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# Pest categorisation of *Coleosporium phellodendri*

EFSA Panel on Plant Health (PLH),
Claude Bragard, Paula Baptista, Elisavet Chatzivassiliou, Francesco Di Serio, Paolo Gonthier, Josep Anton Jaques Miret, Annemarie Fejer Justesen, Alan MacLeod, Christer Sven Magnusson, Panagiotis Milonas, Juan A Navas-Cortes, Stephen Parnell, Roel Potting, Emilio Stefani, Hans-Hermann Thulke, Wopke Van der Werf, Antonio Vicent Civera, Jonathan Yuen, Lucia Zappalà, Quirico Migheli, Irene Vloutoglou, Andrea Maiorano, Franz Streissl and Philippe Lucien Reignault

## Abstract

The EFSA Plant Health Panel performed a pest categorisation of *Coleosporium phellodendri* Kom., a basidiomycete fungus belonging to the order Pucciniales, causing rust diseases on *Pinus* spp. (aecial host) and on *Phellodendron* spp. (telial host). *C. phellodendri* has been reported only from Asia (namely, China, Republic of Korea, Japan and Russia) and is not known to be present in the EU territory. The pathogen is not listed in Annex II of Commission Implementing Regulation (EU) 2019/2072, an implementing act of Regulation (EU) 2016/2031, or in any emergency plant health legislation. The pathogen could enter into, become established in, and spread within the EU territory via host plants for planting and host plant parts (e.g. foliage, branches) other than seeds and fruits, respectively. Spread within the EU territory may also occur by natural means if *Phellodendron* spp. were present. Availability of the *Pinus* spp. and climate suitability factors occurring in the EU are favourable for the establishment of the pathogen in areas where *Phellodendron* spp. are also present. Phytosanitary measures are available to prevent the introduction and spread of the pathogen in the EU. *C. phellodendri* does not satisfy all the criteria assessed by EFSA for consideration as a Union quarantine pest as no economic and environmental impact of this pathogen is expected without widespread presence of *Phellodendron* spp. in the EU.

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**Correspondence:** plants@efsa.europa.eu

**Panel members:** Claude Bragard, Paula Baptista, Elisavet Chatzivassiliou, Francesco Di Serio, Paolo Gonthier, Josep Anton Jaques Miret, Annemarie Fejer Justesen, Alan MacLeod, Christer Sven Magnusson, Panagiotis Milonas, Juan A Navas-Cortes, Stephen Parnell, Roel Potting, Philippe L Reignault, Emilio Stefani, Hans-Hermann Thulke, Wopke Van der Werf, Antonio Vicent Civera, Jonathan Yuen and Lucia Zappalà.

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# 1. Introduction

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

### 1.1.1. Background

The new Plant Health Regulation (EU) 2016/2031, on the protective measures against pests of plants, is applying from 14 December 2019. Conditions are laid down in this legislation in order for pests to qualify for listing as Union quarantine pests, protected zone quarantine pests or Union regulated non-quarantine pests. The lists of the EU regulated pests together with the associated import or internal movement requirements of commodities are included in Commission Implementing Regulation (EU) 2019/2072. Additionally, as stipulated in the Commission Implementing Regulation 2018/2019, certain commodities are provisionally prohibited to enter in the EU (high risk plants, HRP). EFSA is performing the risk assessment of the dossiers submitted by exporting to the EU countries of the HRP commodities, as stipulated in Commission Implementing Regulation 2018/2018. Furthermore, EFSA has evaluated a number of requests from exporting to the EU countries for derogations from specific EU import requirements.

In line with the principles of the new plant health law, the European Commission with the Member States are discussing monthly the reports of the interceptions and the outbreaks of pests notified by the Member States. Notifications of an imminent danger from pests that may fulfil the conditions for inclusion in the list of the Union quarantine pest are included. Furthermore, EFSA has been performing horizon scanning of media and literature.

As a follow-up of the above-mentioned activities (reporting of interceptions and outbreaks, HRP, derogation requests and horizon scanning), a number of pests of concern have been identified. EFSA is requested to provide scientific opinions for these pests, in view of their potential inclusion by the risk manager in the lists of Commission Implementing Regulation (EU) 2019/2072 and the inclusion of specific import requirements for relevant host commodities, when deemed necessary by the risk manager.

### 1.1.2. Terms of reference

EFSA is requested, pursuant to Article 29(1) of Regulation (EC) No 178/2002, to provide scientific opinions in the field of plant health.

EFSA is requested to deliver 53 pest categorisations for the pests listed in Annex 1A, 1B, 1D and 1E (for more details see mandate M-2021-00027 on the Open. EFSA portal). Additionally, EFSA is requested to perform pest categorisations for the pests so far not regulated in the EU, identified as pests potentially associated with a commodity in the commodity risk assessments of the HRP dossiers (Annex 1C; for more details see mandate M-2021-00027 on the Open.EFSA portal). Such pest categorisations are needed in the case where there are not available risk assessments for the EU.

When the pests of Annex 1A are qualifying as potential Union quarantine pests, EFSA should proceed to phase 2 risk assessment. The opinions should address entry pathways, spread, establishment, impact and include a risk reduction options analysis.

Additionally, EFSA is requested to develop further the quantitative methodology currently followed for risk assessment, in order to have the possibility to deliver an express risk assessment methodology. Such methodological development should take into account the EFSA Plant Health Panel Guidance on quantitative pest risk assessment and the experience obtained during its implementation for the Union candidate priority pests and for the likelihood of pest freedom at entry for the commodity risk assessment of High Risk Plants.

## 1.2. Interpretation of the terms of reference

*Coleosporium phellodendri* is one of a number of pests listed in Annex 1C to the Terms of Reference (ToRs) to be subject to pest categorisation to determine whether it fulfils the criteria of a potential Union quarantine pest for the area of the EU excluding Ceuta, Melilla and the outermost regions of Member States referred to in Article 355(1) of the Treaty on the Functioning of the European Union (TFEU), other than Madeira and the Azores, and so inform EU decision making as to its appropriateness for potential inclusion in the lists of pests of Commission Implementing Regulation (EU) 2019/2072. If a pest fulfils the criteria to be potentially listed as a Union quarantine pest, risk reduction options will be identified.



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## 1.3. Additional information

This pest categorisation was initiated following the commodity risk assessment of black pine (*Pinus thunbergii* Parl.) bonsai from Japan performed by EFSA (EFSA PLH Panel, 2019), in which *C. phellodendri* was identified as a relevant non-regulated EU pest which could potentially enter the EU on *P. thunbergii*.

# 2. Data and methodologies

## 2.1. Data

### 2.1.1. Literature search

A literature search on *C. phellodendri* 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. Papers relevant for the pest categorisation were reviewed, and further references and information were obtained from experts, as well as from citations within the references and grey literature.

#### 2.1.1.1. Database search

Pest information, on host(s) and distribution, was retrieved from the European and Mediterranean Plant Protection Organization (EPPO) Global Database (EPPO, online), the CABI databases and scientific literature databases as referred above in section 2.1.1.

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 and TRACES databases were 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 SANTÉ) of the European Commission as a subproject of PHYSAN (Phyto-Sanitary Controls) specifically concerned with plant health information. TRACES is the European Commission's multilingual online platform for sanitary and phytosanitary certification required for the importation of animals, animal products, food and feed of non-animal origin and plants into the European Union, and the intra-EU trade and EU exports of animals and certain animal products. Up until May 2020, the Europhyt database managed 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 and the phytosanitary measures taken to eradicate or avoid their spread. The recording of interceptions switched from Europhyt to TRACES in May 2020.

GenBank was searched to determine whether it contained any nucleotide sequences for *C. phellodendri* which could be used as the reference material for molecular diagnosis. GenBank® (www.ncbi.nlm.nih.gov/genbank/) is a comprehensive publicly available database that as of August 2019 (release version 227) contained over 6.25 trillion base pairs from over 1.6 billion nucleotide sequences for 450,000 formally described species (Sayers et al., 2020).

### 2.1.2. Methodologies

The Panel performed the pest categorisation for *Coleosporium phellodendri* following guiding principles and steps presented in the EFSA guidance on quantitative pest risk assessment (EFSA PLH Panel et al., 2018), the EFSA guidance on the use of the weight of evidence approach in scientific assessments (EFSA Scientific Committee et al., 2017) and the International Standards for Phytosanitary Measures No. 11 (FAO, 2013).

The criteria to be considered when categorising a pest as a potential Union quarantine pest (QP) is given in Regulation (EU) 2016/2031 Article 3 and Annex I, Section 1 of the Regulation. Table 1 presents the Regulation (EU) 2016/2031 pest categorisation criteria on which the Panel bases its conclusions. In judging whether a criterion is met the Panel uses its best professional judgement (EFSA Scientific Committee et al., 2017) by integrating a range of evidence from a variety of sources (as presented above in Section 2.1) to reach an informed conclusion as to whether or not a criterion is satisfied.

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



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impact, deemed to be a risk management decision, the Panel will present a summary of the observed impacts in the areas where the pest occurs, and make a judgement about potential likely impacts in the EU. While the Panel may quote impacts reported from areas where the pest occurs in monetary terms, the Panel will seek to express potential EU impacts in terms of yield and quality losses and not in monetary terms, in agreement with the EFSA guidance on quantitative pest risk assessment (EFSA PLH Panel et al., 2018). Article 3 (d) of Regulation (EU) 2016/2031 refers to unacceptable social impact as a criterion for quarantine pest status. Assessing social impact is outside the remit of the Panel.

**Table 1:** Pest categorisation criteria under evaluation, as derived from 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 (article 3) |
|---|---|
| **Identity of the pest (Section 3.1)** | Is the identity of the pest clearly defined, 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?<br>If present, is the pest in a limited part of the EU or is it scarce, irregular, isolated or present infrequently? If so, the pest is considered to be not widely distributed. |
| **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 for entry and spread. |
| **Potential for consequences in the EU territory (Section 3.5)** | Would the pests' introduction have an economic or environmental impact on the EU territory? |
| **Available measures (Section 3.6)** | Are there measures available to prevent pest entry, establishment, spread or impacts? |
| **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. |

# 3. Pest categorisation

## 3.1. Identity and biology of the pest

### 3.1.1. Identity and taxonomy

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

Yes, the identity of *C. phellodendri* is clearly defined. It has been shown to produce consistent rust symptoms and to be transmissible.

*C. phellodendri* Kom. is a plant pathogenic fungus of the family Coleosporiaceae, described by Vladimir Leontyevich Komarov (1869–1945) as a new species in 1899.

The EPPO Global Database (EPPO, online) provides the following taxonomic identification for *C. phellodendri*:

Preferred name: *Coleosporium phellodendri*
Order: Pucciniales
Family: Coleosporiaceae
Genus: *Coleosporium*
Species: *Coleosporium phellodendri*
Common name: Pine needle rust.



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The EPPO code[1] (Griessinger and Roy, 2015; EPPO, 2019) for this species is: COLSPH (EPPO, online).

### 3.1.2. Biology of the pest

*C. phellodendri* is a basidiomycete fungus belonging to the order *Pucciniales*, and causes rust diseases on *Pinus* spp. (aecial host) and on *Phellodendron* spp. (telial host).

Most species of *Coleosporium* share a macrocyclic-heteroecious life cycle, which includes five spore stages that develop on two unrelated groups of host plants. Their spermogonial and aecial stages are found on pine needles, whereas the uredinial and telial stages are formed on different woody and herbaceous angiosperms, referred to as telial hosts (Kaneko, 1981; Hiratsuka et al., 1984; Suzuki et al., 2018). Teliospores produce basidiospores that usually infect current-year pine needles in late summer. Spermogonia and aecia are usually formed on infected needles between November and the following spring.

In late summer, susceptible pine species are infected by wind-borne *C. phellodendri* basidiospores produced on telial hosts (*Phellodendron* spp.). The basidiospores germinate and develop germ tubes infecting needles of the aecial hosts (*Pinus* spp.), where this pathogen overwinters (Suzuki et al., 2018). Aecial hosts include *Pinus densiflora* Siebold and Zucc. (Japanese red pine), *Pinus thunbergii* Parl. (black pine), *Pinus banksiana* Lamb. (Jack pine), *Pinus sylvestris* L. (Scots pine) and *Pinus tabulaeformis* Carr. (Chinese red pine; see Section 3.1.3 for references).

Symptoms on pines are not detectable during the incubation period, since needles are infected by basidiospores in late summer while spermogonia (also referred to as pycnia or pycnidia) appear on the pine needles around November. The infected 1- and 2-year-old needles exhibit yellow spots and develop spermogonia, followed by white aecia. The aecial fruiting bodies release wind-borne bright orange spores (aeciospores) which infect the telial host (*Phellodendron* spp.) during the summer. The aeciospores germinate on the telial host leaves, leading to infection and to the appearance of orange pustules (uredinia). The time taken for these pustules to appear varies with the telial host, i.e. *Phellodendron* spp. and local climatic conditions. Sinclair and Lyon (2005) suggest that the time between infection and the appearance of visible pustules is 10–15 days for the genus *Coleosporium*. The pustules produce urediniospores, which can cause multiple infection cycles on the telial host during the summer season, resulting in build-up of inoculum. Urediniospores may spread by wind or water-splash. In late summer/early autumn, dark-coloured telia develop on the margins of the uredinial pustules. Basidiospores develop from the telia and are wind-blown to the aecial host. If they land upon a susceptible pine host nearby, the needles may become infected, thereby completing the life cycle of the pathogen. The basidiospores may germinate in a wide temperature range from 5 to 25°C, with an optimum temperature of 15–25°C (Hama, 1972; Wei et al., 2013). Albeit not specifically referring to *C. phellodendri*, Lowe (1972) described *Coleosporium* basidiospores as: 'small and delicate and cannot survive even a short period of temperature extremes or drought', and thus, 'unless they land on susceptible pine needles shortly after dissemination and unless climate conditions are favourable, the basidiospores will perish'. The dispersal ability of *C. phellodendri* basidiospores is considered more important than in other *Coleosporium* species, with a maximum dispersal distance of basidiospores of 300 m (Kusunoki et al., 2017). For other *Coleosporium* species, it has been proposed that Diptera, which have been found to feed on rust fungi, may also have the potential to disperse spores (Henk et al., 2011), but their role as vectors has not been demonstrated in the case of *C. phellodendri*.

### 3.1.3. Host range/Species affected

*C. phellodendri* has been reported from the following hosts: *Phellodendron amurense* Rupr., *P. amurense* var. *japonicum* (Maxim.) Ohwi, *P. amurense* Rupr. var. *sachalinense* F. Schmidt (Spaulding, 1961; Kaneko, 1981; Hiratsuka et al., 1992); *Phellodendron lavallei* Dode; *P. sachalinense* (F. Schmidt) Sarg.; *Phellodendron chinense* C.K. Schneid. (Zhang et al., 1997); *P. chinense* var. *glabriusculum* C.K. Schneid. (Zhuang, 1983); *Pinus densiflora* Siebold and Zucc., *Pinus thunbergii* Parl., *Pinus banksiana* Lamb., *Pinus sylvestris* L. (Saho, 1962) and *Pinus tabulaeformis* Carr. (Cao et al., 2000).

[1] An EPPO code, formerly known as a Bayer code, is a unique identifier linked to the name of a plant or plant pest important in agriculture and plant protection. Codes are based on genus and species names. However, if a scientific name is changed the EPPO code remains the same. This provides a harmonised system to facilitate the management of plant and pest names in computerised databases, as well as data exchange between IT systems (Griessinger and Roy, 2015; EPPO, 2019).



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In 2010, rust symptoms were observed on Japanese prickly–ash tree (*Zanthoxylum ailanthoides* Siebold and Zucc.) in Korea, and later reported as caused by *C. phellodendri* (Back et al., 2012). However, in 2019, representative specimens of the pathogen isolated from Japanese prickly–ash tree were reclassified as *Coleosporium zanthoxyli* based on morphology and sequencing of Internal Transcribed Spacer (ITS) and 28S large subunit (LSU) rDNA regions (Shin et al., 2019). Therefore, in the present pest categorisation, *Z. ailanthoides* will not be considered as potential telial host of *C. phellodendri*.

The complete list of the host plants reported for *C. phellodendri* is included in Appendix A (last updated: 24/06/2022).

### 3.1.4. Intraspecific diversity

No intraspecific diversity has been described in *C. phellodendri*.

### 3.1.5. Detection and identification of the pest

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

***Yes**, detection and identification methods are available for C. phellodendri*.

**Symptomatology**

Symptoms on *Pinus* spp. (aecial host) are not detectable during the incubation period, from August (infection by basidiospores) to November. The first symptoms appear on the 1- and 2- year-old needles as yellow spots or bands in the late fall (around November). Fruiting bodies (spermogonia) develop beneath these spots, followed by white, 'tongue-like' fruiting bodies (aecia). The aeciospores are no longer visible on pine hosts at the end of the summer, but they leave tiny scars on yellow-brown spots/bands on partly-yellowed needles.

*Coleosporium* rusts generally cause discolouration and minor needle cast. Normally, only young trees are affected, and only heavily infected older needles are cast prematurely, resulting in growth reduction. However, death of seedlings may result from rust when combined with insect damage. In cases of severe infection, all needles except those of the current growing season may be affected (DEFRA, 2015).

Symptoms on *Phellodendron* spp. (alternate host) appear in early June as tiny yellowish spot on the adaxial side of the leaves. The yellowish spots become rounded and enlarge in size up to 2–4 mm. The uredinia are formed on the abaxial side of the leaves in early July. Later, the uredinia fuse together and form typical rust symptoms that consist in browning of the tissues around uredinia. Uredinia rupture and expose the urediniospores as yellowish spore masses. In rainy seasons, the complete leaf surface can be covered with uredinia producing urediniospores. In late summer/early autumn, yellow to dark-reddish telia are formed on the abaxial leaf side while uredinia may still be present on the same leaves. Severely infected leaves may dry up and fall prematurely in September. Leaf fall may be severe on the telial host, and Zakharova (1958) reports that in the Amur region of Russia, Amur cork tree (*Phellodendron amurense*) plantations were extensively infected by *C. phellodendri*, reaching epiphytotic proportions in wet years. According to Zakharova (1958), severely infected 70- to 90-year-old trees were killed during the 1952 winter due to frost damage, and those which survived did not develop leaves in spring and slowly died.

**Morphology**

It is difficult to distinguish *C. phellodendri* from closely related *Coleosporium* spp. based only on morphology by microscopic examination. The original measurements (Komarov, 1900) of the spores of the uredinial and telial stages of *C. phellodendri* are provided in Hama (1972): urediniospores are 18–24 × 26–31 μm in size, whereas teliospores measure 22–35 × 60–110 μm. A detailed morphological description is provided by Back et al. (2012) for a reportedly *C. phellodendri* isolate from Japanese prickly-ash tree (*Z. ailanthoides*). It should be noted that this specimen has been later reclassified as *C. zanthoxyli* (Shin et al., 2019), but the two species are considered as morphologically identical. By light microscopic examination, urediniospores are described as orange globose, subglobose or broad–ellipsoid and 26–37 × 22–28 μm in size. The surface of urediniospores is columnar verrucae (2.1–2.5 μm high and 0.6–0.9 μm wide). Teliospores are described as reddish–orange, one–celled, oblong ellipsoid, one–layered crusts (43–63 × 23–33 μm).



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A description of the aecial stage of the closely related species *C. zanthoxyli* (*passim* misspelled by the authors as *C. xanthoxyli*) on *Pinus thunbergii* is provided by Lee et al. (2004): peridial cell ovate, ellipsoid or oblong (33–70 × 23–50 μm), inner wall verrucose, outer wall verrucose with striae; aeciospore broad ellipsoid to ellipsoid, 30–52 × 22–34 μm, surface verrucose with a near smooth spot (Hiratsuka et al., 1992).

**DNA-based identification**

Molecular phylogenetic studies have first used the 28S region of rDNA to resolve relationships within and between genera of rust fungi, supporting *Coleosporium* as monophyletic (Maier et al., 2003). Combined analysis of 28S and small subunit (18S) regions of rDNA sequences resolved *Coleosporium* within suborder Melampsorineae (Aime et al., 2006).

In the course of a systematic analysis of *Coleosporium* species infecting *Solidago* and related hosts in North America, McTaggart and Aime (2018) have shown that in cases where the 28S region cannot differentiate between species within the *Coleosporium* genus, the rDNA internal transcribed spacer 2 (ITS2) region may vary between closely related species. In taxonomically challenging groups such as *Coleosporium*, a secondary locus is proposed when accurate identification and confirmation through morphology is not feasible. However, *C. phellodendri* has not been analysed by McTaggart and Aime (2018). In GenBank (accessed on 19 June 2022), 18 accessions referred to *C. phellodendri* are available, including partial and complete sequences of the 5.8S rRNA, ITS2, 28S rRNA regions.

A polymerase chain reaction-restriction fragment length polymorphism (PCR-RFLP) approach has been proposed by Suzuki et al. (2018) to distinguish four *Coleosporium* species affecting pine trees in Central Japan, namely *C. asterum, C. clematidis-apiifoliae, C. lycopodis* and *C. phellodendri*, the latter being the most abundantly distributed throughout the sites studied in Japan. The protocol includes the use of primer pair 5.8 s-coleo (50-CACATCGATGAAGAACACAGTG-30) and itsr-coleo (50-CGGACTCCTGTAAAGAGCCA-30) to amplify the ITS2 region, followed by digestion of the amplicon with a set of restriction enzymes. The restriction enzyme *SspI* has a single site within the PCR product of *C. phellodendri*, generating two bands (214 bp and 162 bp), whereas the other three tested *Coleosporium* species affecting *P. densiflora* in Central Japan (namely *C. asterum, C. clematidis-apiifoliae* and *C. lycopodis*) show only one band (approximately 245 bp). However, according to the same authors, a total of twelve *Coleosporium* species affect *P. densiflora* worldwide. Therefore, a molecular method able to distinguish *C. phellodendri* from the remaining eight *Coleosporium* species affecting *P. densiflora*, as well as from other *Coleosporium* species affecting other *Pinus* species (e.g. *P. thunbergii*, *P. banksiana*, *P. sylvestris*, *P. tabulaeformis*) has not been reported in the literature.

*C. phellodendri*-specific primers are not available to amplify the pathogen directly from diseased host plant tissue or from fungal tissue.

No EPPO Standard is available for the detection and identification of *C. phellodendri*.

## 3.2. Pest distribution

### 3.2.1. Pest distribution outside the EU

*C. phellodendri* has been reported only from Asia, namely from China (Zhang et al., 1997; Zhuang, 1983; Beenken et al., 2017; Cao et al., 2017; Cao et al., 2000), Republic of Korea (Zhang et al., 1997; Back et al., 2012), Japan (Saho, 1962; Zhang et al., 1997; Suzuki et al., 2018) and Russia (Siberia) (Zakharova, 1958; Spaulding, 1961; Zhang et al., 1997) (Figure 1).



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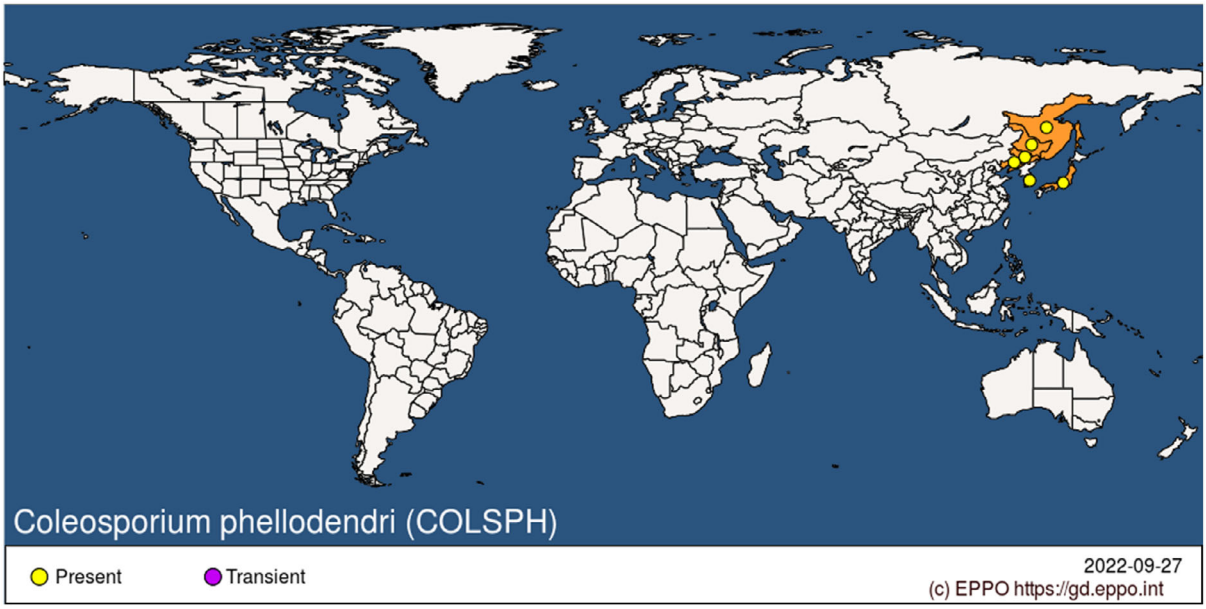


**Figure 1:** Global distribution of *Coleosporium phellodendri* (Source: EPPO Global Database accessed on 27/09/2022)

### 3.2.2. Pest distribution in the EU

*Is the pest present in the EU territory? If present, is the pest in a limited part of the EU or is it scarce, irregular, isolated or present infrequently? If so, the pest is considered to be not widely distributed.*

**No**, *C. phellodendri* is not known to occur in the EU.

## 3.3. Regulatory status

### 3.3.1. Commission implementing Regulation 2019/2072

*C. phellodendri* is not listed in Annex II of Commission Implementing Regulation (EU) 2019/2072, an implementing act of Regulation (EU) 2016/2031, or in any emergency plant health legislation.

### 3.3.2. Hosts or species affected that are prohibited from entering the Union from third countries

The introduction of Pinus plants is prohibited from third countries (see Table 2).

**Table 2:** List of plants, plant products and other objects that are *Coleosporium phellodendri* hosts whose introduction into the Union from certain third countries is prohibited (Source: Commission Implementing Regulation (EU) 2019/2072, Annex VI)

| **List of plants, plant products and other objects whose introduction into the Union from certain third countries is prohibited** | | | |
|---|---|---|---|
| | **Description** | **CN Code** | **Third country, group of third countries or specific area of third country** |
| 1. | Plants of [. . .] *Pinus* L., [. . .]., other than fruit and seeds | ex 0602 20 20 ex 0602 20 80 ex 0602 90 41 ex 0602 90 45 ex 0602 90 46 ex 0602 90 47 ex 0602 90 50 ex 0602 90 70 ex 0602 90 99 ex 0604 20 20 ex 0604 20 40 | Third countries other than Albania, Andorra, Armenia, Azerbaijan, Belarus, Bosnia and Herzegovina, Canary Islands, Faeroe Islands, Georgia, Iceland, Liechtenstein, Moldova, Monaco, Montenegro, North Macedonia, Norway, Russia (only the following parts: Central |



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| List of plants, plant products and other objects whose introduction into the Union from certain third countries is prohibited | | | |
|---|---|---|---|
| | **Description** | **CN Code** | **Third country, group of third countries or specific area of third country** |
| | | | Federal District (Tsentralny federalny okrug), Northwestern Federal District (Severo- Zapadny federalny okrug), Southern Federal District (Yuzhny federalny okrug), North Caucasian Federal District (Severo-Kavkazsky federalny okrug) and Volga Federal District (Privolzhsky federalny okrug)), San Marino, Serbia, Switzerland, Turkey, Ukraine and the United Kingdom |

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

### 3.4.1. Entry

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

**Yes**, the pest is able to enter the EU territory via the host plants for planting other than seeds or parts of the host plants (e.g. foliage, branches) other than fruits.

Host plants for planting other than seeds is a main pathway for the entry of the pathogen into the EU.

The PLH Panel identified the following main pathways for the entry of the pathogen into the EU. territory:

1) Host plants for planting other than seeds.
2) Host plant parts (e.g. foliage, branches) other than fruits.

Seed transmission has never been reported for *Coleosporium* spp.

Given that the reported maximum dispersal distance of *C. phellodendri* spores via wind is 300 m (Hirt, 1936; Kusunoki et al., 2017), it is unlikely for the pathogen to enter the EU by natural means (wind, water-splash, insects, etc.) because of the long distance between the infested third countries and the EU Member States.

Soil and water are not known to be pathways of entry for *C. phellodendri*.

An overview on potential pathways is provided in Table 3.

**Table 3:** Potential pathways for *Coleosporium phellodendri* into the EU 27

| **Pathways (e.g. host/ intended use/source)** | **Life stage** | **Relevant mitigations [e.g. prohibitions (Annex VI), special requirements (Annex VII) or phytosanitary certificates (Annex XI) within Implementing Regulation 2019/2072]** |
|---|---|---|
| Host plants for planting other than seeds | Mycelium, basidiospores, aeciospores, urediniospores, teliospores | Annex VI (1) bans the introduction of plants of planting of *Pinus* L. other than fruit and seed from certain third countries (including countries where the pest occurs: China, Republic of Korea, Japan and the Siberian Federal district of Russia.). There is a derogation for artificially dwarfed pines from Japan (Regulation 2020/1217); Annex VII (10 & 11) requires official statement of special requirements for the introduction into the Union from certain third countries of trees and shrubs, intended for planting, other than seeds |



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| Pathways (e.g. host/ intended use/source) | Life stage | Relevant mitigations [e.g. prohibitions (Annex VI), special requirements (Annex VII) or phytosanitary certificates (Annex XI) within Implementing Regulation 2019/2072] |
|---|---|---|
| | | and plants in tissue culture (Table 4). These requirements are not specifically targeted against *C. phellodendri*. |
| Parts of host plants (e.g. foliage, branches) other than fruits | Mycelium, basidiospores, aeciospores, urediniospores, teliospores | Annex XI (A.3) requires a phytosanitary certificate for foliage, branches and other parts of conifer (Pinales) plants, without flowers or flower buds, being goods of a kind suitable for bouquets or for ornamental purposes, fresh, from third countries other than Switzerland. The pathway is open for *Phellodendron* plant parts. |

Notifications of interceptions of harmful organisms began to be compiled in Europhyt in May 1994 and in TRACES in May 2020. As at (8 September 2022) there were no records of interception of *C. phellodendri* in the Europhyt and TRACES databases.

Table 4 and Appendix D list the annual imports of main hosts from countries where *C. phellodendri* is present.

**Table 4:** EU 27 annual imports of commodities of main hosts from countries where *Coleosporium phellodendri* is present, 2016–2020 (in 100 kg) Source: Eurostat accessed on 22/06/2022

| Potential commodity pathway | HS code | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|
| Fresh conifer branches, suitable for bouquets or ornamental purposes | 0604 20 40 | : | : | 21.65 | : | : |
| Outdoor trees, shrubs and bushes, incl. Their roots, with bare roots (excl. Cuttings, slips and young plants, and fruit, nut and forest trees) | 0602 90 46 | 14.00 | 78.90 | 3.99 | 0.05 | 0.14 |
| Outdoor rooted cuttings and young plants of trees, shrubs and bushes (excl. Fruit, nut and forest trees) | 0602 90 45 | 832.53 | 943.05 | 954.28 | 522.45 | 163.21 |
| Live forest trees | 0602 90 41 | 81.97 | 63.47 | : | : | : |

### 3.4.2. Establishment

*Is the pest able to become established in the EU territory?*

**Yes**. The pest could potentially establish in the risk assessment area.

Given its biology, *C. phellodendri* could potentially be transferred from the pathways of entry (host plants for planting and host plant parts) to the host plants grown in the EU via airborne spores (basidiospores or aeciospores).

The frequency of such transfer depends on the volume and frequency of imported commodities, their destination (e.g. nurseries, retailers), the distance between the aecial or telial hosts grown in the EU as well as on the management of plant residues. The area of the EU where the establishment would be possible is determined by the concurrent presence of host plants of the genera *Pinus* (aecial host; Figure 3) and *Phellodendron* (telial host). Climatic mapping is the principal method for identifying areas that could provide suitable conditions for the establishment of a pest taking key abiotic factors into account (Baker et al., 2002). Availability of hosts is considered in Section 3.4.2.1. Climatic factors are considered in 3.4.2.2.

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

CABI CPC states that *P. amurense* is present in Estonia and Norway, and according to GBIF (https://www.gbif.org/) this host species is also present in Sweden. Some papers (Popa, 1970; Žiogas et al., 2007; Gerulová, 2011; Špaková and Šerá, 2018) indicate that *Phellodendron* spp. (mainly *P. amurense*) are present in botanical gardens/forests/trial plantations in Poland, Slovakia, Romania,



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the Czech Republic and Lithuania. Monumental specimen of the telial host *P. amurense* are reported in Belgium, Germany, the Netherlands, Poland and Slovakia (https://www.monumentaltrees.com/en/europe-phellodendronamurense/).

There is uncertainty on the actual distribution of *Phellodendron* spp. in the EU and their proximity to *Pinus* species (e.g. in nurseries). This suggests a cautious approach in considering the likelihood of the pest being able to complete its life cycle following entry. An overview on the probability of presence of the genus *Pinus* in Europe is provided in Figure 2.

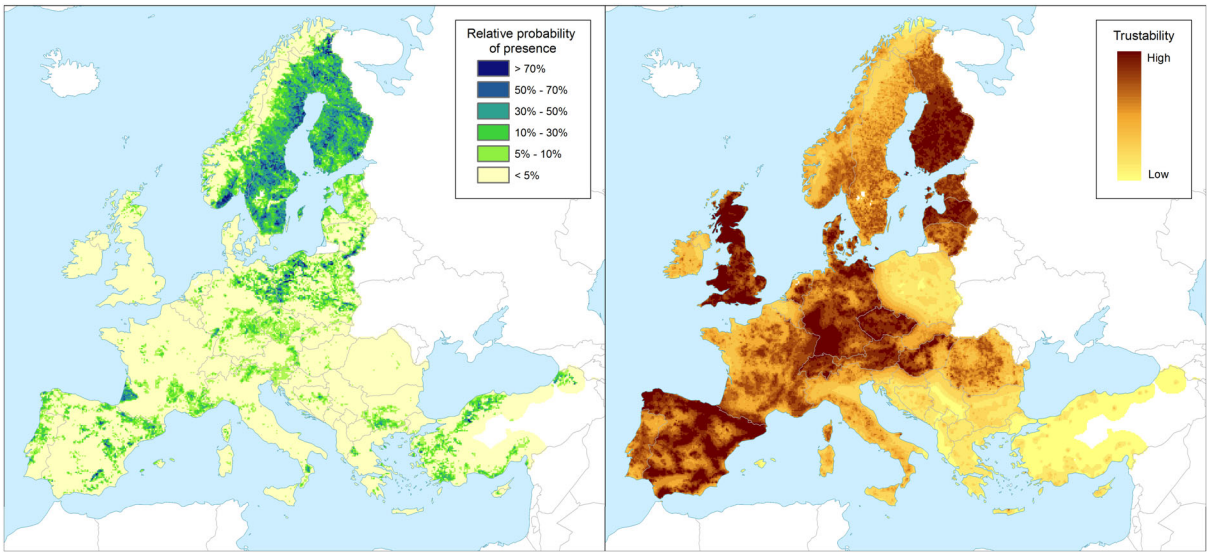


**Figure 2:** Left panel: Relative probability of presence (RPP) of the genus *Pinus* in Europe, mapped at 100 km$^2$ resolution. The underlying data are from European-wide forest monitoring datasets and from national forestry inventories based on standard observation plots measuring in the order of 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 C (courtesy of JRC, 2017). Right 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 C)

### 3.4.2.2. Climatic conditions affecting establishment

*C. phellodendri* has been reported from Asia. Based on the few data available, the Köppen-Geiger climatic zones (BSk, Cfa, Cfb, Dfb and Dfc; Kottek et al., 2006) in China, Japan, Republic of Korea and Russia (Siberia), where the pathogen is present, are comparable to climatic zones within the EU (Figure 3).



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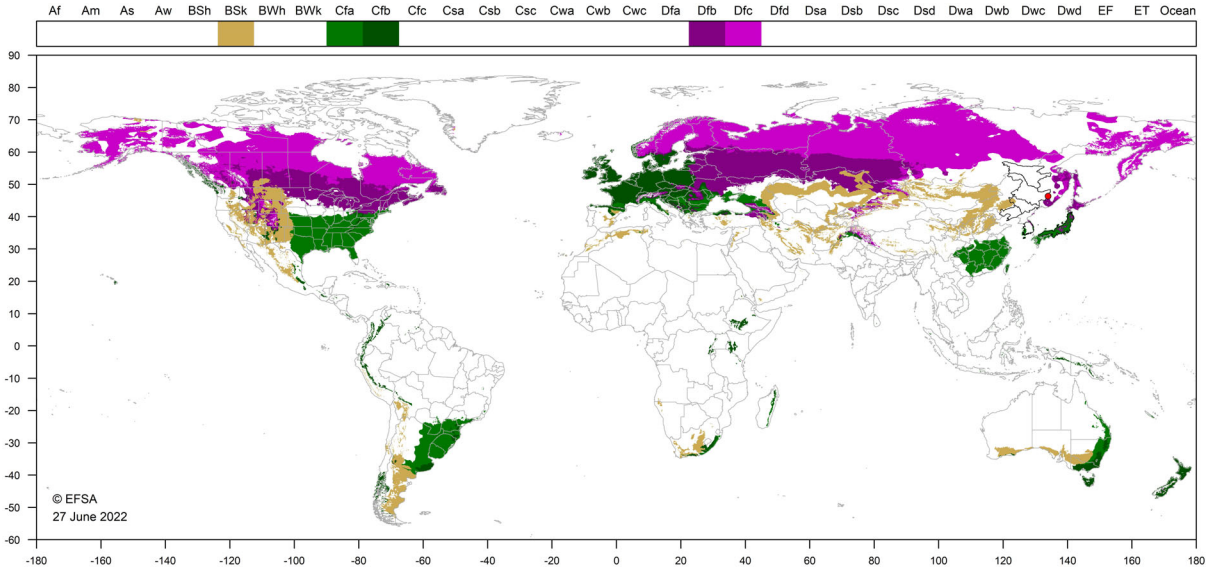


**Figure 3:** Distribution of Köppen–Geiger climate types BSk, Cfa, Cfb, Dfb and Dfc that occur in the EU and in third countries [Japan, China, Republic of Korea and Russia (Siberia)] where *Coleosporium phellodendri* has been reported. The legend shows the list of Köppen–Geiger climates. Red dots indicate point locations where *C. phellodendri* was reported (Appendix B)

### 3.4.3. Spread

*Describe how the pest would be able to spread within the EU territory following establishment?*

*C. phellodendri* could potentially spread within the EU by both natural and human-assisted means.

*Comment on plants for planting as a mechanism of spread*.

Host plants for planting is a main means of spread of the pathogen in the EU.

Following its introduction into the EU territory, *C. phellodendri* would be able to spread by both natural and human-assisted means.

**Spread by natural means.** Wind-borne aeciospores produced on susceptible *Pinus* spp. (aecial host) infect the telial host (*Phellodendron* spp.) during the summer. Urediniospores produced on *Phellodendron* spp. may spread by wind or by water-splash and give rise to multiple infection cycles on the telial host during the summer season. In late summer/early autumn, basidiospores are produced on the telial host and may infect pine needles, thereby completing the life cycle. The dispersal ability of *C. phellodendri* basidiospores is considered more important than that of other *Coleosporium* species. The reported maximum dispersal distance of basidiospores is 300 m (Kusunoki et al., 2017). Hama (1972) observed many aecia on the needles of Japanese red pine (*P. densiflora*) grown at 200 m from infected *Phellodendron* trees. This was further demonstrated by Suzuki et al. (2018), who noted the presence of *P. amurense* at a distance of 200 m southwest of the study site (the Sugadaira Research Station, Mountain Science Center, University of Tsukuba, Japan) where this pathogen was by far the most abundant on a Japanese red pine forest.

For other *Coleosporium* species, it has been proposed that Diptera may also have the potential to act as carriers of infecting propagules, but their role has not been demonstrated in the case of *C. phellodendri*.

**Spread by human-assisted means.** The pathogen could potentially spread over long distance via the movement of infected host plants for planting or plant parts (*Pinus* spp. and *Phellodendron* spp.) but not seeds or fruits.



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## 3.5. Impacts

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

**No**, the pest's introduction is unlikely to have economic and environmental impacts on large areas of the EU territory. Impacts at local scale are possible where *Pinus* spp. and *Phellodendron* spp. co-exist.

*Coleosporium* rusts generally cause discolouration and minor needle cast on susceptible *Pinus* spp. Normally, only young trees are affected, and only heavily infected older needles are cast prematurely, resulting in growth reduction. Death of seedlings may result from combined rust and insect attack, which is fatal to the new shoots (DEFRA, 2015). No information was found on impacts of the pathogen in the area of its current distribution, with the exception of the report of Zakharova (1958), who observed that 70- to 90-year-old *P. amurense* trees in the Siberian Amur region showing a severe infection of their leaves by the pathogen in August 1952 were not prepared for the following winter and froze.

*C. phellodendri* has an heteromacrocyclic life cycle, including five spore stages that develop on two unrelated groups of host plants. The spermogonial and aecial stages are found on *Pinus* spp. (aecial hosts), whereas the uredinial and telial stages are formed on *Phellodendron* spp. (telial hosts). The co-existence (at <300 m distance) of both aecial and telial host plants is needed for *C. phellodendri* to complete its life cycle. Given that *Phellodendron* spp. is not commonly grown in the EU any, impact would be on a local scale only.

## 3.6. Available measures and their limitations

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

**Yes**. Although not specifically targeted against *C. phellodendri*, existing phytosanitary measures (see Sections 3.3.2 and 3.4.1) mitigate the likelihood of the pathogen's entry on certain host plants and plant products into the EU territory. Potential additional measures are also available to further mitigate the risk of entry and spread of the pathogen in the EU (see Section 3.6.1).

### 3.6.1. Identification of potential additional measures

Phytosanitary measures (prohibitions) are currently applied to some host plants for planting (see Section 3.3.2).

Additional potential risk reduction options and supporting measures are shown in Sections 3.6.1.1 and 3.6.1.2.

#### 3.6.1.1. Additional potential risk reduction options

Potential additional control measures are listed in Table 5.

**Table 5:** Selected control measures (a full list is available in EFSA PLH Panel et al., 2018) 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

| Control measure/Risk reduction option (Blue underline = Zenodo doc, Blue = WIP) | RRO summary | Risk element targeted (entry/establishment/ spread/impact) |
|---|---|---|
| Require pest freedom | Plant or plant products should come from a country officially free from the pest, or from a pest-free area or from a pest-free place of production. | Entry/Spread |
| **Growing plants in isolation** | Aecial (*Pinus* spp.) and telial (*Phellodendron* spp.) susceptible host plant species should not be present/grown in the same area to avoid completion of the life cycle of the pathogen. | Entry/Establishment/Spread |



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| Control measure/Risk reduction option (Blue underline = Zenodo doc, Blue = WIP) | RRO summary | Risk element targeted (entry/establishment/ spread/impact) |
|---|---|---|
| Managed growing conditions | Plants collected directly from natural habitats, have been grown for at least two consecutive years prior to dispatch in officially registered nurseries, which are subject to an officially supervised control regime. | Entry/Spread/Impact |
| **Roguing and pruning** | The pathogen may be removed from host plants through pruning activity: removal of new symptomatic shoots should take place in May on *Pinus* spp. and during the summer season on *Phellodendron* spp. | Spread/Impact |
| Chemical treatments on crops including reproductive material | Fungicide treatment (e.g. copper derivatives, carbamates, pyridinecarboxamides (e.g. boscalid) + pyrazoles (e.g. pyraclostrobin), triazoles (e.g. myclobutanil) on the aecial and alternate host are reported to be effective against rust fungi. | Establishment/Spread/Impact |
| Post-entry quarantine and other restrictions of movement in the importing country | Imported host plants should stay for a minimum of 3 months and up to 18 months in a post-entry quarantine station in the EU and are inspected at least twice during that period. Plants with symptoms are tested molecularly for the presence of the pathogen. | Establishment/Spread |

#### 3.6.1.2. Additional supporting measures

Potential additional supporting measures are listed in Table 6.

**Table 6:** Selected supporting measures (a full list is available in EFSA PLH Panel, 2018) in relation to currently unregulated hosts and pathways. Supporting measures are organisational measures or procedures supporting the choice of appropriate risk reduction options that do not directly affect pest abundance

| Supporting measure (Blue underline = Zenodo doc, Blue = WIP) | Summary | Risk element targeted (entry/establishment/ spread/impact) |
|---|---|---|
| **Inspection and trapping** | All plants destined for export are inspected in the production country several times per year (from April to September over a 2-year period) for the presence of rust symptoms or *C. phellodendri* host-specific signs (spermogonia and aecia on *Pinus* spp.; uredia and telia on *Phellodendron* spp.). Plants showing symptoms and signs are removed or tested for the presence of the pathogen. | Entry/Establishment/Spread |
| **Laboratory testing** | DNA-based identification of *C. phellodendri* (e.g. PCR-RFLP analysis as described by Suzuki et al., 2018) is applied to determine if the pathogen is present. | Entry/Spread |
| Sampling | Necessary as part of other RROs. | Entry/Spread |
| Phytosanitary certificate and plant passport | Recommended for host plants, including plant parts (e.g. foliage and branches). | Entry/Spread |
| **Certified and approved premises** | If plant material originates from an approved premise, e.g. from a pest-free area, the likelihood of commodity being infected is assumed to be reduced. | Entry/Spread |



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| Supporting measure (Blue underline = Zenodo doc, Blue = WIP) | Summary | Risk element targeted (entry/establishment/ spread/impact) |
|---|---|---|
| Certification of reproductive material (voluntary/official) | Plants come from within an approved propagation scheme and are certified pest free (level of infestation) following testing. Used to mitigate against pests that are included in a certification scheme. | Entry/Spread |
| **Delimitation of Buffer zones** | Delimitation of a buffer zone is an effective measure to prevent further spread of the pathogen from the outbreak area and to maintain a pest free production place (PFPP), site (PFPS) or area (PFA). For the delimitation of the buffer zone, the minimum distance (at least 300 m) between the aecial and telial hosts should be also taken into consideration. | Spread |
| Surveillance | Surveillance is an effective measure to define pest-free areas or pest-free places of production as well as to prevent further spread of the pathogen. | Spread |

#### 3.6.1.3. Biological or technical factors limiting the effectiveness of measures

- Long incubation period (up to 18 months) before symptoms appear on the aecial host (*Pinus* spp.).
- Asymptomatic plants might remain undetected.
- The similarity of symptoms and signs caused by *C. phellodendri* with those of other *Coleosporium* species affecting *Pinus* spp. hampers the detection of the pathogen based on symptomatology and fruiting bodies. *C. phellodendri*-specific molecular identification methods are unavailable.

### 3.7. Uncertainty

- The distribution of *Phellodendron* spp. in the EU.

## 4. Conclusions

*Coleosporium phellodendri* does not satisfy all the criteria assessed by EFSA for consideration as a Union quarantine pest as no economic and environmental impact of this pathogen is expected without widespread establishment of *Phellodendron* in the EU (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 | Key uncertainties |
|---|---|---|
| **Identity of the pest (Section 3.1)** | The identity of the pathogen is clearly defined and has been shown to be transmissible. | None. |
| **Absence/presence of the pest in the EU (Section 3.2)** | The pathogen is not known to be present in the EU territory. | None. |
| **Pest potential for entry, establishment and spread in the EU (Section 3.4)** | The pathogen is able to enter into, become established in, and spread within the EU territory via host plants for planting and host plant parts (e.g. foliage, branches) other than seeds and fruit, respectively. | The distribution of *Phellodendron* spp. (telial host) in the EU |



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| Criterion of pest categorisation | Panel's conclusions against criterion in Regulation (EU) 2016/2031 regarding Union quarantine pest | Key uncertainties |
|---|---|---|
| **Potential for consequences in the EU (Section 3.5)** | The pest's introduction is unlikely to have economic and environmental impacts on a large scale in the EU territory due to the scattered distribution of the telial host in the EU. | None. |
| **Available measures (Section 3.6)** | Although not specifically targeted against *C. phellodendri*, existing phytosanitary measures mitigate the likelihood of the pathogen's entry into the EU territory. Potential additional measures also exist to mitigate the risk of entry into, establishment or spread of the pathogen within the EU. | None. |
| **Conclusion (Section 4)** | *Coleosporium phellodendri* does not satisfy all the criteria assessed by EFSA for consideration as a Union quarantine pest as no economic and environmental impact of this pathogen is expected without widespread establishment of *Phellodendron* in the EU. | |
| **Aspects of assessment to focus on/scenarios to address in future if appropriate:** | The main knowledge gap concerns the lack of information on the distribution of the telial host *Phellodendron* spp. in the EU. The development of specific PCR primers would allow direct identification of the pathogen on infected host plants upon import/trade. | |

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## Abbreviations

| | |
|---|---|
| EPPO | European and Mediterranean Plant Protection Organization |
| FAO | Food and Agriculture Organization |
| IPPC | International Plant Protection Convention |
| ISPM | International Standards for Phytosanitary Measures |
| MS | Member State |
| PCR-RFLP | polymerase chain reaction-restriction fragment length polymorphism |
| PLH | EFSA Panel on Plant Health |
| PZ | Protected Zone |
| TFEU | Treaty on the Functioning of the European Union |
| ToR | Term of Reference |



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## Glossary

| | |
|---|---|
| Containment (of a pest) | Application of phytosanitary measures in and around an infested area to prevent spread of a pest (FAO, 2021) |
| Control (of a pest) | Suppression, containment or eradication of a pest population (FAO, 2021) |
| 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, 2021) |
| Eradication (of a pest) | Application of phytosanitary measures to eliminate a pest from an area (FAO, 2021) |
| Establishment (of a pest) | Perpetuation, for the foreseeable future, of a pest within an area after entry (FAO, 2021) |
| Greenhouse | A walk-in, static, closed place of crop production with a usually translucent outer shell, which allows controlled exchange of material and energy with the surroundings and prevents release of plant protection products (PPPs) into the environment. |
| Hitchhiker | An organism sheltering or transported accidentally via inanimate pathways including with machinery, shipping containers and vehicles; such organisms are also known as contaminating pests or stowaways (Toy and Newfield, 2010). |
| 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, 2021) |
| Pathway | Any means that allows the entry or spread of a pest (FAO, 2021) |
| 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, 2021) |
| 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, 2021) |
| 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, 2021) |



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# Appendix A – *Coleosporium phellodendri* host plants/species affected

Source: EPPO Global Database (EPPO, online)

| Host status | Host name | Plant family | Common name | Reference |
|---|---|---|---|---|
| Cultivated hosts | *Pinus amurense* | Pinaceae | – | EPPO (2002) |
| | *Pinus banksiana* | Pinaceae | Grey pine | Saho (1962) |
| | *Pinus densiflora* | Pinaceae | Japanese red pine | EPPO (2002) |
| | *Pinus sylvestris* | Pinaceae | Common pine | Saho (1962) |
| | *Pinus tabulaeformis* | Pinaceae | Chinese red pine | Cao et al. (2000) |
| | *Pinus thunbergii* | Pinaceae | Japanese black pine | Kusunoki et al. (2017) |
| | *Phellodendron amurense* | Rutaceae | Amur cork tree | Back et al. (2012) |
| | *Phellodendron amurense var. japonicum* | Rutaceae | Japanese cork tree | Kaneko (1981) |
| | *Phellodendron amurense. Var. sachalinense* | Rutaceae | – | Hiratsuka et al. (1992) |
| | *Phellodendron chinense* | Rutaceae | – | Cao and Zhuang (2000) |
| | *Phellodendron chinense var. glabriusculum* | Rutaceae | – | Zhuang (1983) |
| | *Phellodendron lavallei* | Rutaceae | Lavalle corktree | Spaulding (1961) |
| | *Phellodendron sachalinense* | Rutaceae | Sakhalin cork tree | Back et al. (2012) |
| Artificial/experimental host | *Pinus contorta* | Pinaceae | Beach pine | Saho (1963) |
| | *Pinus mugo* (syn. *P. montana*) | Pinaceae | Dwarf mountain pine | Saho (1963) |
| | *Pinus nigra* | Pinaceae | Austrian pine | Saho (1963) |
| | *Pinus resinosa* | Pinaceae | Red pine | Saho (1963) |



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# Appendix B – Distribution of *Coleosporium phellodendri*

Distribution records based on EPPO Global Database (EPPO, online).

| Region | Country | Sub-national (e.g. State) | Status | References |
|---|---|---|---|---|
| Asia | China | | Present, no details | EPPO (online) |
| | China | Heilongjiang | Present, no details | EPPO (online) |
| | China | Jilin | Present, no details | EPPO (online) |
| | China | Liaoning | Present, no details | EPPO (online) |
| | Japan | | Present, no details | EPPO (online) |
| | Japan | Honshu | Present, no details | EPPO (online) |
| | Korea, Republic | | Present, no details | EPPO (online) |
| | Russia | Siberia (Amur and Ussuri region) | Present, no details | Spaulding (1961), Zhang et al. (1997), Zakharova (1958) |



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# Appendix C – Methodological notes on Figure 3

The relative probability of presence (RPP) reported here and in the European Atlas of Forest Tree Species (de Rigo et al., 2016; San-Miguel-Ayanz et al., 2016) is the probability of a species, and sometimes a genus, occurring in a given spatial unit (de Rigo et al., 2017). The maps of RPP are produced by spatial multi-scale frequency analysis (C-SMFA) (de Rigo et al., 2014; de Rigo et al., 2016) of species presence data reported in geolocated plots by different forest inventories.

## Geolocated plot databases

The RPP models rely on five geo-databases that provide presence/absence data for tree species and genera (de Rigo et al., 2014; de Rigo et al., 2016; de Rigo et al., 2017). The databases report observations made inside geo-localised 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 datasets was performed as activity within the research project at the origin of the European Atlas of Forest Tree Species (de Rigo et al., 2016; San-Miguel-Ayanz, 2016; San-Miguel-Ayanz et al., 2016). All datasets were harmonised 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/).

**European National Forestry Inventories database** This dataset 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; de Rigo et al., 2016).

**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[2]. 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 dataset covers 30 European Countries with more than 8,600 sample points.

**BioSoil data set** This data set was produced by one of a number of demonstration studies initiated in response to the "Forest Focus" Regulation (EC) No. 2152/2003 mentioned above. The aim of the BioSoil project was to provide harmonised soil and forest biodiversity data. It comprised two modules: a Soil Module (Hiederer et al., 2011) and a Biodiversity Module (Houston Durrant et al., 2011). The dataset 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 was recorded for more than 3,300 sample points in 19 European Countries.

**European Information System on Forest Genetic Resources** (EUFGIS) is a smaller geo-database that provides information on tree species composition in over 3,200 forest plots in 34 European countries. The plots are part of a network of forest stands managed for the genetic conservation of one or more target tree species. Hence, the plots represent the natural environment to which the target tree species are adapted (EEUFGIS, online).

**Georeferenced Data on Genetic Diversity** ($GD^2$) is a smaller geo-database as well. It provides information about a 63 species that are of interest for genetic conservation. It counts 6,254 forest plots that are located in stands of natural populations that are traditionally analysed in genetic surveys. While this database covers fewer species than the others, it does covers 66 countries in Europe, North Africa, and the Middle East, making it the data set with the largest geographic extent (INRA, online).

## 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 that comprises 36 countries in the European continent. The density of field

[2] 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.



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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 heterogenous 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.

C-SMFA preforms spatial frequency analysis of the geolocated plot data to create preliminary RPP maps (de Rigo et al., 2014). For each 1km$^2$ grid cell, it estimates kernel densities over a range of kernel sizes to estimate the probability that a given species is present in that cell. The entire array of multi-scale spatial kernels is aggregated with adaptive weights based on the local pattern of data density. Thus, in areas where plot data are scarce or inconsistent, the method tends to put weight on larger kernels. Wherever denser local data are available, they are privileged ensuring a more detailed local RPP estimation. Therefore, a smooth multi-scale aggregation of the entire arrays of kernels and datasets is applied instead of selecting a local "best preforming" 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 define Semantic Array Programming modelling paradigm (de Rigo, 2012).

The probability to find a single species in a 1 km$^2$ grid cell cannot be higher than the probability of presence of all the broadleaved (or coniferous) species combined, because all sample plots are localised inside forested areas. Thus, to improve the accuracy of the maps, the preliminary RPP values were constrained to not exceed the local forest-type cover fraction (de Rigo et al., 2014). The latter was estimated from the "Broadleaved forest", "Coniferous forest", and "Mixed forest" classes of the Corine Land Cover (CLC) maps (Bossard et al., 2000; Büttner et al., 2012), with "Mixed forest" cover assumed to be equally split between broadleaved and coniferous.

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 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 it (de Rigo et al., 2014; de Rigo et al., 2016).

The RPP and relative trustability range from 0 to 1 and are mapped at 1 km spatial. To improve visualisation, these maps can be aggregated to coarser scales (i.e. 10x10 pixels or 25x25 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.



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# Appendix D – EU 27 annual imports of commodities of main hosts from countries where *Coleosporium phellodendri* is present, 2016–2020 (in 100 kg)

Source: Eurostat accessed on 22 June 2022

| | | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|
| **Fresh conifer branches, suitable for bouquets or ornamental purposes** | China | : | : | 21.65 | : | : |
| | Japan | : | : | : | : | : |
| | Russia | : | : | : | : | : |
| | Republic of Korea | : | : | : | : | : |
| | Sum | : | : | 21.65 | : | : |
| | | **2016** | **2017** | **2018** | **2019** | **2020** |
| **Outdoor trees, shrubs and bushes, incl. Their roots, with bare roots (excl. Cuttings, slips and young plants, and fruit, nut and forest trees)** | China | 14.00 | 78.90 | 3.99 | 0.05 | : |
| | Japan | : | : | : | : | : |
| | Russia | : | : | : | : | 0.14 |
| | Republic of Korea | : | : | : | : | : |
| | Sum | 14.00 | 78.90 | 3.99 | 0.05 | 0.14 |



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