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Pest categorisation of *Cronartium* spp. (non-EU)

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Abstract

Following a request from the European Commission, the EFSA Panel on Plant Health performed a pest categorisation of *Cronartium* spp. (non-EU), a well-defined and distinguishable group of fungal pathogens of the family Cronartiaceae. There are at least 40 species described within the *Cronartium* genus, of which two are considered native to the EU (*C. gentianeum* and *C. pini*) and one has been introduced in the 19th century (*C. ribicola*) and is now widespread in the EU – these three species are thus not part of this pest categorisation. In addition, the non-EU *C. harknessii, C. kurilense* and *C. sahoanum* were already dealt with in a previous pest categorisation. All the non-EU *Cronartium* species are not known to be present in the EU and are regulated in Council Directive 2000/29/EC (Annex IAI) as harmful organisms whose introduction into the EU is banned. *Cronartium* spp. are biotrophic obligate plant pathogens. Many of the North American *Cronartium* species alternate between the aecial host *Pinus* spp. and telial hosts of various dicotyledonous plants. *C. conigenum, C. orientale, C. quercuum* and *C. strobilinum* have different *Quercus* spp. as their telial hosts. *C. orientale* and *C. quercuum* also infect *Castanea* spp. and *Castanopsis* spp. The pathogens could enter the EU via host plants for planting and cut flowers and branches. Non-EU *Cronartium* spp. could establish in the EU, as climatic conditions are favourable to many of them and *Pinus* and *Quercus* spp. are common. The pathogens would be able to spread following establishment by movement of host plants, as well as natural spread. Should non-EU *Cronartium* spp. be introduced in the EU, impacts can be expected on pine, oak and chestnut woodlands, plantations, ornamental trees and nurseries. The *Cronartium* species present in North America cause important tree diseases. Symptoms on *Pinus* spp. differ between *Cronartium* spp., but include galls, cankers, dieback of branches and stems, deformity, tree and cone death. The main knowledge gap concerns the limited available information on (sub)tropical *Cronartium* spp. The criteria assessed by the Panel for consideration of *Cronartium* spp. (non-EU) as potential quarantine pests are met, while, for regulated non-quarantine pests, the criterion on the pest presence in the EU is not met.

Keywords: European Union, forest pathology, pest risk, plant health, plant pest, quarantine, tree health

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1. Introduction

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

1.1.1. Background

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

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

1.1.2. Terms of reference

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

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

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

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

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

[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

Aleurocanthus spp.
Anthonomus bisignifer (Schenkling)
Anthonomus signatus (Say)
Aschistonyx eppoi Inouye
Carposina niponensis Walsingham
Enarmonia packardi (Zeller)
Enarmonia prunivora Walsh
Grapholita inopinata Heinrich
Hishomonus phycitis
Leucaspis japonica Ckll.
Listronotus bonariensis (Kuschel)
Numonia pyrivorella (Matsumura)
Oligonychus perditus Pritchard and Baker
Pissodes spp. (non-EU)
Scirtothrips aurantii Faure
Scirtothrips citri (Moultex)
Scolytidae spp. (non-EU)
Scrobipalpopsis solanivora Povolny
Tachypterellus quadrigibbus Say
Toxoptera citricida Kirk.
Unaspis citri Comstock

(b) Bacteria

Citrus variegated chlorosis
Erwinia stewartii (Smith) Dye
Xanthomonas campestris pv. *oryzae* (Ishiyama) Dye and pv. *oryzicola* (Fang. et al.) Dye

(c) Fungi

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

(d) Virus and virus-like organisms

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

Annex IIB

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

Anthonomus grandis (Boh.)
Cephalcia lariciphila (Klug)
Dendroctonus micans Kugelan
Gilphinia hercyniae (Hartig)
Gonipterus scutellatus Gyll.
Ips amitinus Eichhof
Ips cembrae Heer
Ips duplicatus Sahlberg
Ips sexdentatus Börner
Ips typographus Heer
Sternochetus mangiferae Fabricius

(b) Bacteria

Curtobacterium flaccumfaciens pv. flaccumfaciens (Hedges) Collins and Jones

(c) Fungi

Glomerella gossypii Edgerton

Gremmeniella abietina (Lag.) Morelet

Hypoxylon mammatum (Wahl.) J. Miller

1.1.2.2. Terms of Reference: Appendix 2

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

Annex IAI

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

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

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

Group of Tephritidae (non-EU) such as:

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

(c) Viruses and virus-like organisms

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

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

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

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

Annex IIAI

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

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

1) *Margarodes vitis* (Phillipi)
2) *Margarodes vredendalensis* de Klerk
3) *Margarodes prieskaensis* Jakubski

1.1.2.3. Terms of Reference: Appendix 3

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

Annex IAI

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

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

(b) Fungi

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

(c) Viruses and virus-like organisms

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

(d) Parasitic plants

Arceuthobium spp. (non-EU)

Annex IAII

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

Meloidogyne fallax Karssen

Popillia japonica Newman

Rhizoecus hibisci Kawai and Takagi

(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

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

The term 'non-EU' species is interpreted to refer to those *Cronartium* spp. native outside of the EU, and, if introduced in the EU, with restricted distribution and under official control.

There are two *Cronartium* species that are native to the EU: *Cronartium pini* (synonym: *Cronartium flaccidum*) (Kummer and Klenke, 2015; CABI, 2018) and *Cronartium gentianeum* (Klebahn, 1939; Widder, 1941) – these species are thus not part of this pest categorisation.

Cronartium ribicola, the fungus causing white pine blister rust (Geils et al., 2010), is considered to have its centre of origin most likely in central Eurasia (East of the Ural mountains) (Hummer, 2000), but given that *C. ribicola* was reported in Europe already in the mid-1800s and that it is now widespread in the EU (EPPO, 2018), this species is not included in this pest categorisation.

In addition, the non-EU *C. harknessii, C. kurilense* and *C. sahoanum* are not considered in this pest categorisation, as they were already dealt with in a previous one (EFSA PLH Panel, 2018a).

2. Data and methodologies

2.1. Data

2.1.1. Literature search

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

2.1.2. Database search

Pest information, on host(s) and distribution, was retrieved from the European and Mediterranean Plan Protection Organization (EPPO) Global Database (EPPO, 2018) and relevant publications.

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 (Statistical Office of the European Communities).

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 Member States (MS) and the phytosanitary measures taken to eradicate or avoid their spread.

2.2. Methodologies

The Panel performed the pest categorisation for *Cronartium* spp. (non-EU), following guiding principles and steps presented in the EFSA guidance presented in the EFSA guidance on quantitative pest risk assessment (EFSA PLH Panel, 2018b) and as defined in the International Standard for Phytosanitary Measures No 11 (FAO, 2013) and No 21 (FAO, 2004).

In accordance with the guidance quantitative pest risk assessment (EFSA PLH Panel, 2018b), this work was started following an evaluation of the EU plant health regime. Therefore, to facilitate the decision-making process, in the conclusions of the pest categorisation, the Panel addresses explicitly each criterion for a Union quarantine pest and for a Union RNQP in accordance with Regulation (EU) 2016/2031 on protective measures against pests of plants, and includes additional information required in accordance with the specific terms of reference received by the European Commission. In addition, for each conclusion, the Panel provides a short description of its associated uncertainty.

Table 1 presents the Regulation (EU) 2016/2031 pest categorisation criteria on which the Panel bases its conclusions. All relevant criteria have to be met for the pest to potentially qualify either as a quarantine pest or as a RNQP. If one of the criteria is not met, the pest will not qualify. A pest that does not qualify as a quarantine pest may still qualify as a RNQP that 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, whereas addressing social impacts is outside the remit of the Panel, in agreement with the EFSA guidance on quantitative pest risk assessment (EFSA PLH Panel, 2018b).

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 RNQP. (A RNQP must be present in the risk assessment area)

Criterion of pest categorisation	Criterion in Regulation (EU) 2016/2031 regarding Union quarantine pest	Criterion in Regulation (EU) 2016/2031 regarding protected zone quarantine pest (articles 32–35)	Criterion in Regulation (EU) 2016/2031 regarding Union regulated non-quarantine pest
Regulatory status (Section 3.3)	If the pest is present in the EU but not widely distributed in the risk assessment area, it should be under official control or expected to be under official control in the near future.	The protected zone system aligns with the pest free area system under the International Plant Protection Convention (IPPC) The pest satisfies the IPPC definition of a quarantine pest that is not present in the risk assessment area (i.e. protected zone)	Is the pest regulated as a quarantine pest? If currently regulated as a quarantine pest, are there grounds to consider its status could be revoked?
Pest potential for entry, establishment and spread in the EU territory (Section 3.4)	Is the pest able to enter into, become established in, and spread within, the EU territory? If yes, briefly list the pathways!	Is the pest able to enter into, become established in, and spread within, the protected zone areas? Is entry by natural spread from EU areas where the pest is present possible?	Is spread mainly via specific plants for planting, rather than via natural spread or via movement of plant products or other objects? Clearly state if plants for planting is the main pathway!
Potential for consequences in the EU territory (Section 3.5)	Would the pests' introduction have an economic or environmental impact on the EU territory?	Would the pests' introduction have an economic or environmental impact on the protected zone areas?	Does the presence of the pest on plants for planting have an economic impact, as regards the intended use of those plants for planting?
Available measures (Section 3.6)	Are there measures available to prevent the entry into, establishment within or spread of the pest within the EU such that the risk becomes mitigated?	Are there measures available to prevent the entry into, establishment within or spread of the pest within the protected zone areas such that the risk becomes mitigated? Is it possible to eradicate the pest in a restricted area within 24 months (or a period longer than 24 months where the biology of the organism so justifies) after the presence of the pest was confirmed in the protected zone?	Are there measures available to prevent pest presence on plants for planting such that the risk becomes mitigated?
Conclusion of pest categorisation (Section 4)	A statement as to whether (1) all criteria assessed by EFSA above for consideration as a potential quarantine pest were met and (2) if not, which one(s) were not met	A statement as to whether (1) all criteria assessed by EFSA above for consideration as potential protected zone quarantine pest were met, and (2) if not, which one(s) were not met	A statement as to whether (1) all criteria assessed by EFSA above for consideration as a potential RNQP 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, *Cronartium* is a valid genus containing several species of known plant pathogens.

Cronartium is a genus of fungi of the family Cronartiaceae. There are at least 40 species listed within the genus (Table 2; www.indexfungorum.org), but this is likely to change because of ongoing taxonomic revisions. Many more species within the genus have been described earlier, but they have either been reclassified as belonging to other genera or been merged together with currently described species.

Cronartium is a genus including several well-known heteroecious rusts alternating between *Pinus* spp. and dicotyledonous plants (Sinclair and Lyon, 2005). Other species are genetically similar to species within the *Cronartium* genus, but since they are autoecious and endocyclic they had been classified as belonging to the genus *Endocronartium*. In accordance with the International Code of Nomenclature for algae, fungi and plants (McNeill et al., 2012), *Endocronartium* species have been moved to the genus *Cronartium,* e.g. *Endocronartium harknessii* (renamed as *Cronartium harknessii*), *Endocronartium sahoanum* var. *hokkaidoense* (renamed as *Cronartium kurilense*), *E. sahoanum* var. *sahoanum* (renamed as *Cronartium sahoanum*) and *Endocronartium yamabense* (renamed as *Cronartium yamabense*) (Aime et al., 2018). Some asexual morphs recognised in the genus *Peridermium* have also been recently suggested to belong to the genus *Cronartium*, e.g. *Cronartium bethelii* (Aime et al., 2018). Although these proposals have been taken on board by Index Fungorum, given the separate request to conduct a pest categorisation on *Endocronartium* spp. (non-EU), the Panel opted for dealing with these former *Endocronartium* spp. (non-EU) in a separate pest categorisation (EFSA PLH Panel, 2018a) (see Section 1.2).

The ongoing reclassification of *Cronartium* species implies that the number of species included in the genus may be revised in the future. *Cronartium* is nevertheless a valid genus containing numerous well-known plant pathogens.

Three *Cronartium* spp. are reported as present in Europe, *Cronartium gentianeum, Cronartium pini* and *Cronartium ribicola* (see Section 1.2). The species *C. pini* has many synonyms consisting of earlier described separate species, e.g. *C. flaccidum* and *C. asclepiadeum* (www.indexfungorum.org). Another six species are suggested to be conspecific with *C. flaccidum* (Farr and Rossman, 2018), which in turn is considered conspecific with *C. pini* (www.indexfungorum.org), i.e. a species with a Eurasian distribution.

The species status of another three of the included species is unclear and they have been suggested to be synonymous of other *Cronartium* spp. (*Cronartium filamentosum*, *Cronartium opheliae* and *Cronartium pedicularis*).

There is very limited information for most of the species reported from tropical or subtropical countries.

Table 2: List of species currently listed as *Cronartium* spp. (www.indexfungorum.org), the reported distribution (based on: Sinclair and Lyon, 2005; www.indexfungorum.org; Farr and Rossman, 2018) and whether the species is present in the EPPO Global Database and reported as present in the EU. "–" implies no information available

Species name	Distribution	EPPO GD	Present in the EU
Cronartium andinum	Ecuador	No	–
Cronartium antidesmae-dioicae	South Africa, Ivory Coast, Uganda, China, Indonesia, Japan, New Guinea, Philippines, Vietnam	No	–
Cronartium appalachianum	Southern Appalachians (USA)	No	–
Cronartium arizonicum	South-western USA, South Dakota, Mexico, Guatemala	No	–
Cronartium balsaminae	Austria (Magnus, 1905), Germany (Klebahn, 1890)	No	Yes?
Cronartium bresadolanum	Mozambique	No	–

Species name	Distribution	EPPO GD	Present in the EU
Cronartium byrsonimae	Brazil	No	–
Cronartium coleosporioides	Canada, USA	Yes	No
Cronartium comandrae	Canada, USA	Yes	No
Cronartium comptoniae	Canada, USA	Yes	No
Cronartium conigenum	South-western United States, Costa Rica, Guatemala, Mexico, El Salvador	No	–
Cronartium delawayi	China (Stevenson, 1926)	No	–
Cronartium eupatorinum	Argentina	No	–
Cronartium euphrasiae	–	No	–
Cronartium fici	India	No	–
Cronartium filamentosum[1]	Arizona, California	Yes	No
Cronartium gentianeum	China, Romania, Slovakia, Switzerland, former USSR	No	Yes
Cronartium gramineum	–	No	–
Cronartium himalayense	Nepal and India	Yes	No
Cronartium hystrix	–	No	–
Cronartium kamtschaticum[2]	Eastern Russia and Japan	Yes	No
Cronartium kemangae	Indonesia	No	–
Cronartium malloti	Indonesia, Philippines	No	–
Cronartium nemesiae[3]	–	No	–
Cronartium notatum	Puerto Rico	No	–
Cronartium occidentale	Western USA	No	–
Cronartium opheliae[4]	India, Nepal, Pakistan, Philippines	No	–
Cronartium orientale	China, Japan, South Korea, Russia, Vietnam	No	–
Cronartium pedicularis[3]	–	No	–
Cronartium peridermii-pini[3]	–	No	–
Cronartium pini	Europe and Asia	Yes[5]	Yes
Cronartium quercuum[6]	Canada, USA, Mexico, Costa Rica, Cuba, Panama, El Salvador, Guyana, Honduras, Nicaragua, China, India, Japan, North and South Korea, Philippines, Taiwan, Russia (far eastern)	Yes[7]	No
Cronartium ribicola[8]	Northern hemisphere	Yes	Yes
Cronartium ruelliae	Taiwan	No	–
Cronartium sawadae	Taiwan, Philippines	No	–
Cronartium strobilinum	South-eastern USA, Cuba	No	–
Cronartium thesii	USA (California, Ohio)	No	–
Cronartium uleanum	Peru	No	–
Cronartium verbenae[9]	–	No	–
Cronartium vincetoxici[3]	Spain (Daniëls, 2003-2005)	No	Yes
Cronartium wilsonianum	Cuba, Costa Rica	No	–
Cronartium yamabense	Japan	No	–

1: Considered conspecific with *C. coleosporioides* in the USDA fungal database (Farr and Rossman, 2018).
2: Considered conspecific with *C. ribicola* by Aime et al. (2018) citing Imazu et al. (2000) and Kim et al. (2010).
3: Considered conspecific with *C. flaccidum* by USDA fungal database (Farr and Rossman, 2018) (i.e. conspecific with *C. pini* according to IndexFungorum (www.indexfungorum.org)).
4: Considered conspecific with *C. himalayense* by USDA fungal database (Farr and Rossman, 2018).
5: Listed as *C. flaccidum* in EPPO (2018).
6: Additional f. sp. listed separately in IndexFungorum (www.indexfungorum.org) include *Cronartium quercuum* f. sp. *banksianae*, *Cronartium quercuum* f. sp. *echinatae*, *Cronartium quercuum* f. sp. *fusiforme*, *Cronartium quercuum* f. sp. *virginianae*.
7: Listed as two separate species in EPPO (2018), *C. quercuum* and *C. fusiforme.*
8: Additional f. sp. listed separately in IndexFungorum (www.indexfungorum.org) include *C. ribicola* f. sp. *pedicularis.*
9: Additionally var. listed separately in IndexFungorum (www.indexfungorum.org): *C. verbenae* var. *verbenae*. Basionym listed considered conspecific with *C. ribicola*.

3.1.2. Biology of the pest

Many of the North American *Cronartium* species in the genus alternate between the aecial host *Pinus* spp. and telial hosts of different dicotyledonous plants in the Fagaceae, Grossulariaceae, Myricaceae, Santalaceae and Scrophulariaceae families (Sinclair and Lyon, 2005).

The biology of North American, heteroecious *Cronartium* spp. is broadly similar (EPPO, 1997a). Spermagonia and aecia are produced in the spring and early summer, one to several years after infection of the aecial hosts, i.e. *Pinus* spp. (EPPO, 1997a). Aeciospores are windborne and may be carried over long distances to infect the leaves of the telial hosts (EPPO, 1997a).

About 2 weeks after infection of the telial hosts, uredinia develop on the surface on the underside of the leaves and on stems of some herbaceous hosts (EPPO, 1997a; Sinclair and Lyon, 2005). Uredinia are continuously produced throughout the summer and urediniospores produced therein reinfect the telial hosts (EPPO, 1997a). Urediniospores are windborne and may be carried over long distances.

Telia are produced in late summer and the teliospores germinate in place to produce basidiospores (Sinclair and Lyon, 2005). Basidiospores are sensitive to drying and solar radiation and mostly released during night time (Sinclair and Lyon, 2005). Dispersal is usually limited to an area within 1.5 km of the telial host (EPPO, 1997a; see Zambino (2010) for a review of dispersal distances for *C. ribicola*).

The windborne basidiospores infect the first-year needles or young cones of the aecial hosts during summer and autumn (EPPO, 1997a; Sinclair and Lyon, 2005). The duration between infection of the aecial hosts and the formation of spermagonia ranges from several weeks to more than two years depending on the *Cronartium* species (Sinclair and Lyon, 2005). Cross-fertilisation of the spermagonia occurs through hyphal anastomoses or by insects (Sinclair and Lyon, 2005). Spermagonia on the conifer hosts are mainly produced on branches and stems in association with cankers or swellings (or on cones). After several weeks (up to one year), aecia are produced where spermagonia previously appeared producing yellow to orange (rarely white) aeciospores (Sinclair and Lyon, 2005). The aeciospores have thick walls, tolerate dry air and can disperse over long distances (Sinclair and Lyon, 2005).

The rust may overwinter in bark and galls of *Pinus* spp. (EPPO, 1997a). Most of the *Cronartium* spp. are perennial in pine tissue after infection and grow into the outer rings of sapwood (Sinclair and Lyon, 2005). Limb rusts can also grow into the deeper layers of the sapwood (Sinclair and Lyon, 2005).

For both *C. coleosporioides* and *C. comandrae,* most infections (on *Pinus contorta*) were found to occur within 2 m from the ground (Van der Kamp, 1994).

The species are often grouped according to the symptoms they cause. *Gall rusts* are stem rusts causing gall formation, but usually no cankers, *blister rusts* are stem rusts that cause cankers and *limb rusts* are rusts causing infections leading to dieback of branches but no cankers (Sinclair and Lyon, 2005).

Some *Cronartium* species are autoecious, as they do not need alternate hosts to complete their life cycle.

There is very limited information on the biology of most of the species reported from tropical or subtropical countries.

3.1.3. Intraspecific diversity

For most of the non-EU *Cronartium* species, there is little information on their intraspecific diversity. Within *C. quercuum*, several host specific *formae speciales* have been described (Burdsall and Snow, 1977; EPPO, 1997f; Nakamura et al., 1998). In the US, four genetically distinct regional groups of *C. quercuum* were distinguished in the south Atlantic and Gulf coastal plains (Kubisiak et al., 2004). In China, the genetic diversity of *C. quercuum* was found to be higher in genotypes from *P. sylvestris* var. *mongolica* than on other pine hosts (Cheng et al., 1998).

3.1.4. Detection and identification of the pest

Are detection and identification methods available for the pest?
Yes, detection and identification methods are available for several (but not all) non-EU *Cronartium* species.

Morphological features of the sporulating structures can be used to differentiate between most of the different *Cronartium* species. However, some species are very similar and inoculation of the telial host may be needed to differentiate species, e.g. *C. coleosporioides* and *C. comptoniae* (EPPO, 1997a,c).

Morphological descriptions in Data Sheets on Quarantine Pests are available for *C. coleosporioides, C. comandrae, C. comptoniae, C. himalayense, C. kamtschaticum, C. fusiforme* (no longer accepted as a valid name, i.e. regarded as synonym of *C. quercuum*) and *C. quercuum* (EPPO, 1997a–f).

Isozyme and protein pattern analysis of aeciospores can differentiate between *C. appalachianum, C. comandrae*, *C. harknessii*, *C. ribicola*, and several *formae speciales* of *C. quercuum* (Powers et al., 1989).

3.2. Pest distribution

3.2.1. Pest distribution outside the EU

Cronartium species are reported from many different countries across the globe (Table 2). The *Cronartium* spp. with a documented association with hosts of the genus *Pinus* spp. appear to be mostly limited to the northern hemisphere.

Detailed maps are only available for some of the species, e.g. *C. coleosporioides, C. comandrae, C. comptonidae, C. fusiforme* (see comment in Section 3.1.4)*, C. himalayense*, *C. kamtschaticum,* and *C. quercuum* (EPPO, 2018). A distribution map for non-EU *Cronartium* spp. based on Table 2 is presented in Figure 1.

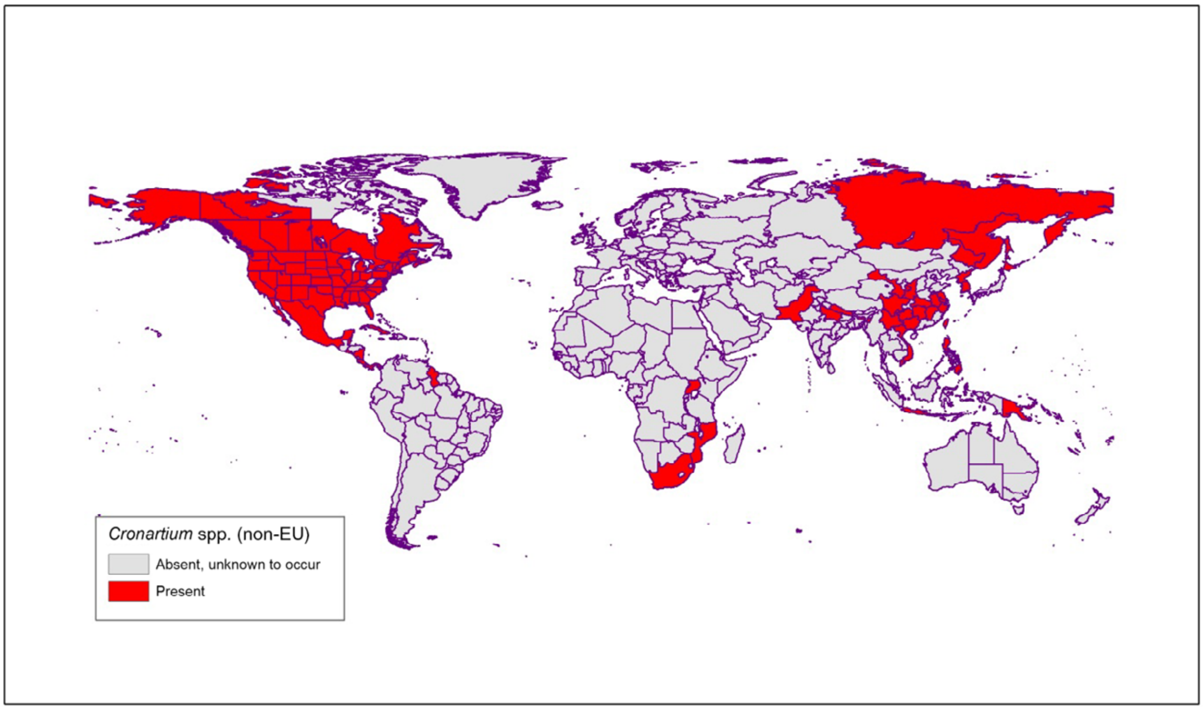

Figure 1: Global distribution map for non-EU *Cronartium spp.* (based on Table 2)

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 non-EU Cronartium spp. are not reported to be present in the EU.

There are only few reports of absence of non-EU *Cronartium* species from EU MS that have been confirmed by surveys. *C. coleosporioides*, *C. comandrae, C. comptoniae*, *C. himalayense*, *C. kamtschatichum* and *C. quercuum* are reported as absent in the Netherlands (confirmed by survey) (EPPO, 2018). These species are also listed as absent in the UK Plant Health Risk Register (https://secure.fera.defra.gov.uk/phiw/riskRegister/).

3.3. Regulatory status

3.3.1. Council Directive 2000/29/EC

Cronartium spp. (non-EU) are listed in Council Directive 2000/29/EC as *Cronartium* spp. (non-European) (see Section 1.1.2). Details are presented in Tables 3 and 4.

Table 3: *Cronartium* spp. (non-EU) 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
3.	*Cronartium* spp. (non-European)

3.3.2. Legislation addressing the hosts of Cronartium spp. (non-EU)

Table 4: Regulated hosts and commodities that may involve *Cronartium* spp. (non-EU) 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
2.	Plants of *Castanea* Mill., and *Quercus* L., with leaves, other than fruit and seeds	Non-European countries
Annex V, Part A	**Special requirements which must be laid down by all member states for the introduction and movement of plants, plant products and other objects into and within all Member States**	
Section I	Plants, plant products and other objects originating outside the Community	
11.1.	Plants of *Castanea* Mill. and *Quercus* L., other than fruit and seeds, originating in non-European countries	Without prejudice to the prohibitions applicable to the plants listed in Annex III(A)(2) and IV(A)(I)(11.01.), official statement that no symptoms of *Cronartium* spp. (non-European) have been observed at the place of production or its immediate vicinity since the beginning of the last complete cycle of vegetation
Annex V	**Plants, plant products and other objects which must be subject to a plant health inspection (at the place of production if originating in the Community, before being moved within the Community—in the country of origin or the consignor country, if originating outside the Community) before being permitted to enter the Community**	
Part A	Plants, plant products and other objects originating in the Community	
Section II	Plants, plant products and other objects produced by producers whose production and sale is authorised to persons professionally engaged in plant production, other than those plants, plant products and other objects which are prepared and ready for sale to the final consumer, and for which it is ensured by the responsible official bodies of the Member States, that the production thereof is clearly separate from that of other products	
1.1.	Plants of *Abies* Mill., *Larix* Mill., *Picea* A. Dietr., *Pinus* L. and *Pseudotsuga* Carr.	

3.4. Entry, establishment and spread in the EU

3.4.1. Host range

The known aecial and telial hosts of the known heteroecious species are listed in Table 5.

The European species *Pinus cembra*, *Pinus halepensis*, *Pinus pinaster, Pinus pinea*, *Pinus sylvestris*, *Pinus nigra* and *Pinus mugo* and the commonly planted *Pinus contorta*, *Pinus ponderosa* and *Pinus strobus* are reported to be hosts of at least some of the non-EU *Cronartium* species (EPPO, 2018).

C. conigenum, C. orientale, C. quercuum and *C. strobilinum* have different *Quercus* spp. as their telial hosts (Table 5). *C. orientale* and *C. quercuum* also infect *Castanea* spp. and *Castanopsis* spp. (EPPO, 2018).

Several herbaceous plants are also telial hosts (Table 5). Many new alternate hosts of *C. ribicola* (which is not part of this pest categorisation, see Section 1.2) have been recently reported (e.g. Kaitera et al., 2017, 2018), suggesting that there could be several unknown alternate hosts of non-EU *Cronartium* spp. too. Uncertainty in the host range of non-EU *Cronartium* spp. is added by the observation of interspecific hybridisation between *C. ribicola* and *C. comandrae* in Canada (Joly et al., 2006). Hybridisation between different *Cronartium* spp. could lead to pathogens with unexpected host ranges (Olson and Stenlid, 2002; Ghelardini et al., 2016; Stukenbrock, 2016).

Some of the *Cronartium* spp., especially those reported from more tropical or subtropical regions, have only been reported on angiosperm plant species (Table 5).

In Council Directive 2000/29/EC, *Cronartium* spp. (non-EU) are not regulated on a particular host or commodity; their introduction into the EU is banned (Annex IAI).

Table 5: *Cronartium* spp. and their known aecial and telial hosts.

***Cronartium* species**	**Aecial host species**	**Telial host species**	**References**
Cronartium andinum	–	*Eupatorium pseudochilca*	Farr and Rossman (2018)
Cronartium antidesmae-dioicae	–	*Antidesma ghaesembilla, A. venosum*	Berndt and Wood (2012), Farr and Rossman (2018)
Cronartium appalachianum	*Pinus virginiana*	*Bucklyea distichophylla*	Sinclair and Lyon (2005)
Cronartium arizonicum	*Pinus ponderosa*, other two and three needle pines	*Castilleja*, *Orthocarpus* and *Pedicularis* spp.	Sinclair and Lyon (2005)
Cronartium bethelii[(a)]	*Pinus murrayana*	–	Farr and Rossman (2018)
Cronartium bresadolanum	–	*Erythroxylum*	www.indexfungorum.org
Cronartium byrsonimae	–	*Byrsonima coccolobifolia*	www.indexfungorum.org
Cronartium coleosporioides	Major: *Pinus banksiana, Pinus contorta* Minor: *Pinus jeffreyi, Pinus ponderosa*, *Pinus sylvestris* and *Pinus nigra*	*Melampyrum lineare* and *Castilleja* spp. prob. *Orthocarpus*, *Pedicularis* and *Rhinanthus* spp.	Sinclair and Lyon (2005), EPPO (2018), Farr and Rossman (2018)
Cronartium comandrae	Major: *P. banksiana, P. contorta, P. ponderosa* Minor: *Pinus mugo, P. nigra, Pinus pinaster, P. sylvestris* (among others)	*Comandra livida*, *C. umbellata, C. richardsiana* and *Geocaulon lividum*	EPPO (1997b, 2018); Sinclair and Lyon (2005)
Cronartium comptoniae	Major: *P. banksiana, P. contorta, Pinus rigida*; Minor: *P. sylvestris*; Incidental: *P. mugo, P. nigra, P. pinaster* (among others)	*Myrica* spp. (*M. gale*) and *Comptonia peregrina*	EPPO (2018)

Cronartium species	Aecial host species	Telial host species	References
Cronartium conigenum	*Pinus* spp. (*P. chihuahuana, P. leiophylla, P. montezumae, P. oocarpa, P. pseudostrobus*)	*Quercus* spp. (*Q. arizonica, Q. dunnii, Q. emoryi, Q. grisea, Q. oblongifolia, Q. oocarpa, Q. peduncularis, Q. rugosa*)	Farr and Rossman (2018)
Cronartium eupatorinum	–	*Eupatorium* spp.	Farr and Rossman (2018)
Cronartium fici	–	*Ficus* spp.	www.indexfungorum.org
Cronartium filamentosum	*P. ponderosa*	*Castilleja minitata*	Farr and Rossman (2018)
Cronartium himalayense	*Pinus roxburghii* and *Pinus* spp.	*Swertia angustifolia*	EPPO (2018)
Cronartium kamtschaticum	Major: *Pinus cembra, Pinus pumila;* Minor: *Pinus* spp.; Incidental: *Pinus strobus*	*Castilleja* spp. (*C. pallida*), *Pedicularis* spp. and *Ribes* spp.	EPPO (2018)
Cronartium kemangae	–	*Mangifera kemanga* and *M. caesia*	www.indexfungorum.org; Farr and Rossman (2018)
Cronartium maloti	–	*Melanolepis multiglandulosa*	Farr and Rossman (2018)
Cronartium notatum	–	*Byrsonima crassifolia*	www.indexfungorum.org
Cronartium occidentale	*Pinus cembroides, Pinus edulis, Pinus monophylla* and *Pinus* subgenus *strobus*	*Ribes* spp.	Sinclair and Lyon (2005), Farr and Rossman (2018)
Cronartium opheliae	*Pinus roxburghii*	*Swertia* spp.	Farr and Rossman (2018)
Cronartium orientale	*Pinus* spp. (incl. *P. nigra, P. pinaster, P. sylvestris*)	Various *Castanea*, *Castanopsis* and *Quercus* spp. (incl. *Q. rubra*)	Farr and Rossman (2018)
Cronartium quercuum	Major: *P. banksiana, Pinus densiflora, P. echinata, Pinus thunbergii, Pinus virginiana* Minor: *P. nigra, P. sylvestris*	*Quercus* spp. (*Q. acutissima, Q. rubra*), *Castanea* spp. (*C. dentata, C. pumila*) and *Castanopsis*	EPPO (2018)
Cronartium sawadae	–	*Glochidion* spp.	Farr and Rossman (2018)
Cronartium strobilinum	*Pinus caribea, Pinus elliottii, Pinus palustris*	*Quercus* spp.	Sinclair and Lyon (2005)
Cronartium ruelliae	–	*Ruellia formosa*	Farr and Rossman (2018)
Cronartium thesii	–	*Comandra umbellata*	Farr and Rossman (2018)
Cronartium uleanum	–	*Cyphomandra* spp.	Farr and Rossman (2018)
Cronartium wilsonianum	–	*Cissus rhombifolia*	Farr and Rossman (2018)
Cronartium yamabense[(a)]	*Pinus monticola, P. pumila, Pinus strobiformis, P. strobus*	–	Hiratsuka (1986)

(a): Autoecious species lacking telial hosts.

3.4.2. Entry

Is the pest able to enter into the EU territory? If yes, identify and list the pathways!

Yes, *Cronartium* spp. could enter the EU via host plants for planting and cut flowers and branches.

Host commodities on which the pathogens could enter the EU are (EPPO, 1997a–f, 2018):

- Plants for planting of *Pinus*, *Quercus*, *Castanea*, *Castanopsis* spp. and other hosts.
- Cut flowers and branches of *Pinus, Quercus*, *Castanea*, *Castanopsis* spp. and other hosts, when leaves are present.

- Non-squared wood of *Pinus* spp.

Non-squared wood is listed as a pathway of entry of various non-EU *Cronartium* spp. in EPPO (2018). However, since these fungi are biotrophs and require live host tissue, they would presumably not survive long in wood after harvest. Nevertheless, some *Cronartium* spp. are reported to be able to overwinter in bark of *Pinus* spp. (EPPO, 1997a). Moreover, even though these are biotrophic fungi, their aecia may be able to survive for some time in wood.

That the pathogens may be transported with plants for planting has been observed for *C. comandrae* on nursery trees within the USA (EPPO, 1997b). *Cronartium* spp. are reported to have long incubation periods and latent infections may thus go undetected (EPPO, 1997f).

The pathways plants for planting and cut branches of *Pinus* spp. are regulated with a ban on importing plants of *Pinus* spp., other than fruit and seeds, from non-European countries (see Section 3.3.2).

On the telial woody hosts *Quercus* spp., *Castanea* spp. and *Castanopsis* spp., only the leaves are infected (EPPO, 1997f). There is an import ban from non-European countries of plants of *Castanea* and *Quercus* (but not *Castanopsis*), other than fruit and seeds (see Section 3.3.2).

There is no reported risk associated with movement of seeds or pollen (EPPO, 1997a). It is unclear whether cone infecting species could be associated with seeds and thus be a pathway of entry. There is also uncertainty about whether cut flowers could be a pathway of entry.

As of September 2018, there was one record of interception of *Cronartium* spp. in the Europhyt database. In year 2000, the UK reported the interception of a *Cronartium* species (non-EU) on *Mahonia* spp.

3.4.3. Establishment

Is the pest able to become established in the EU territory?
Yes, non-EU *Cronartium* species 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

Cronartium spp. can infect a wide range of *Pinus* spp. (Section 3.4.1). All the European species (*P. cembra*, *P. halepensis*, *P. mugo, P. nigra, P. pinaster, P. pinea* and *P. sylvestris*) and other commonly planted non-native species (e.g. *P. contorta* and *P. ponderosa*) are reported to be hosts of at least one of the *Cronartium* species.

Pinus species are widely distributed across the EU (EFSA PLH Panel, 2018a) (Figure 2) and aecial hosts are therefore available. For the heteroecious species the potential establishment depends on the presence of not just the aecial, but also of the telial hosts (see Table 5).

Different *Quercus* spp. and *Castanea sativa* are found distributed across much of Europe. There is however an uncertainty regarding the susceptibility of the European *Quercus* and *Castanea* spp. Telial hosts of *C. quercuum* in North America and Asia are mainly native to their respective continent (EPPO, 1997f).

The known telial hosts of *C. comandrae* (*Comandra livida*, *C. umbellata*, *C. richardsiana* and *Geocaulon lividum*) are not present in Europe (EPPO, 1997b). Only one related species, *Comandra elegans*, is present but uncommon and limited to the Balkan peninsula (EPPO, 1997b).

Of the known telial hosts of *C. comptoniae*, *Myrica gale* is widespread on poor soils in north western Europe (EPPO, 1997c).

Several of the known telial host genera of *C. coleosporioides* are present in Europe, i.e. *Melampyrum*, *Pedicularis* and *Rhinanthus* (EPPO, 1997a). But none of the host species infected in North America is reported to occur in Europe (EPPO, 1997a).

Known telial host genera of *C. kamtschaticum* present in Europe are *Pedicularis*, which occurs widely in the Palaearctic region, and *Ribes* (EPPO, 1997e).

C. himalayense and *C. opheliae* have telial hosts within the genus *Swertia*. The genus is represented by *S. perennis* in Europe, which occurs mainly in the mountains of central Europe (EPPO, 1997d).

Different *Castilleja* species are telial hosts of some of the *Cronartium* spp. According to the Plants of the World Online database, this genus is only found in Arctic/Asian Russia and the Americas (http://powo.science.kew.org/taxon/urn:lsid:ipni.org:names:325881-2).

For some *Cronartium* species reported on angiosperm hosts (Table 5), the lack of hosts in the EU could be a factor limiting establishment.

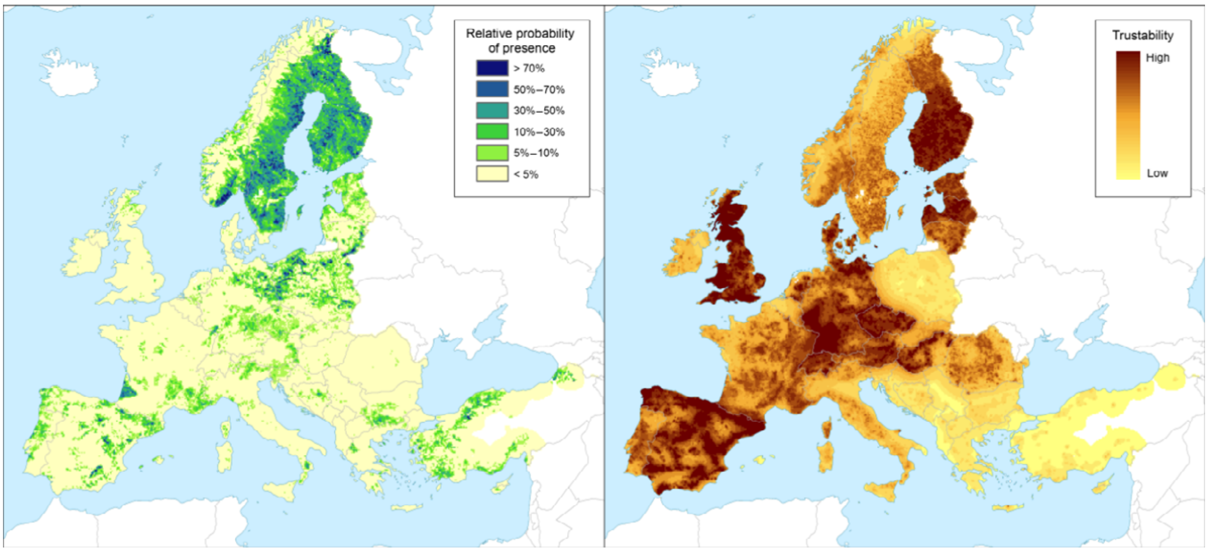

Figure 2: Left-hand panel: Relative probability of presence (RPP) of the genus *Pinus* (based on data from the species: *P. sylvestris, P. pinaster, P. halepensis, P. nigra, P. pinea, P. contorta, P. cembra, P. mugo, P. radiata, P. canariensis, P. strobus, P. brutia, P. banksiana, P. ponderosa, P. heldreichii, P. leucodermis* and *P. wallichiana*) in Europe, mapped at 100 km^2 pixel resolution. The underlying data are from European-wide forest monitoring data sets and from national forestry inventories based on standard observation plots measuring in the order of hundreds 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)

3.4.3.2. Climatic conditions affecting establishment

Several non-EU *Cronartium* spp. with *Pinus* and *Quercus* spp. as reported hosts (Table 5) occur in areas with climatic conditions similar to those found in large parts of the EU (see Section 3.2.1). Climate is thus not expected to be a limiting factor for the establishment of such non-EU *Cronartium* species.

For the non-EU *Cronartium* spp. occurring in (sub)tropical areas, climate may be a limiting factor for establishment, unless those *Cronartium* spp. occur in their native range in mountainous areas with a more temperate climate.

3.4.4. Spread

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

Yes, by natural dispersal and movement of infected host plants for planting and cut flowers and branches.

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

No, plants for planting are not the main pathway of spread, as wind-blown spores can travel over long distances.

Cronartium spp. have windborne aeciospores that can travel long distances (Chang and Blenis, 1989; EPPO, 1997a). The aeciospores tolerate dry air (Sinclair and Lyon, 2005). Urediniospores from the telial hosts may also be able to spread over long distances.

There is research available on the spread of *C. ribicola* (which is not part of this pest categorisation, see Section 1.2) (e.g. Hatala et al., 2011; Leung and Kot, 2015; Evans, 2016), but also e.g. on the factors affecting the spread of *C. comptoniae* in Minnesota, US (Smeltzer and French, 1981) and on the connectivity of the landscape in southern Mississippi with regard to *C. quercuum* (this connectivity has been shown to have increased over time; Perkins and Matlack, 2002). Late spring frosts and dry weather were found to limit the dispersal of aeciospores of *C. quercuum* in Wisconsin, US (Nighswander and Patton, 1965).

These pathogens may also be transported across large distances on plants for planting (EPPO, 1997f). By analogy with entry (see Section 3.4.2), cut flowers and branches could be a means of spread of these pathogens.

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 on pine, oak and chestnut forests, plantations, ornamental trees 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 pest introduction could have an impact on the intended use of plants for planting.

The North American *Cronartium* spp. cause very important tree diseases (EPPO, 1997a–f; Vogler and Bruns, 1998). Symptoms on *Pinus* spp. differ between *Cronartium* spp., but include galls, cankers, dieback of branches and stems, deformity, tree and cone death (Sinclair and Lyon, 2005) (Figure 3). The impact of the rusts may depend on the abundance of the telial hosts, as shown for *C. comptoniae* (Gross et al., 1983).

Symptoms on the telial hosts include yellow leafs spots, yellow to necrotic leaf blotches and premature defoliation (Sinclair and Lyon, 2005).

There is limited information on the impact of various non-EU *Cronartium* spp. However, in general, should non-EU *Cronartium* species be introduced to the EU, impacts can be expected in pine, oak and chestnut forests, plantations, ornamental trees and nurseries. For example, it has been assessed that the introduction of *C. comptoniae* into Britain might have very serious consequences on *P. contorta* plantations (Pawsey, 1974).

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

Figure 3: *Pinus ponderosa* showing symptoms of eastern pine gall rust caused by the fungus *Cronartium quercuum*. Photo by Howard F. Schwartz, Colorado State University. Available online: https://www.forestryimages.org/browse/detail.cfm?imgnum=5357475

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, see Sections 3.3 and 3.6.1.

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

No, given that symptoms become visible only many years after infection and given the long-distance spore dispersal potential, preventing pest presence on plants for planting is difficult.

3.6.1. Identification of additional measures

Phytosanitary measures are currently applied to some of the host species of non-EU *Cronartium* spp. (see Section 3.3.2). Given that symptoms do not become visible for many years after infection, EPPO (1997a–f) concluded that the only practical way to avoid introduction of non-EU *Cronartium* spp. is to ban the import of host plants (especially *Pinus* and *Quercus* spp.) from countries where these pathogens are present.

3.6.1.1. Additional control measures

Potential additional control measures are listed in Table 6.

Table 6: Selected control measures (a full list is available in EFSA PLH Panel, 2018b) for pest entry/establishment/spread/impact in relation to currently unregulated hosts and pathways. Control measures are measures that have a direct effect on pest abundance

Information sheet title (with hyperlink to information sheet if available)	Control measure summary	Risk component (entry/establishment/spread/impact)
Growing plants in isolation	Plant nurseries should be located far away from infected forests stands (EPPO, 1997a)	Entry/Spread
Use of resistant and tolerant plant species/varieties	The use of resistant cultivars can reduce impacts, as shown for *C. quercuum* in forest nurseries (EPPO, 1997f)	Impact

Information sheet title (with hyperlink to information sheet if available)	Control measure summary	Risk component (entry/establishment/spread/impact)
Roguing and pruning	Because girdling cankers develop slowly and infrequently in the Rocky Mountains, potential losses from *C. comandrae* were found to be reduced by timely removal of damaged *P. contorta* trees (Geils and Jacobi, 1990)	Impact
Crop rotation, assoc iations and density, weed/volunteer control	Plant nurseries should be located far away from telial hosts	Impact

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

- Latent infections may go undetected (EPPO, 1997a).
- Given the long-distance dispersal potential of the aeciospores and urediniospores, it would be very difficult to contain them (Sinclair and Lyon, 2005; Kobziar et al., 2018).

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

- Wind-borne aeciospores and urediniospores can be carried over long distances (EPPO, 1997a; Sinclair and Lyon, 2005).

3.7. Uncertainty

- The taxonomic resolution at the species level within the genus is uncertain.
- The geographic distribution and host range (for both telial and aecial hosts) of many of the species in the genus is unclear, especially for the species reported from tropical and sub-tropical areas.
- It is unclear whether seeds and cut flowers could be a pathway of entry.
- The susceptibility of European host species is uncertain, both with regard to the aecial hosts species in combination with the different *Cronartium* spp. and with regard to European species representing known telial host genera.

4. Conclusions

Cronartium species (non-EU) meet the criteria assessed by EFSA for consideration as potential quarantine pests (Table 7).

Table 7: 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 *Cronartium* spp. (non-EU) as a group of species is clear	The identity of *Cronartium* spp. (non-EU) as a group of species is clear	The taxonomic resolution at the species level within the genus is uncertain
Absence/presence of the pest in the EU territory (Section 3.2)	The pathogens are not reported to be present in the EU	The pathogens are not reported to be present in the EU	The geographic distribution of many of the species in the genus is unclear

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
Regulatory status (Section 3.3)	*Cronartium* spp. (non-EU) are regulated by Council Directive 2000/29/EC (Annex IAI) as harmful organisms whose introduction into, and spread within, all Member States shall be banned	*Cronartium* spp. (non-EU) are regulated by Council Directive 2000/29/EC (Annex IAI) as harmful organisms 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 host plants for planting and cut flowers and branches. Establishment: for several species, hosts are common and climatic conditions are favourable in the risk assessment area Spread: the pest could spread following establishment by movement of host plants for planting and cut flowers and branches, as well as natural spread	Plants for planting are not the main pathway of spread, given the potential contribution of cut branches and natural spread	It is unclear whether seeds and cut flowers could be a pathway of entry
Potential for consequences in the EU territory (Section 3.5)	The introduction of *Cronartium* spp. (non-EU) would have economic and environmental impacts in pine forests, plantations, ornamental trees and nurseries	The introduction of the pest could have an impact on the intended use of plants for planting	The susceptibility of European host species is often uncertain
Available measures (Section 3.6)	Import prohibition of host plants and selecting resistant trees as seed source are available measures	Given the long-distance dispersal potential of the aeciospores, production of plants for planting in pest free areas would be difficult to achieve	None
Conclusion on pest categorisation (Section 4)	The criteria assessed by the Panel for consideration of *Cronartium* spp. (non-EU) as potential quarantine pests 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 is the limited information on several non-EU *Cronartium* spp., in terms of biology, epidemiology, host range and observed/potential impacts		

References

Aime MC, Castlebury LA, Abbasi M, Begerow D, Berndt R, Kirschner R, Marvanová L, Yoshitaka O, Padamsee M, Scholler M, Thines M and Rossman AY, 2018. Competing sexual and asexual generic names in Pucciniomycotina and Ustilaginomycotina (Basidiomycota) and recommendations for use. IMA Fungus, 9, 75–89.

Berndt R and Wood AR, 2012. Additions to the rust fungi of South Africa. Mycological Progress, 11, 483–497.

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

Burdsall HH and Snow GA, 1977. Taxonomy of *Cronartium quercuum* and *C. fusiforme*. Mycologia, 69, 503–508.

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

CABI, 2018. *Cronartium flaccidum* (Scots pine blister rust). CABI Invasive Species Compendium. Available online: https://www.cabi.org/ISC/datasheet/16148 [Accessed: September 2018].

Chang KF and Blenis PV, 1989. Survival of *Endocronartium harknessii* teliospores in a simulated airborne state. Canadian Journal of Botany, 67, 928–932.

Cheng D, Xue Y, Pan X and Li W, 1998. Population genetic structures of three *Cronartium* species from China based upon allozyme analysis. Mycosystema, 17, 32–39.

Chirici G, Bertini R, Travaglini D, Puletti N and Chiavetta U, 2011a. The common NFI database. In: Chirici G, Winter S and McRoberts RE (eds.). National forest inventories: contributions to forest biodiversity assessments. Springer, Berlin. pp. 99–119.

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

Daniëls PP, 2003–2005. La diversidad fúngica en la provincia de Teruel. Teruel - Revista del Instituto de Estudios Turolenses, 90, 27–102. Available online: http://www.ieturolenses.org/media/downloadable/files/links/c/i/ciencias_90_completa.pdf [Accessed: September 2018].

EFSA PLH Panel (EFSA Panel on Plant Health), Bragard C, Di Serio F, Gonthier P, Jacques M-A, Jaques Miret JA, Fejer Justesen AM, MacLeod A, Magnusson CS, Milonas P, Navas-Cortes JA, Parnell S, Potting R, Reignault PL, Thulke H-H, Van der Werf W, Vicent A, Yuen J, Zappalà L, Boberg J, Jeger M, Pautasso M and Dehnen-Schmutz K, 2018a. Scientific opinion on the pest categorisation of *Endocronartium* spp. (non-EU). EFSA Journal 2018;16 (10):e05443, 27 pp. https://doi.org/10.2903/j.efsa.2018.5443

EFSA PLH Panel (EFSA Panel on Plant Health), Jeger M, Bragard C, Caffier D, Candresse T, Chatzivassiliou E, Dehnen-Schmutz K, Gregoire J-C, Jaques Miret JA, MacLeod A, Navajas Navarro M, Niere B, Parnell S, Potting R, Rafoss T, Rossi V, Urek G, Van Bruggen A, Van Der Werf W, West J, Winter S, Hart A, Schans J, Schrader G, Suffert M, Kertesz V, Kozelska S, Mannino MR, Mosbach-Schulz O, Pautasso M, Stancanelli G, Tramontini S, Vos S and Gilioli G, 2018b. Guidance on quantitative pest risk assessment. EFSA Journal 2018;16(8):5350, 86 pp. https://doi.org/10.2903/j.efsa.2018.5350

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

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

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

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

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

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

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

Evans AM, 2016. The speed of invasion: rates of spread for thirteen exotic forest insects and diseases. Forests, 7, 99.

FAO (Food and Agriculture Organization of the United Nations), 1995. ISPM (International standards for phytosanitary measures) No 4. Requirements for the establishment of pest free areas. Available online: https://www.ippc.int/en/publications/614/

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

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

FAO (Food and Agriculture Organization of the United Nations), 2017. ISPM (International standards for phytosanitary measures) No 5. Glossary of phytosanitary terms. Available online: https://www.ippc.int/en/publications/622/

Farr DF and Rossman AY, 2018. Fungal Databases, US National Fungus Collections, Agricultural Research Service, USDA. Available online: https://nt.ars-grin.gov/fungaldatabases/ [Accessed: May 2018].

Geils BW and Jacobi WR, 1990. Development of comandra blister rust on lodgepole pine. Canadian Journal of Forest Research, 20, 159–165.
Geils BW, Hummer KE and Hunt RS, 2010. White pines, *Ribes*, and blister rust: a review and synthesis. Forest Pathology, 40, 147–185.
Ghelardini L, Pepori AL, Luchi N, Capretti P and Santini A, 2016. Drivers of emerging fungal diseases of forest trees. Forest Ecology and Management, 381, 235–246.
Gross HL, Ek AR and Patton RF, 1983. Site character and infection hazard for the sweetfern blister rust disease in northern Ontario. Forest Science, 29, 771–778.
Hatala JA, Dietze MC, Crabtree RL, Kendall K, Six D and Moorcroft PR, 2011. An ecosystem-scale model for the spread of a host-specific forest pathogen in the Greater Yellowstone Ecosystem. Ecological Applications, 21, 1138–1153.
Hiederer R, Houston Durrant T, Granke O, Lambotte M, Lorenz M, Mignon B and Mues V, 2007. Forest focus monitoring database system - validation methodology. Vol. EUR 23020 EN of EUR – Scientific and Technical Research. Office for Official Publications of the European Communities. https://doi.org/10.2788/51364
Hiederer R, Houston Durrant T and Micheli E, 2011. Evaluation of BioSoil demonstration project - Soil data analysis. Vol. 24729 of EUR - Scientific and Technical Research. Publications Office of the European Union. https://doi.org/10.2788/56105
Hiratsuka Y, 1986. Cytology of an autoecious soft pine blister rust (*Peridermium yamabense*) in Japan. Mycologia, 78, 637–640.
Houston Durrant T and Hiederer R, 2009. Applying quality assurance procedures to environmental monitoring data: a case study. Journal of Environmental Monitoring, 11, 774–781.
Houston Durrant T, San-Miguel-Ayanz J, Schulte E and Suarez Meyer A, 2011. Evaluation of BioSoil demonstration project: forest biodiversity - Analysis of biodiversity module. Vol. 24777 of EUR – Scientific and Technical Research. Publications Office of the European Union. https://doi.org/10.2788/84823
Hummer KE, 2000. History of the origin and dispersal of white pine blister rust. Horttechnology, 10, 515–517.
Imazu M, Azbukina ZM, Kakishima M, Fukushima K, Nishimura K and Miyaji M, 2000. Identification of a rust fungus on *Pinus pumila* collected in the North Kurils, Russia. Mycoscience, 41, 139–144.
Joly DL, Langor DW and Hamelin RC, 2006. Molecular and morphological evidence for interspecific hybridization between *Cronartium ribicola* and *C. comandrae* on *Pinus flexilis* in Southwestern Alberta. Plant Disease, 90, 1552.
Kaitera J, Hiltunen R and Hantula J, 2017. *Nasa*, *Nemesia* and *Euphrasia*: new alternate hosts of *Cronartium* spp. Forest Pathology, 47, e12306.
Kaitera J, Kauppila T and Hantula J, 2018. New alternate hosts for *Cronartium* spp.: *Odontites*, *Euphrasia*, *Rhinanthus* and *Papaver*. Forest Pathology, 2018, e12466.
Kim MS, Klopfenstein NB, Ota Y, Lee SK, Woo KS and Kaneko S, 2010. White pine blister rust in Korea, Japan and other Asian regions: comparisons and implications for North America. Forest Pathology, 40, 382–401.
Klebahn H, 1890. Ueber die Formen und den Wirthswechsel der Blasenroste der Kiefern. Berichte der Deutschen Botanischen Gesellschaft, 8, 60–71. Available online: http://www.zobodat.at/pdf/Ber-Deutschen-Bot-Ges_8_1059-1070.pdf [Accessed: September 2018].
Klebahn H, 1939. Untersuchungen über *Cronartium gentianeum* v. Thümen. Berichte der Deutschen Botanischen Gesellschaft, 57, 92–98.
Kobziar LN, Pingree MR, Larson H, Dreaden TJ, Green S and Smith JA, 2018. Pyroaerobiology: the aerosolization and transport of viable microbial life by wildland fire. Ecosphere, 9, e02507.
Kubisiak TL, Roberds JH, Spaine PC and Doudrick RL, 2004. Microsatellite DNA suggests regional structure in the fusiform rust fungus *Cronartium quercuum* f. sp fusiforme. Heredity, 92, 41–50.
Kummer V and Klenke F, 2015. The rust fungus *Cronartium flaccidum* and its host range in Germany. Schlechtendalia, 28, 59–70.
Leung MR and Kot M, 2015. Models for the spread of white pine blister rust. Journal of Theoretical Biology, 382, 328–336.
Magnus P, 1905. *Die Pilze von Tirol*. Vorarlberg und Liechtenstein, Wagner, Innsbruck, Austria. 716 pp.
McNeill J, Turland NJ, Barrie FR, Buck WR, Greuter W and Wiersema JH, 2012. *International Code of Nomenclature for Algae, Fungi, and Plants*. Koeltz Scientific Books, Konigstein, Germany. 208 pp.
Nakamura H, Kaneko S and Spaine P, 1998. Differences in molecular characteristics between Cronartium quercuum from Japan and fusiform rust from USA. In: Proceedings of the first IUFRO Rusts of Forest Trees Working Party Conference; 1998 August 2-7; Saariselka, Finland. Finnish Forest Research Institute, Metla, Finland. pp. 235–241. Available online: https://www.fs.usda.gov/treesearch/pubs/893 [Accessed: September 2018]
Nighswander JE and Patton RF, 1965. The epidemiology of the jack pine–oak gall rust (*Cronartium quercuum*) in Wisconsin. Canadian Journal of Botany, 43, 1561–1581.
Olson Å and Stenlid J, 2002. Pathogenic fungal species hybrids infecting plants. Microbes and Infection, 4, 1353–1359.
Pawsey RG, 1974. *Cronartium comptoniae*, a potential threat to *Pinus contorta* in Britain. Forestry, 47, 89–91.
Perkins TE and Matlack GR, 2002. Human-generated pattern in commercial forests of southern Mississippi and consequences for the spread of pests and pathogens. Forest Ecology and Management, 157, 143–154.
Powers HR Jr, Lin D and Hubbes M, 1989. Interspecific and intraspecific differentiation within the genus *Cronartium* by isozyme and protein pattern analysis. Plant Disease, 73, 691–694.

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

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

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

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

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

San-Miguel-Ayanz J, de Rigo D, Caudullo G, Houston Durrant T and Mauri A (eds.), 2016. European Atlas of Forest Tree Species. Publication Office of the European Union, Luxembourg.

Sinclair WA and Lyon HH, 2005. Diseases of Trees and Shrubs, 2nd Edition. Cornell University Press, Ithaca, NY. 660 pp.

Smeltzer DL and French DW, 1981. Factors affecting spread of *Cronartium comptoniae* on the sweetfern host. Canadian Journal of Forest Research, 11, 401–409.

Stevenson JA, 1926. A Manual of Economic Plant Diseases Which are New or Not Widely Distributed in the United States. Government Printing Office, Washington, D.C., US. Available online: https://archive.org/stream/CAT10505738/CAT10505738_djvu.txt [Accessed: September 2018].

Stukenbrock EH, 2016. The role of hybridization in the evolution and emergence of new fungal plant pathogens. Phytopathology, 106, 104–112.

Van der Kamp BJ, 1994. Lodgepole pine stem diseases and management of stand density in the British Columbia interior. Forestry Chronicle, 70, 773–779.

Vogler DR and Bruns TD, 1998. Phylogenetic relationships among the pine stem rust fungi (*Cronartium* and *Peridermium* spp.). Mycologia, 90, 244–257.

Widder F, 1941. Untersuchungen über forstschädliche *Cronartium*-Arten. Österreichische Botanische Zeitschrift, 90, 107–117.

Zambino PJ, 2010. Biology and pathology of *Ribes* and their implications for management of white pine blister rust. Forest Pathology, 40, 264–291.

Abbreviations

C-SMFA	constrained spatial multi-scale frequency analysis
CLC	Corine Land Cover
DG SANTE	Directorate General for Health and Food Safety
EPPO	European and Mediterranean Plant Protection Organization
EUFGIS	European Information System on Forest Genetic Resources
FAO	Food and Agriculture Organization
GD^2	Georeferenced Data on Genetic Diversity
IPPC	International Plant Protection Convention
MS	Member State
PLH	EFSA Panel on Plant Health
RNQP	Regulated non-quarantine pest
RPP	relative probability of presence
ToR	Terms of Reference

Glossary

Containment (of a pest)	Application of phytosanitary measures in and around an infested area to prevent spread of a pest (FAO, 1995, 2017)
Control (of a pest)	Suppression, containment or eradication of a pest population (FAO, 1995, 2017)
Entry (of a pest)	Movement of a pest into an area where it is not yet present, or present but not widely distributed and being officially controlled (FAO, 2017)

Eradication (of a pest)	Application of phytosanitary measures to eliminate a pest from an area (FAO, 2017)
Establishment (of a pest)	Perpetuation, for the foreseeable future, of a pest within an area after entry (FAO, 2017)
Impact (of a pest)	The impact of the pest on the crop output and quality and on the environment in the occupied spatial units
Introduction (of a pest)	The entry of a pest resulting in its establishment (FAO, 2017)
Measures	Control (of a pest) is defined in ISPM 5 (FAO 2017) as 'Suppression, containment or eradication of a pest population' (FAO, 1995) Control measures are measures that have a direct effect on pest abundance Supporting measures are organisational measures or procedures supporting the choice of appropriate Risk Reduction Options that do not directly affect pest abundance
Pathway	Any means that allows the entry or spread of a pest (FAO, 2017)
Phytosanitary measures	Any legislation, regulation or official procedure having the purpose to prevent the introduction or spread of quarantine pests, or to limit the economic impact of regulated non-quarantine pests (FAO, 2017)
Protected zones (PZ)	A protected zone is an area recognised at EU level to be free from a harmful organism, which is established in one or more other parts of the Union.
Quarantine pest	A pest of potential economic importance to the area endangered thereby and not yet present there, or present but not widely distributed and being officially controlled (FAO, 2017)
Regulated non-quarantine pest	A non-quarantine pest whose presence in plants for planting affects the intended use of those plants with an economically unacceptable impact and which is therefore regulated within the territory of the importing contracting party (FAO, 2017)
Risk reduction option (RRO)	A measure acting on pest introduction and/or pest spread and/or the magnitude of the biological impact of the pest should the pest be present. A RRO may become a phytosanitary measure, action or procedure according to the decision of the risk manager
Spread (of a pest)	Expansion of the geographical distribution of a pest within an area (FAO, 2017)

Appendix A – Methodological notes on Figure 2

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

A.1. Geolocated plot databases

The RPP models rely on five geodatabases that provide presence/absence data for tree species and genera: four European-wide forest monitoring data sets and a harmonised collection of records from national forest inventories (de Rigo et al., 2014, 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.

[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.

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

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

GD^2 (http://gd2.pierroton.inra.fr) provides information about 63 species of interest for genetic conservation. The database covers 6,254 forest plots located in stands of natural populations that are traditionally analysed in genetic surveys. While this database covers fewer species than the others, it covers 66 countries in Europe, North Africa and the Middle East, making it the data set with the largest geographic extent.

A.2. Modelling methodology

For modelling, the data were harmonised in order to have the same spatial resolution (1 km^2) and filtered to a study area comprising 36 countries in the European continent. The density of field observations varies greatly throughout the study area and large areas are poorly covered by the plot databases. A low density of field plots is particularly problematic in heterogeneous landscapes, such as mountainous regions and areas with many different land use and cover types, where a plot in one location is not representative of many nearby locations (de Rigo et al., 2014). To account for the spatial variation in plot density, the model used here (C-SMFA) considers multiple spatial scales when estimating RPP. Furthermore, statistical resampling is systematically applied to mitigate the cumulated data-driven uncertainty.

The presence or absence of a given forest tree species then refers to an idealised standard field sample of negligible size compared with the 1 km^2 pixel size of the harmonised grid. The modelling methodology considered these presence/absence measures as if they were random samples of a binary quantity (the punctual presence/absence, not the pixel one). This binary quantity is a random variable having its own probability distribution which is a function of the unknown average probability of finding the given tree species within a plot of negligible area belonging to the considered 1 km^2 pixel (de Rigo et al., 2014). This unknown statistic is denoted hereinafter with the name of 'probability of presence'.

C-SMFA performs spatial frequency analysis of the geolocated plot data to create preliminary RPP maps (de Rigo et al., 2014). For each 1 km^2 grid cell, the model estimates kernel densities over a range of kernel sizes to estimate the probability that a given species is present in that cell. The entire array of 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 data sets is applied instead of selecting a local 'best performing' one and discarding the remaining information. This array-based processing, and the entire data harmonisation procedure, are made possible thanks to the semantic modularisation which defines the Semantic Array Programming modelling paradigm (de Rigo, 2012).

The probability to find a single species (e.g. a particular coniferous tree species) in a 1 km^2 grid cell cannot be higher than the probability of presence of all the coniferous species combined. The same logical constraints applied to the case of single broadleaved species with respect to the probability of presence of all the broadleaved species combined. Thus, to improve the accuracy of the maps, the preliminary RPP values were constrained so as not to exceed the local forest-type cover fraction with an iterative refinement (de Rigo et al., 2014). The forest-type cover fraction was estimated from the classes of the Corine Land Cover (CLC) maps which contain a component of forest trees (Bossard et al., 2000; Büttner et al., 2012).

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

The robustness of RPP maps depends strongly on sample plot density, as areas with few field observations are mapped with greater uncertainty. This uncertainty is shown qualitatively in maps of 'RPP trustability'. RPP trustability is computed on the basis of the aggregated equivalent number of sample plots in each grid cell (equivalent local density of plot data). The trustability map scale is relative, ranging from 0 to 1, as it is based on the quantiles of the local plot density map obtained using all field observations for the species. Thus, trustability maps may vary among species based on the number of databases that report a particular species (de Rigo et al., 2014, 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 km^2 and 625 km^2) by averaging the values in larger grid cells.