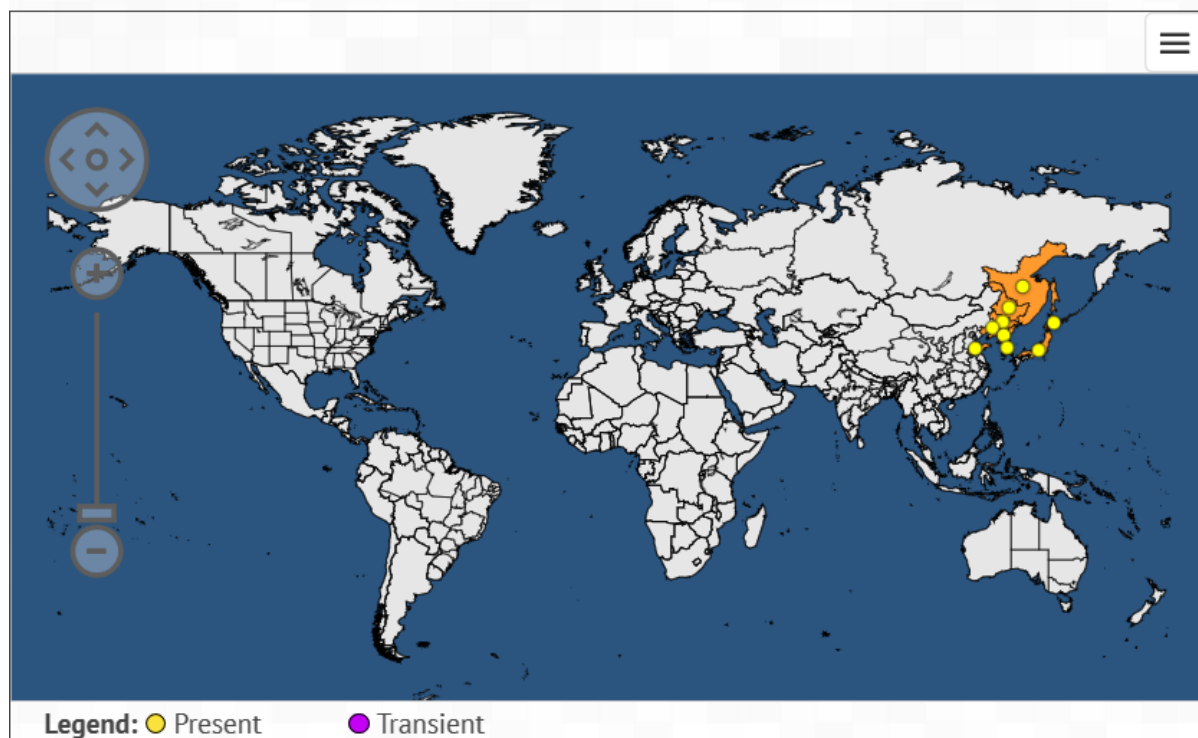


**Figure 1:** Global distribution map for *Guignardia laricina* (EPPO, 2018, accessed January 2018). There are no reports of transient populations

### 3.2.1.   Pest distribution outside the EU

In addition to North and South Korea, the pathogen is reported as present, with no further detail, in the following Chinese provinces: Heilongjiang, Jilin, Liaoning and Shandong (EPPO, 2018). It is reported as present, with no further detail, in Hokkaido and with restricted distribution in Honshu, Japan (EPPO, 2018). In Russia, the pathogen is reported to be present, with no further detail, only in the Far East (EPPO, 2018).

### 3.2.2.   Pest distribution in the EU

> *Is the pest present in the EU territory? If present, is the pest widely distributed within the EU?*
>
> **No**, the pest is not reported to be present in the EU.

Slovenia reported the pest as absent in 2017 (EPPO, 2018). Also the UK, as of January 2018, reports the pathogen (as *Botryosphaeria laricina*) as absent in the UK Plant Health Risk Register (https://secure.fera.defra.gov.uk/phiw/riskRegister/viewPestRisks.cfm?cslref=22501). There are no reports of absence available to the Panel that have been confirmed by survey.

### 3.3.   Regulatory status

### 3.3.1.   Council Directive 2000/29/EC

*G. laricina* is listed in Council Directive 2000/29/EC. Details are presented in Tables 2 and 3.

**Table 2:**  *Guignardia laricina* in Council Directive 2000/29/EC

| Annex I, Part A | Harmful organisms whose introduction into, and spread within, all member states shall be banned |
|---|---|
| Section I | Harmful organisms not known to occur in any part of the community and relevant for the entire community |
| (c) | Fungi |
| | Species |
| 5. | *Guignardia laricina* (Saw.) Yamamoto and Ito |

### 3.3.2. Legislation addressing the hosts of *G. laricina*

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

| Annex III, Part A | Plants, plant products and other objects the introduction of which shall be prohibited in all Member States | |
|---|---|---|
| | Description | Country of origin |
| 1. | Plants of *Abies* Mill., *Cedrus* Trew, *Chamaecyparis* Spach, *Juniperus* L., *Larix* Mill., *Picea* A. Dietr., *Pinus* L., *Pseudotsuga* Carr. and *Tsuga* Carr., other than fruit and seeds | Non-European countries |
| **Annex V** | **Plants, plant products and other objects which must be subject to a plant health inspection (at the place of production if originating in the Community, before being moved within the Community—in the country of origin or the consignor country, if originating outside the Community) before being permitted to enter the Community** | |
| **Part A** | Plants, plant products and other objects originating in the Community | |
| **Section II** | Plants, plant products and other objects which are potential carriers of harmful organisms of relevance for certain protected zones, and which must be accompanied by a plant passport valid for the appropriate zone when introduced into or moved within that zone | |
| 1.1. | Plants of *Abies* Mill., *Larix* Mill., *Picea* A. Dietr., *Pinus* L. and *Pseudotsuga* Carr. | |

## 3.4. Entry, establishment and spread in the EU

### 3.4.1. Host range

The genus *Larix* is reported to be a host (EPPO, 2018). Major (i.e., highly susceptible) hosts for *G. laricina* are European larch (*Larix decidua*) and two North American larch species: *Larix laricina* (tamarack) and *Larix occidentalis* (Western larch) (Ito, 1963). Japanese larch (*Larix kaempferi*) is reported as susceptible (Ito, 1963), while *Larix gmelinii* (Dahurian larch) and *Larix olgensis* var. *koreana* are reported as resistant (Ito, 1963; EPPO, 2018). Hybrid larch *L. x marschlinisii* (syn. *L. x eurolepis*) is mentioned as susceptible (Ito, 1963). The only other host in nature is *Pseudotsuga menziesii*, (Douglas fir), which is reported as an incidental host (EPPO, 2018).

Several other conifers have been reported as susceptible, but only following artificial inoculation. Most of these species are native to East Asia (*Abies firma*, *Abies homolepis*, *Abies mariesii*, *Abies veitchii*, *Chamaecyparis obtusa*, *Chamaecyparis pisifera*, *Picea glehni*, *Pinus densiflora*, *Pinus koraiensis*, *Pinus parviflora*, *Pinus thunbergii*, *Thuja standishii*, *Thujopsis dolabrata* var. *hondai* and *Tsuga diversifolia*) (Ito, 1963).

Other artificially infected species are native to North America (*Pinus rigida*, *Pinus banksiana*, *Pinus strobus*, *Taxodium distichum* and *Thuja occidentalis*) and Europe (*Picea abies*) (Ito, 1963; EPPO, 1997). Pycnidia formation was found on the lesions of some of the artificially infected species (*Abies homolepis*, *Picea glehni*, *Pinus banksiana*, *Pinus densiflora*) as well as of *Pseudotsuga menziesii* (Ito, 1963).

In Council Directive 2000/29/EC, the pest is not regulated on a particular host or commodity (Annex IAI).

### 3.4.2. Entry

> *Is the pest able to enter into the EU territory?*
>
> **Yes**, the pest could enter the EU through the introduction of plants for planting and cut branches of host species.

Host commodities which could provide a pathway of entry for the pathogen (EPPO, 2018) are:

- Plants for planting (including artificially dwarfed plants) of *Larix* spp.
- Cut branches of *Larix* spp.

The plants for planting pathway is closed due to the ban on importing into the EU *Larix* plants from non-European countries. However, in the ISEFOR database of traded plants for planting, there are two records of shipments of *Larix* spp. nursery plants from China to the Netherlands (of 600 and 1000 pieces, respectively, both in 2002), which are 'refused entry' records (EFSA PLH Panel, 2018).

Pollen and seed are unlikely to harbour the pathogen (EPPO, 1997).

As of December 2017, there were no records of interception of *G. laricina* in the Europhyt database.

### 3.4.3. Establishment

> *Is the pest able to become established in the EU territory?*
>
> **Yes**, the pest could establish in the EU, as hosts are present and favourable climatic conditions are common.

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

The natural distribution of *L. decidua* is mainly restricted to the Alps and the Carpathians (Figures 2 and 3), although the species has been planted elsewhere mostly in central and northern Europe (Figure 4).
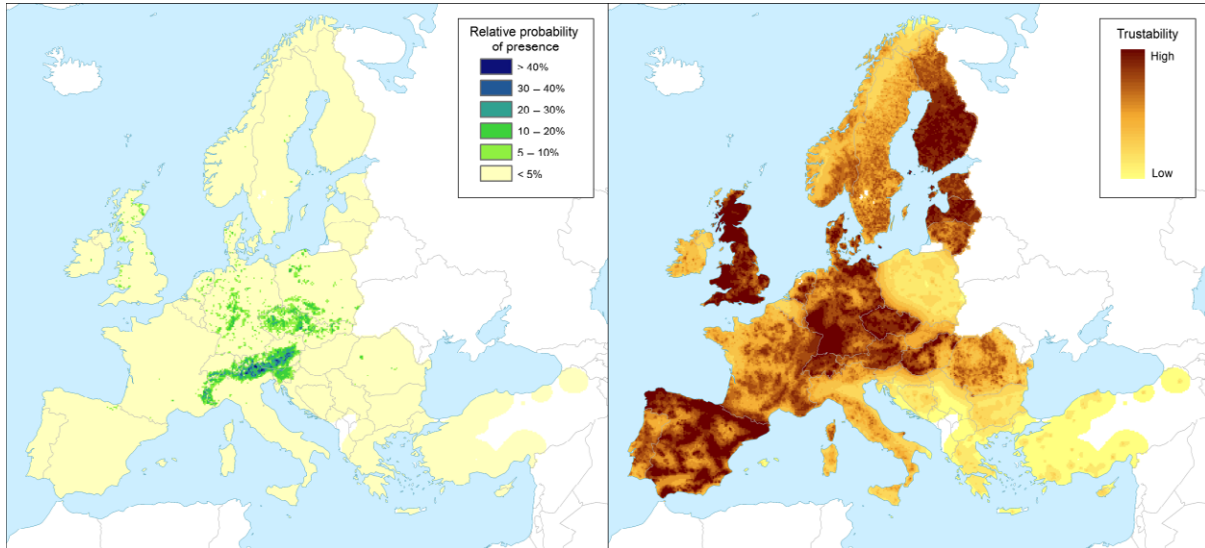


**Figure 2:** Left-hand panel: Relative probability of presence (RPP) of the genus *Larix* (based on data from the species: *L. decidua, L. kaempferi* and *L. sibirica*) in Europe, mapped at 100 km$^2$ resolution. The underlying data are from European-wide forest monitoring data sets and from national forestry inventories based on standard observation plots measuring in the order of hundreds m$^2$. RPP represents the probability of finding at least one individual of the taxon in a standard plot placed randomly within the grid cell. For details, see Appendix A (courtesy of JRC, 2017). Right-hand panel: Trustability of RPP. This metric expresses the strength of the underlying information in each grid cell and varies according to the spatial variability in forestry inventories. The colour scale of the trustability map is obtained by plotting the cumulative probabilities (0−1) of the underlying index (for details see Appendix A)
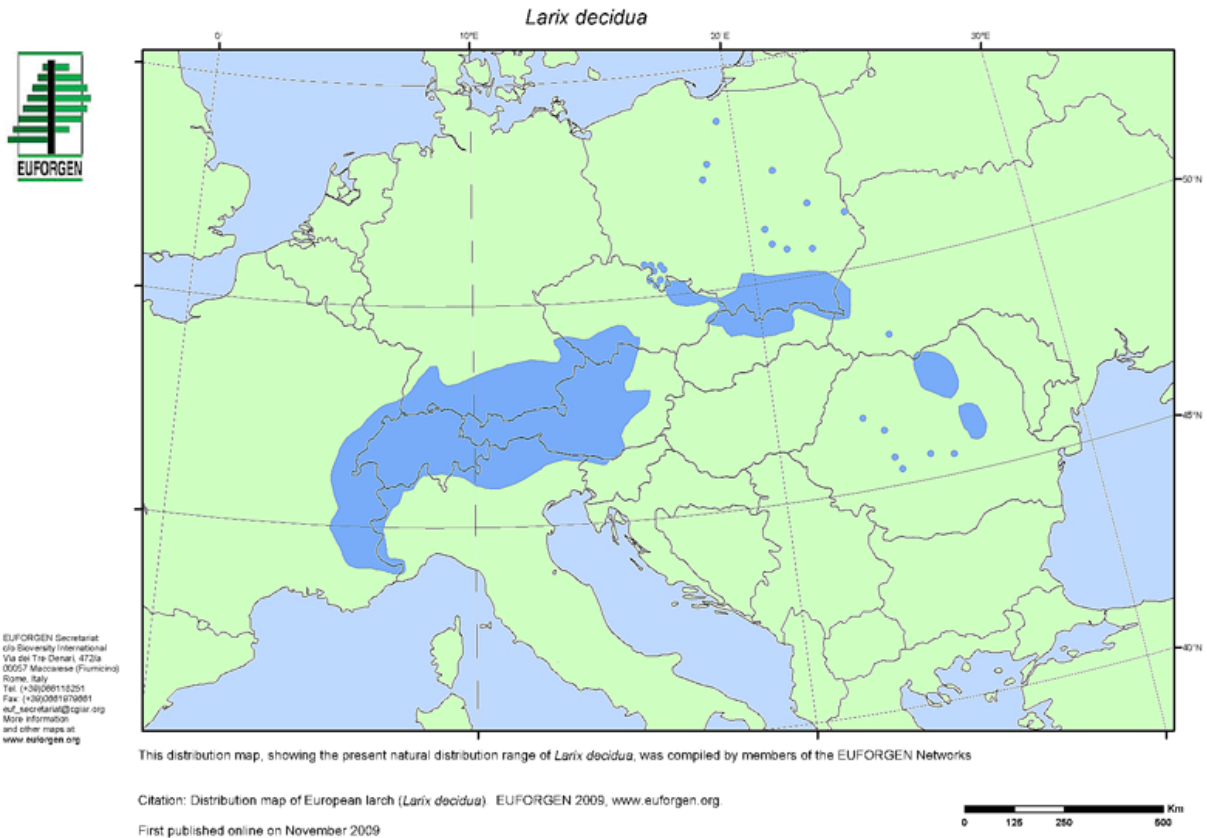
**Figure 3:** Native range of *Larix decidua* (map prepared by Euforgen in 2009). Blue dots represent isolated occurrences of the species

Distribution map of
*Larix decidua Mill.*
in Europe
Preliminary version 0.2  2011–03–17
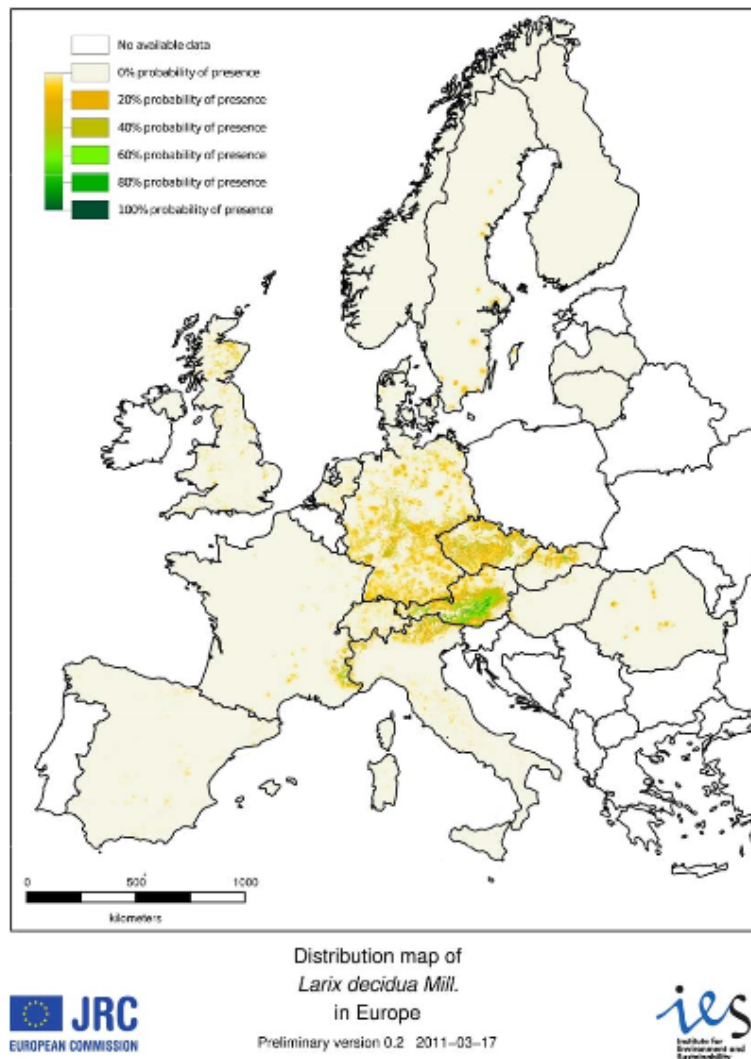
**Figure 4:** Distribution map of native stands and plantations of *Larix decidua* in Europe made by JRC, taken from EFSA PLH Panel (2011)

### 3.4.3.2. Climatic conditions affecting establishment

The distribution of *G. laricina* in East Asia (Figure 1; Section 3.2) covers areas with cold (continental) Köppen–Geiger climate types (Peel et al., 2007). These climate types overlap to a large extent with the distribution of the native *Larix* species in Europe. Therefore, climate is assumed not to be a limiting factor for the establishment of the pathogen in the EU.

### 3.4.4. Spread

I*s the pest able to spread within the EU territory following establishment? How?*

**Yes**, by human movement of infected plants for planting and by dissemination of ascospores and pycnospores.

*Regulated Non-Quarantine Pests (RNQP): Is spread mainly via specific plants for planting, rather than via natural spread or via movement of plant products or other objects?*

**No**, spread may occur both via plants for planting and natural spread.

Spread of the pathogen occurs by means of the dissemination of ascospores and pycnospores (EPPO, 1997). The potential range of dispersal of ascospores and pycnospores is unknown. However, because the pycnospores of *G. laricina* are disseminated mainly with rain splash, the distance of potential dispersal must be shorter than that of ascospores (Yokota, 1966). Therefore, it was suggested that

ascospores contribute mainly to propagate the disease from one stand (tree) to the other, and pycnospores play the role of increasing the degree of the damage on infected trees (Yokota, 1966).

Spread may also occur via trade of plants for planting and cut branches of host trees (EPPO, 2018).

## 3.5. Impacts

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

**Yes**, the pest introduction could have an impact, especially in larch plantations and nurseries.

*RNQPs: Does the presence of the pest on plants for planting have an economic impact, as regards the intended use of those plants for planting?*[4]

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

*G. laricina* is the agent of a shoot blight disease of *Larix* spp. causing discoloration, wilting and death of the current season's growth (Figure 5). Although young trees do not usually die, their subsequent growth is retarded or stopped as a result of infection (EPPO, 1997). Trees of all ages are susceptible, but young trees are heavily attacked (Imazeki and Ito, 1963). The fungus has been reported as the most serious disease agent of *Larix* forests and nurseries in Japan (Imazeki and Ito, 1963). The disease was rare until 1958, but starting from 1959 damage became significant and increased year after year (Yokota, 1966). In a survey conducted in 1962, the total damaged area was as large as 63,000 ha, 18% of the total area of larch plantations in Hokkaido (Yokota, 1966). In damaged plantations, almost 100% of the trees can be affected by the disease (Ito, 1963).

It was reported that 1,160,000 seedlings, about 6% of the total number of seedlings cultivated in 74 private nurseries were damaged by the disease in 1963 (reviewed by Yokota, 1966).

Impacts can be expected in the EU, should the pathogen be introduced, given that *L. decidua* is highly susceptible, thus leading to reduced tree growth and ecosystem service provision.



**Figure 5:** Symptoms caused by *Guignardia laricina* on an 8-year-old tree of *Larix kaempferi* (=*L. leptolepis*). Photo: T. Kobayashi, in EPPO (2018), with kind reprint permission of EPPO. Available online: https://gd.eppo.int/taxon/GUIGLA/photos

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[4] See Section 2.1 on what falls outside EFSA's remit.

## 3.6. Availability and limits of mitigation measures

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

Yes, please see Section 3.6.2.

*RNQPs: Are there measures available to prevent pest presence on plants for planting such that the risk becomes mitigated?*

**Yes**, production of plants for planting in pest free areas can prevent pest presence on plants for planting.

### 3.6.1. Phytosanitary measures

Phytosanitary measures are currently applied to the natural hosts *Larix* spp. and *Pseudotsuga menziesii* (see Section 3.3.2). Some artificially inoculated hosts are not covered by phytosanitary measures (e.g. *Taxodium*, *Thuja* and *Thujopsis*) (see Section 3.4.1).

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

- Disease symptoms appear about 2 weeks after infection (EPPO, 1997).
- Wind during the growing season is considered to be one of the most important environmental factors leading to a heavy disease outbreak (Ito, 1963).

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

- It is uncertain whether chemical control in nurseries might just mask symptoms, hence allowing the movement of the pathogen via the trade in plants for planting.

### 3.6.2. Pest control methods

- Nurseries should be established far away from pure larch forests (Xin and Chen, 2004).
- Removal and burning of infected trees and reforestation by other species are carried out in heavily diseased stands (EPPO, 1997).
- Dipping of *Larix* seedlings into polyoxin is used in highly infested nurseries (EPPO, 1997), but the use of this fungicide is limited under Commission Decision (2005/303/EC).

## 3.7. Uncertainty

- There is limited information on the occurrence of the spermogonial stage of the fungus.
- There is little information on the current distribution and on the level of recent impact of *G. laricina* in East Asia.

# 4. Conclusions

*G. laricina* meets the criteria assessed by EFSA for consideration as a potential quarantine pest (Table 4).

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

| Criterion of pest categorisation | Panel's conclusions against criterion in Regulation (EU) 2016/2031 regarding Union quarantine pest | Panel's conclusions against criterion in Regulation (EU) 2016/2031 regarding Union regulated non-quarantine pest | Key uncertainties |
|---|---|---|---|
| **Identity of the pest (Section 3.1)** | The identity of the pest as a species is clear | The identity of the pest as a species is clear | None |
| **Absence/ presence of the pest in the EU territory (Section 3.2)** | The pest is not reported to be present in the EU | The pest is not reported to be present in the EU | None |
| **Regulatory status (Section 3.3)** | *G. laricina* is regulated by Council Directive 2000/29/EC (Annex IAI) as a harmful organism whose introduction into, and spread within, all Member States shall be banned | *G. laricina* is regulated by Council Directive 2000/29/EC (Annex IAI) as a harmful organism whose introduction into, and spread within, all Member States shall be banned | None |
| **Pest potential for entry, establishment and spread in the EU territory (Section 3.4)** | Entry: the pest could enter the EU via plants for planting, and cut branches<br><br>Establishment: hosts and favourable climatic conditions are widespread in the risk assessment area<br><br>Spread: the pest would be able to spread following establishment by movement of infected plants for planting and cut branches, and natural spread | Plants for planting are not the main pathway of spread, given that spread may occur both via plants for planting and natural spread | There is little information on the current distribution of *G. laricina* in East Asia |
| **Potential for consequences in the EU territory (Section 3.5)** | The pest introduction would have economic and environmental impacts in woodlands and larch plantations | The pest introduction could have an impact on the intended use of plants for planting | There is little information on the current level of impacts of *G. laricina* in East Asia |
| **Available measures (Section 3.6)** | Import prohibition of *Larix* plants for planting is an available measure to reduce the risk of introduction | Production of plants for planting in pest free areas can prevent pest presence on plants for planting | It is uncertain whether chemical control in nurseries might just mask symptoms, hence allowing the movement of the pathogen via the trade in plants for planting |
| **Conclusion on pest categorisation (Section 4)** | The criteria assessed by the Panel for consideration as a potential quarantine pest are met | The criterion on the pest presence in the EU is not met | |
| **Aspects of assessment to focus on/ scenarios to address in future if appropriate** | The main knowledge gap concerns the current distribution and level of impacts in the native range of the pathogen<br>However, the present categorisation has explored most if not all of the data available to the Panel on this uncertainty | | |

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## Abbreviations

| | |
|---|---|
| C-SMFA | Constrained spatial multi-scale frequency analysis |
| DG SANTE | Directorate General for Health and Food Safety |
| EPPO | European and Mediterranean Plant Protection Organization |
| EUFGIS | European Information System on Forest Genetic Resources |
| FAO | Food and Agriculture Organization |
| GD$^2$ | Georeferenced Data on Genetic Diversity |
| IPPC | International Plant Protection Convention |
| MS | Member State |
| PLH | EFSA Panel on Plant Health |
| RH | relative humidity |
| RNQP | Regulated Non-Quarantine Pest |
| RPP | Relative Probability of Presence |
| ToR | Terms of Reference |

## Appendix A – Methodological notes on Figure 2

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

### A.1. Geolocated plot databases

The RPP models rely on five geodatabases that provide presence/absence data for tree species and genera: four European-wide forest monitoring data sets and a harmonised collection of records from national forest inventories (de Rigo et al., 2014, 2016, 2017). The databases report observations made inside geolocalised sample plots positioned in a forested area, but do not provide information about the plot size or consistent quantitative information about the recorded species beyond presence/absence.

The harmonisation of these data sets was performed within the research project at the origin of the European Atlas of Forest Tree Species (de Rigo et al., 2016; San-Miguel-Ayanz, 2016; San-Miguel-Ayanz et al., 2016). Given the heterogeneity of strategies of field sampling design and establishment of sampling plots in the various national forest inventories (Chirici et al., 2011a,b), and also given legal constraints, the information from the original data sources was harmonised to refer to an INSPIRE compliant geospatial grid, with a spatial resolution of 1 km$^2$ pixel size, using the ETRS89 Lambert Azimuthal Equal-Area as geospatial projection (EPSG: 3035, http://spatialreference.org/ref/epsg/etrs89-etrs-laea/).

#### A.1.1. European National Forestry Inventories database

This data set was derived from National Forest Inventory data and provides information on the presence/absence of forest tree species in approximately 375,000 sample points with a spatial resolution of 1 km$^2$/pixel, covering 21 European countries (de Rigo et al., 2014, 2016).

#### A.1.2. Forest Focus/Monitoring data set

This project is a Community scheme for harmonised long-term monitoring of air pollution effects in European forest ecosystems, normed by EC Regulation No 2152/2003[5]. Under this scheme, the monitoring is carried out by participating countries on the basis of a systematic network of observation points (Level I) and a network of observation plots for intensive and continuous monitoring (Level II). For managing the data, the JRC implemented a Forest Focus Monitoring Database System, from which the data used in this project were taken (Hiederer et al., 2007; Houston Durrant and Hiederer, 2009). The complete Forest Focus data set covers 30 European Countries with more than 8,600 sample points.

#### A.1.3. BioSoil data set

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

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

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

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[5] Council of the European Union, 2003. Regulation (EC) No 2152/2003 of the European Parliament and of the Council of 17 November 2003 concerning monitoring of forests and environmental interactions in the Community (Forest Focus). Official Journal of the European Union 46 (L 324), 1–8.

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

### A.1.5. Georeferenced Data on Genetic Diversity (GD²)

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

## A.2. Modelling methodology

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

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

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

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

The resulting probability of presence is relative to the specific tree taxon, irrespective of the potential co-occurrence of other tree taxa with the measured plots, and should not be confused with the absolute abundance or proportion of each taxon in the plots. RPP represents the probability of finding at least one individual of the taxon in a plot placed randomly within the grid cell, assuming that the plot has negligible area compared with the cell. As a consequence, the sum of the RPP associated with different taxa in the same area is not constrained to be 100%. For example, in a forest with two co-dominant tree species which are homogeneously mixed, the RPP of both may be 100% (see e.g. the Glossary in San-Miguel-Ayanz et al. (2016), http://forest.jrc.ec.europa.eu/media/atlas/Glossary.pdf).

The robustness of RPP maps depends strongly on sample plot density, as areas with few field observations are mapped with greater uncertainty. This uncertainty is shown qualitatively in maps of

'RPP trustability'. RPP trustability is computed on the basis of the aggregated equivalent number of sample plots in each grid cell (equivalent local density of plot data). The trustability map scale is relative, ranging from 0 to 1, as it is based on the quantiles of the local plot density map obtained using all field observations for the species. Thus, trustability maps may vary among species based on the number of databases that report a particular species (de Rigo et al., 2014, 2016).

The RPP and relative trustability range from 0 to 1 and are mapped at a 1 km spatial resolution. To improve visualisation, these maps can be aggregated to coarser scales (i.e. 10 × 10 pixels or 25 × 25 pixels, respectively summarising the information for aggregated spatial cells of 100 and 625 km$^2$) by averaging the values in larger grid cells.