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.

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1. Introduction

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

1.1.1. Background

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

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

1.1.2. Terms of reference

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

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

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

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

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

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

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

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

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

Annex IIA
(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
- Hischomonus phycitis
- Leucaspis japonica Ckll.
- Listronotus bonariensis (Kuschel)

(b) Bacteria

- Citrus variegated chlorosis
- Erwinia stewartii (Smith) Dye

(c) Fungi

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

(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

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

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

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(b) Bacteria

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

(c) Fungi

*Glomerella gossypii* Edgerton

*Hypoxylon mammatum* (Wahl.) J. Miller

*Gremmeniella abietina* (Lag.) Morelet

1.1.2. Terms of Reference: Appendix 2

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

Annex IAI

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

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

1) *Carneocephala fulgida* Nottingham

2) *Draeculacephala minerva* Ball

Group of Tephritidae (non-EU) such as:

1) *Anastrepha fraterculus* (Wiedemann)

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)

(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 mycoplasm

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 zeae* (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
- *Nacobbis aberrans* (Thorne) Thorne and Allen
- *Naupactus leucoloma* Boheman
- *Premnotrypes* spp. (non-EU)
- *Pseudopityophthorus minutissimus* (Zimmermann)
- *Pseudopityophthorus pruinosis* (Eichhoff)
- *Scaphoideus luteolus* (Van Duzee)
- *Spodoptera eridania* (Cramer)
- *Spodoptera litura* (Fabricius)
- *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
- *Treichispora 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

(b) Bacteria

Clavibacter michiganensis (Smith) Davis et al. ssp. sepedonicus (Spieckermann and Kotthoff) Davis et al.

(c) Fungi

Melampsora medusae Thümen

Annex I B

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

Leptinotarsa decemlineata Say

(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) |
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 autecious 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 (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 gentianum, 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 balsamiae     | 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 delawai           | China (Stevenson, 1926)                                                     | No      | –                 |
| Cronartium eupatorinum       | Argentina                                                                    | No      | –                 |
| Cronartium euphrasiae        |                                                                              | No      | –                 |
| Cronartium fici              | India                                                                        | No      | –                 |
| Cronartium filamentosum1     | Arizona, California                                                          | Yes     | No                |
| Cronartium gentianum         | China, Romania, Slovakia, Switzerland, former USSR                           | No      | Yes               |
| Cronartium gramineum         |                                                                              | No      | –                 |
| Cronartium himalayense       | Nepal and India                                                              | Yes     | No                |
| Cronartium hystrix           |                                                                              | No      | –                 |
| Cronartium kamtschaticum2    | Eastern Russia and Japan                                                     | Yes     | No                |
| Cronartium kemangae          | Indonesia                                                                    | No      | –                 |
| Cronartium malloti           | Indonesia, Philippines                                                      | No      | –                 |
| Cronartium nemesiae3         |                                                                              | No      | –                 |
| Cronartium notatum           | Puerto Rico                                                                  | No      | –                 |
| Cronartium occidentale       | Western USA                                                                  | No      | –                 |
| Cronartium opheliae4         | India, Nepal, Pakistan, Philippines                                          | No      | –                 |
| Cronartium orientale         | China, Japan, South Korea, Russia, Vietnam                                   | No      | –                 |
| Cronartium pedicularis3      |                                                                              | No      | –                 |
| Cronartium peridermi-pini3   |                                                                              | No      | –                 |
| Cronartium pini              | Europe and Asia                                                              | Yes5    | Yes               |
| Cronartium quercuum5         | Canada, USA, Mexico, Costa Rica, Cuba, Panama, El Salvador, Guyana, Honduras, | Yes7    | No                |
|                              | Nicaragua, China, India, North and South Korea, Philippines, Taiwan, Russia  |         |                   |
|                              | (far eastern)                                                                |         |                   |
| Cronartium ribicola8         | 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 verbenae3         |                                                                              | No      | –                 |
| Cronartium vincetoxici3      | 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).

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 *forma 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. comptoniae*, *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)](image_url)

3.2.2. Pest distribution 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. kamtschaticum* 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                                                                                             |
| 3.              | *Cronartium* spp. (non-European)                                                                    |

**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).

| Cronartium species | Aecial host species | Telial host species | References |
|--------------------|--------------------|--------------------|------------|
| Cronartium andinum | – | Eupatorium pseudochilca | Farr and Rossman (2018) |
| Cronartium antidsemae-dioicae | – | Antidesma ghaesembilla, A. venosum | Berndt and Wood (2012), Farr and Rossman (2018) |
| Cronartium appalachianum | Pinus virginiana | Buckleya 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 brezadolatum | – | Erythroxylum | www.indexfungorum.org |
| Cronartium byroniae | – | Byrsonima coccolobifolia | www.indexfungorum.org |
| Cronartium colesporioides | 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. richardiana 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 spp. (non-EU): pest categorisation

| **Cronartium species** | **Aecial host species** | **Telial host species** | **References** |
|------------------------|-------------------------|-------------------------|---------------|
| Cronartium conigenum   | *Pinus* spp. (P. chihuahua, P. leophylla, 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 munitata**  | 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 strobos* | **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 multiglandulosoa** | Farr and Rossman (2018) |
| Cronartium notatum     | –                       | **Byronima crassifolia** | www.indexfungorum.org |
| Cronartium occidentale | *Pinus cembroides*, *Pinus edulis*, *Pinus monophylla* and *Pinus subgenus strobos* | **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 sawadace    | –                       | **Glochidion** spp.      | Farr and Rossman (2018) |
| Cronartium strobilinum | *Pinus carieba*, *Pinus elliottii*, *Pinus palustris* | *Quercus* spp. | Sinclair and Lyon (2005) |
| Cronartium uleaneum    | –                       | **Ruellia formosa**      | Farr and Rossman (2018) |
| Cronartium thesii      | –                       | **Comandra umbellata**   | Farr and Rossman (2018) |
| Cronartium wilsonianum | –                       | **Cyphomandra** spp.     | Farr and Rossman (2018) |
| Cronartium yamabense(a) | *Pinus monticola*, *P. pumila*, *Pinus strobiformis*, *P. strobos* | –                       | 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 sp. 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. mug, 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. richardsonia 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://www.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.

### 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.

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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 km² 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 m². RPP represents the probability of finding at least one individual of the taxon in a standard plot placed randomly within the grid cell. For details, see Appendix A (courtesy of JRC, 2017). Right-hand panel: Trustability of RPP. This metric expresses the strength of the underlying information in each grid cell and varies according to the spatial variability in forestry inventories. The colour scale of the trustability map is obtained by plotting the cumulative probabilities (0–1) of the underlying index (for details see Appendix A)
**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?**

| **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 leaf 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).

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4 See Section 2.1 on what falls outside EFSA’s remit.
3.6. Availability and limits of mitigation 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. Identification of additional measures

Potential additional control measures are listed in Table 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?

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.

3.6.1.1. 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                                             |
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 subtropical 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 |
|---------------------------------|------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------|------------------|
| **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 | None |
| **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 | | |

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**Abbreviations**

| Abbreviation | Description |
|--------------|-------------|
| 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 |
| GD²          | 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 1995) 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 km² pixel size, using the ETRS89 Lambert Azimuthal Equal-Area as geospatial projection (EPSG: 3035, http://spatialreference.org/ref/epsg/ets89-ets-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 km²/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. 2152/20035. 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.

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5 Council of the European Union, 2003. Regulation (EC) No 2152/2003 of the European Parliament and of the Council of 17 November 2003 concerning monitoring of forests and environmental interactions in the Community (Forest Focus). Official Journal of the European Union 46 (L 324), 1-8.
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 (GD²)

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

A.2. Modelling methodology

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

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

C-SMFA performs spatial frequency analysis of the geolocated plot data to create preliminary RPP maps (de Rigo et al., 2014). For each 1 km² grid cell, the model estimates kernel densities over a range of kernel sizes to estimate the probability that a given species is present in that cell. The entire array of 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 km² grid cell cannot be higher than the probability of presence of all the coniferous species combined. The same logical constraints applied to the case of single broadleaved species with respect to the probability of presence of all the broadleaved species combined. Thus, to improve the accuracy of the maps, the preliminary RPP values were constrained so as not to exceed the local forest-type cover fraction with an iterative refinement (de Rigo et al., 2014). The forest-type cover fraction was estimated from the classes of the Corine Land Cover (CLC) maps which contain a component of forest trees (Bossard et al., 2000; Büttner et al., 2012).

The resulting probability of presence is relative to the specific tree taxon, irrespective of the potential co-occurrence of other tree taxa with the measured plots, and should not be confused with the absolute abundance or proportion of each taxon in the plots. RPP represents the probability of finding at least one individual of the taxon in a plot placed randomly within the grid cell, assuming that...
the plot has negligible area compared with the cell. As a consequence, the sum of the RPP associated with different taxa in the same area is not constrained to be 100%. For example, in a forest with two 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 km² and 625 km²) by averaging the values in larger grid cells.