

ADOPTED: 1 February 2018

doi: 10.2903/j.efsa.2018.5185

Pest categorisation of *Bretziella fagacearum*

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

Abstract

Following a request from the European Commission, the EFSA Plant Health (PLH) Panel performed a pest categorisation of *Bretziella fagacearum*, a well-defined and distinguishable fungal species of the family Ceratocystidaceae. The species was moved from the genus *Ceratocystis* to a new genus *Bretziella* following phylogenetic analysis of the species and its close relatives. The former species name *Ceratocystis fagacearum* is used in the Council Directive 2000/29/EC. The pathogen is regulated in Annex IAI as a harmful organism whose introduction into the EU is banned. *B. fagacearum* is only reported from the USA, where it causes a wilt disease on *Quercus* spp. Other hosts are reported based on inoculation trials, although Chinese chestnut (*Castanea mollissima*) is reported to be naturally infected. No North American oak species has been found to be immune to the disease. The European oak species *Quercus robur*, *Quercus petraea* and *Quercus pubescens* were found to be susceptible in inoculation experiments. The pest could enter the EU via wood (with and without bark, including wood packaging material), plants for planting and cut branches. Hosts and favourable climatic conditions are common in the EU, thus facilitating establishment. The pest would be able to spread following establishment by means of root grafts, insect vectors and movement of wood, plants for planting and other means. The pest introduction would have impacts in woodland and plantations, as oak wilt disease is often lethal in a short period of time. Wood treatment (debarking, kiln drying, fumigation), prompt removal of affected trees and creating root-free zones between affected and healthy stands are available control measures. The main knowledge gaps concern (i) the survival of the fungus in wood during transport and the association with propagation material, (ii) the presence of suitable vectors in Europe and (iii) the relative susceptibility of the oak species native to Europe under natural conditions. The criteria assessed by the Panel for consideration as a potential quarantine pest are met. For regulated non-quarantine pests, the criterion on the pest presence in the EU is not met.

© 2018 European Food Safety Authority. *EFSA Journal* published by John Wiley and Sons Ltd on behalf of European Food Safety Authority.

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

Requestor: European Commission

Question number: EFSA-Q-2017-00378

Correspondence: alpha@efsa.europa.eu

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

Suggested citation: EFSA PLH Panel (EFSA Panel on Plant Health), Jeger M, Bragard C, Caffier D, Candresse T, Chatzivassiliou E, Dehnen-Schmutz K, Gilioli G, Grégoire J-C, Jaques Miret JA, MacLeod A, Navajas Navarro M, Niere B, Parnell S, Potting R, Rafoss T, Rossi V, Urek G, Van Bruggen A, Van der Werf W, West J, Winter S, Boberg J, Gonthier P and Pautasso M, 2018. Scientific Opinion on the pest categorisation of *Bretziella fagacearum*. EFSA Journal 2018;16(2):5185, 30 pp. <https://doi.org/10.2903/j.efsa.2018.5185>

ISSN: 1831-4732

© 2018 European Food Safety Authority. *EFSA Journal* published by John Wiley and Sons Ltd on behalf of European Food Safety Authority.

This is an open access article under the terms of the [Creative Commons Attribution-NoDerivs License](#), which permits use and distribution in any medium, provided the original work is properly cited and no modifications or adaptations are made.

Reproduction of the images listed below is prohibited and permission must be sought directly from the copyright holder:

Figure 1: © European and Mediterranean Plant Protection Organization (EPPO); Figure 2: © European Union; Figures 3–4: © EUFORGEN; Figure 5: © Bugwood.org.



The EFSA Journal is a publication of the European Food Safety Authority, an agency of the European Union.



Table of contents

Abstract.....	1
1. Introduction.....	4
1.1. Background and Terms of Reference as provided by the requestor.....	4
1.1.1. Background.....	4
1.1.2. Terms of Reference.....	4
1.1.2.1. Terms of Reference: Appendix 1.....	5
1.1.2.2. Terms of Reference: Appendix 2.....	6
1.1.2.3. Terms of Reference: Appendix 3.....	7
1.2. Interpretation of the Terms of Reference.....	8
2. Data and Methodologies.....	8
2.1. Data.....	8
2.1.1. Literature search.....	8
2.1.2. Database search.....	8
2.2. Methodologies.....	9
3. Pest categorisation.....	11
3.1. Identity and biology of the pest.....	11
3.1.1. Identity and taxonomy.....	11
3.1.2. Biology of the pest.....	11
3.1.3. Intraspecific diversity.....	12
3.1.4. Detection and identification of the pest.....	12
3.2. Pest distribution.....	12
3.2.1. Pest distribution outside the EU.....	13
3.2.2. Pest distribution in the EU.....	13
3.3. Regulatory status.....	13
3.3.1. Council Directive 2000/29/EC.....	13
3.3.2. Legislation addressing the hosts of <i>B. fagacearum</i>	14
3.4. Entry, establishment and spread in the EU.....	15
3.4.1. Host range.....	15
3.4.2. Entry.....	16
3.4.3. Establishment.....	16
3.4.3.1. EU distribution of main host plants.....	16
3.4.3.2. Climatic conditions affecting establishment.....	19
3.4.4. Spread.....	19
3.4.4.1. Vectors and their distribution in the EU.....	19
3.5. Impacts.....	20
3.6. Availability and limits of mitigation measures.....	21
3.6.1. Phytosanitary measures.....	21
3.6.1.1. Biological or technical factors limiting the feasibility and effectiveness of measures to prevent the entry, establishment and spread of the pest.....	21
3.6.1.2. Biological or technical factors limiting the ability to prevent the presence of the pest on plants for planting.....	22
3.6.2. Control methods.....	22
3.7. Uncertainty.....	22
4. Conclusions.....	22
References.....	24
Abbreviations.....	27
Appendix A – Methodological notes on Figure 2.....	28

1. Introduction

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

1.1.1. Background

Council Directive 2000/29/EC¹ 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) 2016/2031² 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 178/2002³, to provide scientific opinion in the field of plant health.

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

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

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

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

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

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

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

1.1.2.1. Terms of Reference: Appendix 1

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

Annex IIAI

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

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

(b) Bacteria

Citrus variegated chlorosis	<i>Xanthomonas campestris</i> pv. <i>oryzae</i> (Ishiyama)
<i>Erwinia stewartii</i> (Smith) Dye	Dye and pv. <i>oryzicola</i> (Fang, et al.) Dye

(c) Fungi

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

(d) Virus and virus-like organisms

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

Annex IIB

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

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

(b) Bacteria

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

(c) Fungi

Glomerella gossypii Edgerton

Hypoxyton mammatum (Wahl.) J. Miller

Gremmeniella abietina (Lag.) Morelet

1.1.2.2. Terms of Reference: Appendix 2

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

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

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

- | | |
|--|---|
| 1) <i>Carneocephala fulgida</i> Nottingham | 3) <i>Graphocephala atropunctata</i> (Signoret) |
| 2) <i>Draeculacephala minerva</i> Ball | |

Group of Tephritidae (non-EU) such as:

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

(c) Viruses and virus-like organisms

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

- | | |
|----------------------------------|--|
| 1) Andean potato latent virus | 4) Potato black ringspot virus |
| 2) Andean potato mottle virus | 5) Potato virus T |
| 3) Arracacha virus B, oca strain | 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 | 8) Peach yellows mycoplasma |
| 2) Cherry rasp leaf virus (American) | 9) Plum line pattern virus (American) |
| 3) Peach mosaic virus (American) | 10) Raspberry leaf curl virus (American) |
| 4) Peach phony rickettsia | 11) Strawberry witches' broom mycoplasma |
| 5) Peach rosette mosaic virus | 12) Non-EU viruses and virus-like organisms of <i>Cydonia</i> Mill., <i>Fragaria</i> L., <i>Malus</i> Mill., <i>Prunus</i> L., <i>Pyrus</i> L., <i>Ribes</i> L., <i>Rubus</i> L. and <i>Vitis</i> L. |
| 6) Peach rosette mycoplasma | |
| 7) Peach X-disease mycoplasma | |

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

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

(b) Fungi

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

(c) Viruses and virus-like organisms

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

(d) Parasitic plants

Arceuthobium spp. (non-EU)

Annex I A II**(a) Insects, mites and nematodes, at all stages of their development**

Meloidogyne fallax Karssen

Rhizoecus hibisci Kawai and Takagi

Popillia japonica Newman

(b) Bacteria

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

Ralstonia solanacearum (Smith) Yabuuchi et al.

(c) Fungi

Melampsora medusae Thümen

Synchytrium endobioticum (Schilbersky) Percival

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

Leptinotarsa decemlineata Say

Liriomyza bryoniae (Kaltenbach)

(b) Viruses and virus-like organisms

Beet necrotic yellow vein virus

1.2. Interpretation of the Terms of Reference

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

The species was moved from the genus *Ceratocystis* to a new genus *Bretziella* following phylogenetic analysis of the species and its close relatives in the family Ceratocystidaceae (de Beer et al., 2017). Therefore, the recommended valid name for the fungus is *Bretziella fagacearum* (de Beer et al., 2017).

2. Data and Methodologies**2.1. Data****2.1.1. Literature search**

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

2.1.2. Database search

Pest information, on host(s) and distribution, was retrieved from the EPPO Global Database (EPPO, 2017).

Data about the area of hosts grown in the EU were obtained from EUROSTAT (<http://ec.europa.eu/eurostat/web/agriculture/data/database>).

Information on EU Member State (MS) imports of *Quercus* plants for planting from North America was sought in the ISEFOR database (Eschen et al., 2017).

The Europhyt database was consulted for pest-specific notifications on interceptions and outbreaks. Europhyt is a web-based network launched by the Directorate General for Health and Consumers (DG SANCO), 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 MSs and the phytosanitary measures taken to eradicate or avoid their spread.

2.2. Methodologies

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

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

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

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

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

Criterion of pest categorisation	Criterion in Regulation (EU) 2016/2031 regarding Union quarantine pest	Criterion in Regulation (EU) 2016/2031 regarding protected zone quarantine pest (articles 32-35)	Criterion in Regulation (EU) 2016/2031 regarding Union regulated non-quarantine pest
Identity of the pest (Section 3.1)	Is the identity of the pest established, or has it been shown to produce consistent symptoms and to be transmissible?	Is the identity of the pest established, or has it been shown to produce consistent symptoms and to be transmissible?	Is the identity of the pest established, or has it been shown to produce consistent symptoms and to be transmissible?
Absence/ presence of the pest in the EU territory (Section 3.2)	Is the pest present in the EU territory? If present, is the pest widely distributed within the EU? Describe the pest distribution briefly!	Is the pest present in the EU territory? If not, it cannot be a protected zone quarantine organism.	Is the pest present in the EU territory? If not, it cannot be a regulated non-quarantine pest. (A regulated non-quarantine pest must be present in the risk assessment area).

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

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

3. Pest categorisation

3.1. Identity and biology of the pest

3.1.1. Identity and taxonomy

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

Yes

B. fagacearum (Bretz) Z.W.deBeer, Marinc., T.A.Duong & M.J.Wingf., comb. nov. is a fungus of the family Ceratocystidaceae.

Recent reclassification of the Ceratocystidaceae (Microascales) based on multigene phylogenetic inference has shown that the oak wilt fungus *C. fagacearum* (a well-supported monophyletic lineage in the Ceratocystidaceae, but distinct from all other genera in the family) does not reside in any of the four genera in which it has previously been treated. Therefore, a new genus *Bretziella* was described to accommodate the oak wilt fungus (de Beer et al., 2017). In this pest categorisation, the Panel accepts the change of name. The former species name *C. fagacearum* is used in the Council Directive 2000/29/EC.

Other species synonyms are *Chalara quercina*, *Endoconidiophora fagacearum* and *Thielaviopsis quercina* (Index Fungorum, <http://www.indexfungorum.org/names/names.asp>).

3.1.2. Biology of the pest

B. fagacearum is a classic vascular wilt pathogen infecting mainly *Quercus* spp. Other tree species have also been found to be susceptible to infection, including *Castanea mollissima* (Chinese chestnut) and *Castanea sativa* (European chestnut) (see Section 3.4.1 on Host range).

The pathogen is spread from diseased to healthy oaks through grafted root systems or through transmission by insect vectors. The disease is systemic and once in the vascular system, conidia are spread throughout the tree. As a response, the tree produces tyloses and dark gummy substances that plug the xylem vessels. Together with plugging caused by fungal products, the sap flow is disrupted which causes the wilting symptoms and subsequent death in susceptible trees (Sinclair and Lyon, 2005). After the tree has been killed, the fungus grows out into the inner bark where mats of mycelium and fruiting structures are produced. These mycelial mats produce pressure cushions or pads that push the bark away from the sapwood causing cracking of the bark and exposure of the sporulating mats.

The sporulating mats fruity odour attracts fungus-feeding arthropods such as nitidulid beetles (e.g. *Carpophilus sayi* and *Colopterus truncatus*). These then act as vectors of the fungus (Juzwik and French, 1983; Harrington, 2009; Juzwik et al., 2011) as the insects move to fresh wounds on trees. Pruning wounds and other trunk wounds are common infection sites (Gibbs and French, 1980; Sinclair and Lyon, 2005). Wounds more than a few days old are not suitable sites for infection (Sinclair and Lyon, 2005).

The sporulating mats initially produce endoconidiophores and endoconidia (hyaline, continuous, cylindrical, truncate at each end, $2\text{--}4.5 \times 4\text{--}22 \mu\text{m}$ (mean $3 \times 6.5 \mu\text{m}$), endogenous and catenulate). If visiting insects carry conidia of the opposite mating type, fertilisation occurs and perithecia are formed (True et al., 1960). Ascospores are hyaline, one-celled, elliptical ($2\text{--}3 \times 5\text{--}10 \mu\text{m}$) and exuded in a sticky creamy white mass (Hepting et al., 1952).

B. fagacearum overwinters in diseased or dead trees and insect vectored infection generally takes place in the spring when the trees are most susceptible (Sinclair and Lyon, 2005).

The nitidulid beetles are reported as the most important vectors of *B. fagacearum* but also the oak bark beetles (Scolytinae, Coleoptera) *Pseudopityophthorus minutissimus* and *Pseudopityophthorus pruinosus* and the oak timber worm *Arrhenodes minutus* (Brentidae, Coleoptera) have been identified as vectors (Buchanan, 1957; Sinclair and Lyon, 2005). However, it has been suggested that there is no foundation to consider *A. minutus* as a vector (EPPO, 1997). Subsequently, the role as vectors of the two *Pseudopityophthorus* species has also been debated. It is argued that these species are not well adapted to vector the disease and are thus considered to be of lesser importance (Sinclair and Lyon,

2005; Harrington, 2009, 2013). Nevertheless, *A. minutus*, *P. minutissimus* and *P. pruinosus* are included in Annex IAI of Council Directive 2000/29/EC as harmful organisms whose introduction into and spread within all MSs shall be banned.

North American red oaks are highly susceptible and do not recover from the disease. The trees typically die within a year but often within 6 weeks following the appearance of symptoms (Sinclair and Lyon, 2005).

While there are no North American oaks known to be immune to the disease (EPPO, 1997), North American white oak species (subgenus *Lepidobalanus*) appear to be more tolerant and the distribution of the fungus in the xylem is more restricted (Gibbs and French, 1980). Some trees die quickly, but others survive several years progressively showing dieback while some even recover (Sinclair and Lyon, 2005). In the latter category, the infected ring will be buried under the new xylem vessels being produced and such trees are unlikely to constitute a significant source of inoculum (Gibbs and French, 1980).

Mat formation is suppressed in dry areas and years (Sinclair and Lyon, 2005).

The pathogen usually disappears from the above-ground parts of a dead tree within a year due to competition from other antagonistic fungi, heating and drying (Gibbs and French, 1980; Sinclair and Lyon, 2005). Survival below ground may be more prolonged, up to 4 years (Sinclair and Lyon, 2005), especially if the root system is grafted to neighbouring trees.

Oak trees are more likely to be infected by *B. fagacearum* through root grafts than through wounds (Bruhn et al., 1991; Appel, 1995; Harrington, 2013), although the likelihood of functional root grafts depends upon the oak species (Harrington, 2013). In oak stands where root grafting is naturally common, the pathogen can easily spread from tree to tree. Disease centres commonly expand 1–15 m per year (up to 40 m recorded) and adjacent trees usually wilt 1–6 years after infection (Sinclair and Lyon, 2005).

3.1.3. Intraspecific diversity

The North American population of *B. fagacearum* has a very limited genetic variation despite the sexual reproduction (Juzwik et al., 2008; and references therein).

The origin of the fungus is not known, but Juzwik et al. (2008) argue that the pathogen was introduced to the USA most likely from Central America, South America or Mexico.

3.1.4. Detection and identification of the pest

Are detection and identification methods available for the pest?

Yes

Cultures of *B. fagacearum* isolated from infected wood tissue may be identified based on specific morphological characteristics following the EPPO diagnostic protocols for regulated pests PM 7/1(1): *C. fagacearum* (EPPO, 2001).

The species can also be identified based on molecular methods and a protocol for amplification and sequencing of the ITS region is found at Qbank (Qbank-www.q-bank.eu). There is also a nested real-time polymerase chain reaction (PCR) assay (Wu et al., 2011) and a TaqMan assay for *B. fagacearum* available (Lamarche et al., 2015) that can be used on environmental samples.

3.2. Pest distribution

B. fagacearum is only known to occur in Texas and the eastern and midwestern parts of the USA based on information dated 2011 (EPPO, 2017) (Figure 1).

Distribution

Last updated: 2017-09-13

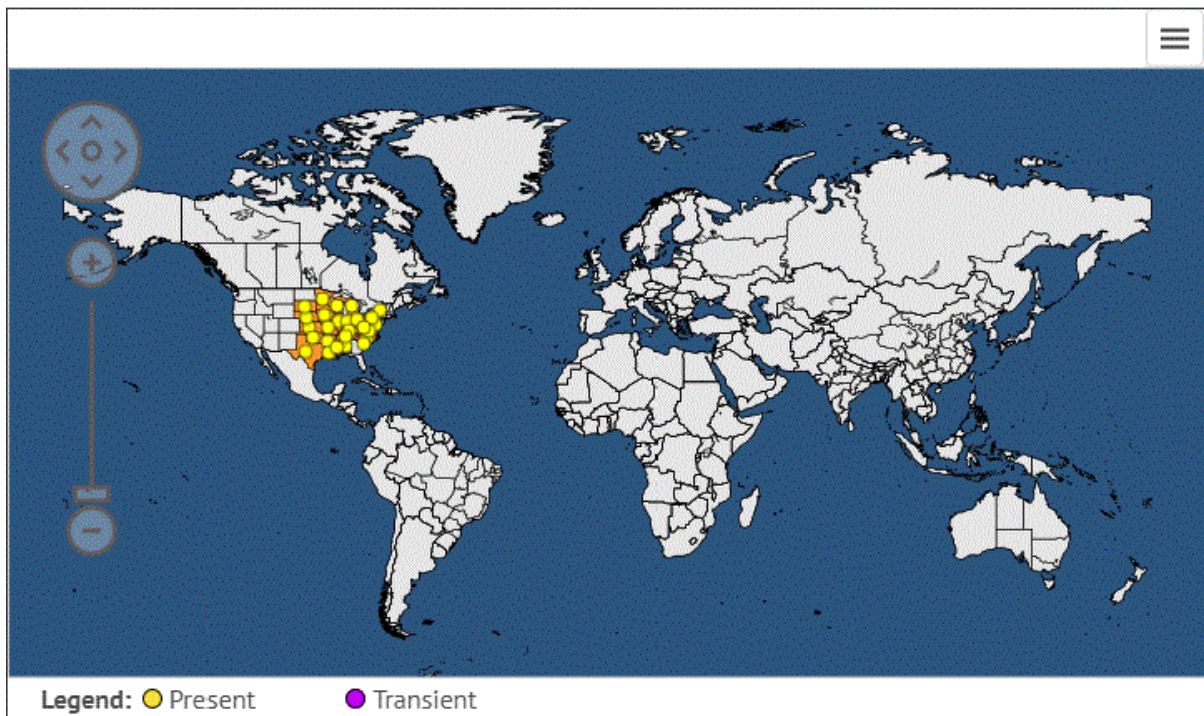


Figure 1: Global distribution map for *B. fagacearum* (extracted from EPPO, 2017, accessed November 2017). There are no reports of transient populations

3.2.1. Pest distribution outside the EU

The pathogen is reported as present in Texas and the eastern and mid-western states of the USA (EPPO, 2017). The pathogen is reported as widespread only in Texas (EPPO, 2017).

There is a report of *B. fagacearum* killing oaks in Turkey (Boyras and Bastas, 2001), but no follow-up information about this finding could be found (Anon, 2017). It is possible that this record was due to misidentification (as happened in Bulgaria, Poland and Romania, see Section 3.2.2) of *Ceratocystis*-like fungi found in declining oaks (EPPO, 2017).

3.2.2. Pest distribution in the EU

Is the pest present in the EU territory? If present, is the pest widely distributed within the EU?

No, the pest is not reported to be present in the EU.

There are no reports of *B. fagacearum* from the EU (EPPO, 2017).

Earlier records of the pathogen from different European countries, i.e. Bulgaria, Poland and Romania, have been shown to be misidentifications of *Ceratocystis*-like fungi found in declining oaks (EPPO, 2017).

Lithuania, the Netherlands and Slovenia have reported the pathogen as absent, confirmed by survey in 2017 (EPPO, 2017).

3.3. Regulatory status

3.3.1. Council Directive 2000/29/EC

B. fagacearum is listed in Council Directive 2000/29/EC as *C. fagacearum*. Details are presented in Tables 2 and 3.

Table 2: *Bretziella fagacearum* in Council Directive 2000/29/EC

Annex I, Part A	Harmful organisms whose introduction into, and spread within, all Member States shall be banned
Section I	Harmful organisms not known to occur in any part of the community and relevant for the entire community
(c)	Fungi
	Species
1.	<i>Ceratocystis fagacearum</i> (Bretz) Hunt

3.3.2. Legislation addressing the hosts of *B. fagacearum*

Table 3: Regulated hosts and commodities that may involve *B. fagacearum* 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
2.	Plants of <i>Castanea</i> Mill., and <i>Quercus</i> L., with leaves, other than fruit and seeds	Non-European countries
6.	Isolated bark of <i>Quercus</i> L., other than <i>Quercus suber</i> L.	North American countries
Annex IV, 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	
	Plants, plant products and other objects	Special requirements
3.	<p>Wood of <i>Quercus</i> L., other than in the form of:</p> <ul style="list-style-type: none"> — chips, particles, sawdust, shavings, wood waste and scrap, — casks, barrels, vats, tubs and other coopers' products and parts thereof, of wood, including staves where there is documented evidence that the wood has been produced or manufactured using heat treatment to achieve a minimum temperature of 176°C for 20 minutes — Wood packaging material, in the form of packing cases, boxes, crates, drums and similar packings, pallets, box pallets and other load boards, pallet collars, dunnage, whether or not actually in use in the transport of objects of all kinds, except dunnage supporting consignments of wood, which is constructed from wood of the same type and quality as the wood in the consignment and which meets the same Union phytosanitary requirements as the wood in the consignment, but including wood which has not kept its natural round surface, originating in the USA. 	<p>Official statement that the wood:</p> <ul style="list-style-type: none"> (a) is squared so as to remove entirely the rounded surface, or (b) is bark-free and the water content is less than 20% expressed as a percentage of the dry matter, or (c) is bark-free and has been disinfected by an appropriate hot-air or hot water treatment, or (d) if sawn, with or without residual bark attached, has undergone kiln-drying to below 20% moisture content, expressed as a percentage of dry matter, achieved through an appropriate time/temperature schedule. There shall be evidence thereof by a mark 'Kiln-dried' or 'KD' or another internationally recognised mark, put on the wood or on any wrapping in accordance with current usage.

7.2	Whether or not listed among the CN codes in Annex V, Part B, wood in the form of chips, particles, sawdust, shavings, wood waste and scrap and obtained in whole or part from <i>Quercus</i> L. originating in the USA.	Official statement that the wood: (a) has undergone kiln-drying to below 20% moisture content, expressed as a percentage of dry matter achieved through an appropriate time/temperature schedule, or (b) has undergone an appropriate fumigation to a specification approved in accordance with the procedure laid down in Article 18.2. There shall be evidence of the fumigation by indicating on the certificates referred to in Article 13.1.(ii), the active ingredient, the minimum wood temperature, the rate (g/m ³) and the exposure time (h), or (c) has undergone an appropriate heat treatment to achieve a minimum temperature of 56°C for a minimum duration of 30 continuous minutes throughout the entire profile of the wood (including at its core), the latter to be indicated on the certificates referred to in Article 13.1.(ii).
11.01	Plants of <i>Quercus</i> L., other than fruit and seeds, originating in the USA	Without prejudice to the provisions applicable to the plants listed in Annex III(A)(2), official statement that the plants originate in areas known to be free from <i>Ceratocystis fagacearum</i> (Bretz) Hunt.
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 I	Plants, plant products and other objects which are potential carriers of harmful organisms of relevance for the entire Community and which must be accompanied by a plant passport	
2.1	Plants intended for planting, other than seeds, of the genera [...] <i>Quercus</i> L.	

3.4. Entry, establishment and spread in the EU

3.4.1. Host range

B. fagacearum mainly cause symptoms on *Quercus* spp. and no North American oak species has been found to be immune (EPPO, 1997). Red oaks (subgenus *Erythrobalanus*) are the most susceptible and usually die within a few weeks of infection. American white oaks (subgenus *Lepidobalanus*) are found to be more tolerant. Oak species belonging to this subgenus may take several years to die or recover from the disease (Sinclair and Lyon, 2005).

The susceptibility of European white oaks (*Quercus robur*, *Quercus petraea*, *Quercus pubescens*) was assessed by inoculating hundreds of oaks in West Virginia and South Carolina (EPPO, 1997; Webber, 2015 referring to Pinon et al., 1997; MacDonald et al., 2001). All inoculated oaks, regardless of species, appeared to be susceptible and died within a year after inoculation. No effect was observed due to mode of inoculation (stem or branch) or species provenance (collections were made from various European countries).

Other tree species have also been found to be susceptible to infection. Chinese chestnut (*C. mollissima*) is reported to be naturally infected and highly susceptible (Rexrode and Brown, 1983). Inoculation experiments have shown that American chestnut (*Castanea dentata*), European chestnut (*C. sativa*), American chinquapin (*Castanea pumila*), tanoak (*Lithocarpus*) and several varieties of apple (*Malus*) are also susceptible (Bretz and Long, 1950; Rexrode and Brown, 1983).

In Council Directive 2000/29/EC, the pest is not regulated on a particular host or commodity; its introduction into the EU is banned (Annex IAI). However, the hosts covered in Annex III are only *Quercus* spp. and *Castanea* spp. (see Section 3.3.2).

3.4.2. Entry

Is the pest able to enter into the EU territory?

Yes, the pest could enter the EU on wood (with and without bark), isolated bark, plants for planting and cut branches.

The most likely pathway of entry is wood from diseased *Quercus* trees as sporulating mycelial mats can be produced on logs from diseased trees (EPPO, 1997; Robinet et al., 2016). Not just wood with bark can be a pathway for entry but also wood without bark, as *B. fagacearum* can be isolated from sawn lumber up to 24 weeks after sawing (Gibbs and French, 1980), and wood packaging material (Webber, 2015).

Wood from American red oak species is considered to pose a higher risk than wood from American white oak species, due to the higher susceptibility of the former oak species and the association with mycelial mat formation and nitidulid beetles (Miller et al., 1985; Webber, 2015; Robinet et al., 2016).

Nevertheless, the moisture content of the wood needs to be between 37% and 45% for mycelial mats to form (Campbell and French, 1955) and *B. fagacearum* does not tolerate temperatures above 32°C (Sinclair and Lyon, 2005).

Plants for planting as well as cut branches of *Quercus* spp. are considered potential host commodities providing a pathway for entry (EPPO, 2017). However, there are no reports of oak seedlings or saplings in nurseries getting infected in the USA (Juzwik et al., 2008).

There is no evidence that seeds or foliage of infected hosts serve as a means of movement for *B. fagacearum*, either locally or over long distances (Bretz and Buchanan, 1957; Gibbs et al., 1984; Webber, 2015).

The main pathways of entry are thus (for *Quercus* spp. and the other hosts mentioned in Section 3.4.2):

- Wood with and without bark
- Isolated bark
- Plants for planting other than seeds
- Cut branches

As there is a ban on importing (i) plants for planting of *Quercus* spp. from non-European countries and (ii) isolated bark of *Quercus* spp. from North American countries (see Section 3.3.2), these two potential pathways (at least for *Quercus* spp.) are closed by the existing legislation.

As of November 2017, there were no records of interception of *B. fagacearum* in the Europhyt database.

3.4.3. Establishment

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

Yes

3.4.3.1. EU distribution of main host plants

The main hosts, *Quercus* spp. are widely distributed within the EU territory but the northern limit excludes the most northern parts of Scandinavia (Figure 2). There are about 20 species of *Quercus* native to Europe.

Three of the oak species native to Europe (*Q. robur*, *Q. petraea* and *Q. pubescens*) have been shown to be highly susceptible to *B. fagacearum* in inoculations trials (see Section 3.4.1). The distribution ranges of *Q. robur* and *Q. petraea* overlap to a large extent and cover most of Europe (Figures 3 and 4).

Quercus palustris and *Quercus rubra*, which were introduced from North America into Europe as planted trees, are also susceptible to the disease (Webber, 2015).

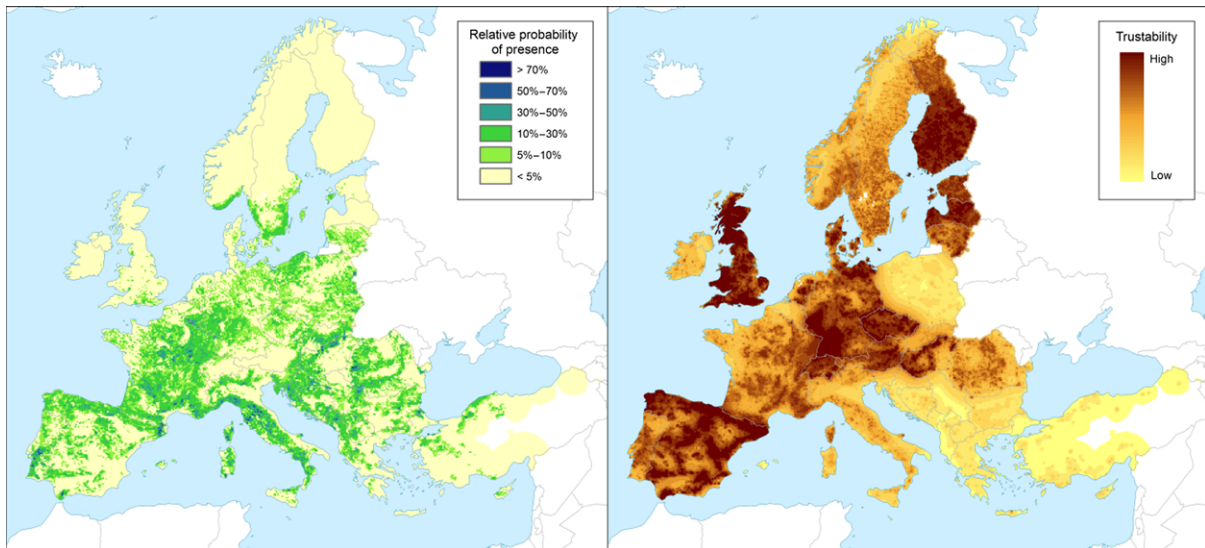


Figure 2: Left-hand panel: Relative probability of presence (RPP) of the genus *Quercus* (based on data from the species: *Q. cerris*, *Q. petraea*, *Q. robur*, *Q. pubescens*, *Q. rubra*, *Q. frainetto*, *Q. ilex*, *Q. suber*, *Q. trojana*, *Q. virgiliana*, *Q. palustris*, *Q. pedunculiflora*, *Q. coccifera*, *Q. vulcanica*, *Q. faginea*, *Q. pyrenaica*, *Q. canariensis*, *Q. macrolepis*, *Q. dalechampii*, *Q. congesta*, *Q. x streimii* and *Q. alnifolia*) in Europe, mapped at 100 km² 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)

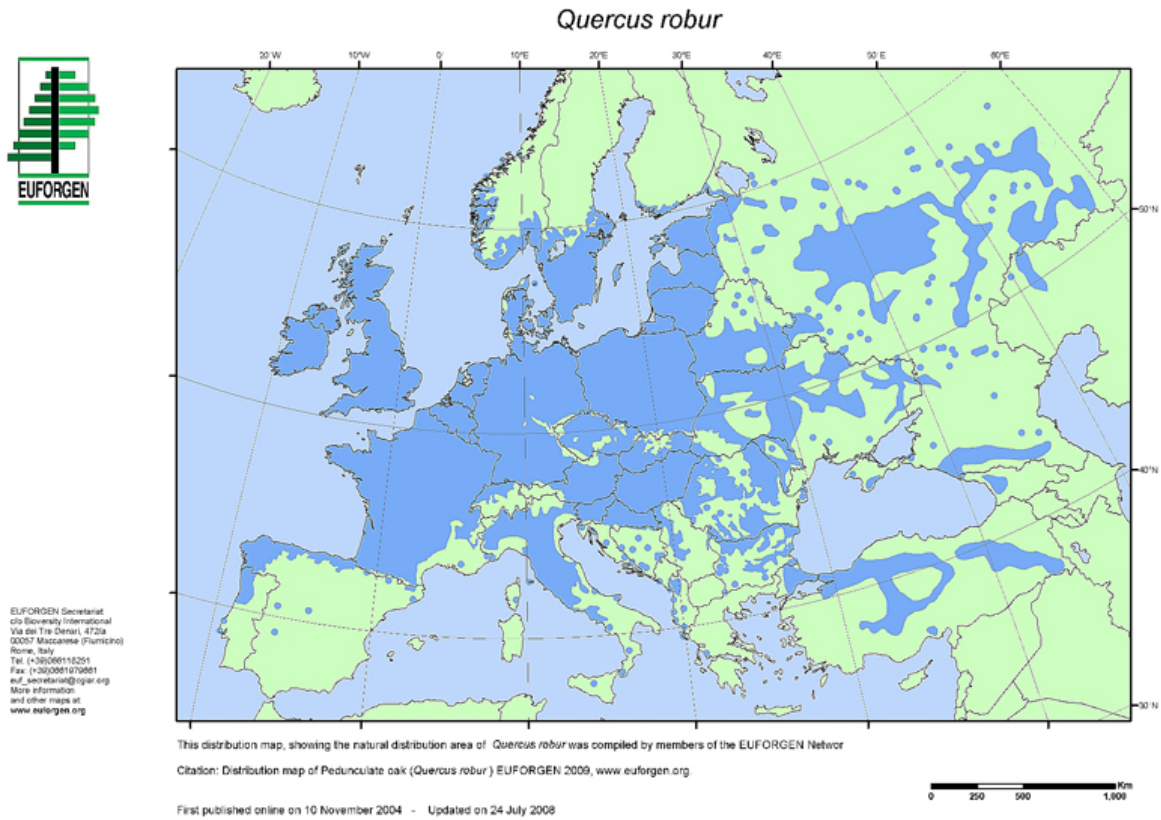


Figure 3: Native range of *Quercus robur* (map prepared by Euforgen in 2008). Blue dots represent isolated occurrences of the species

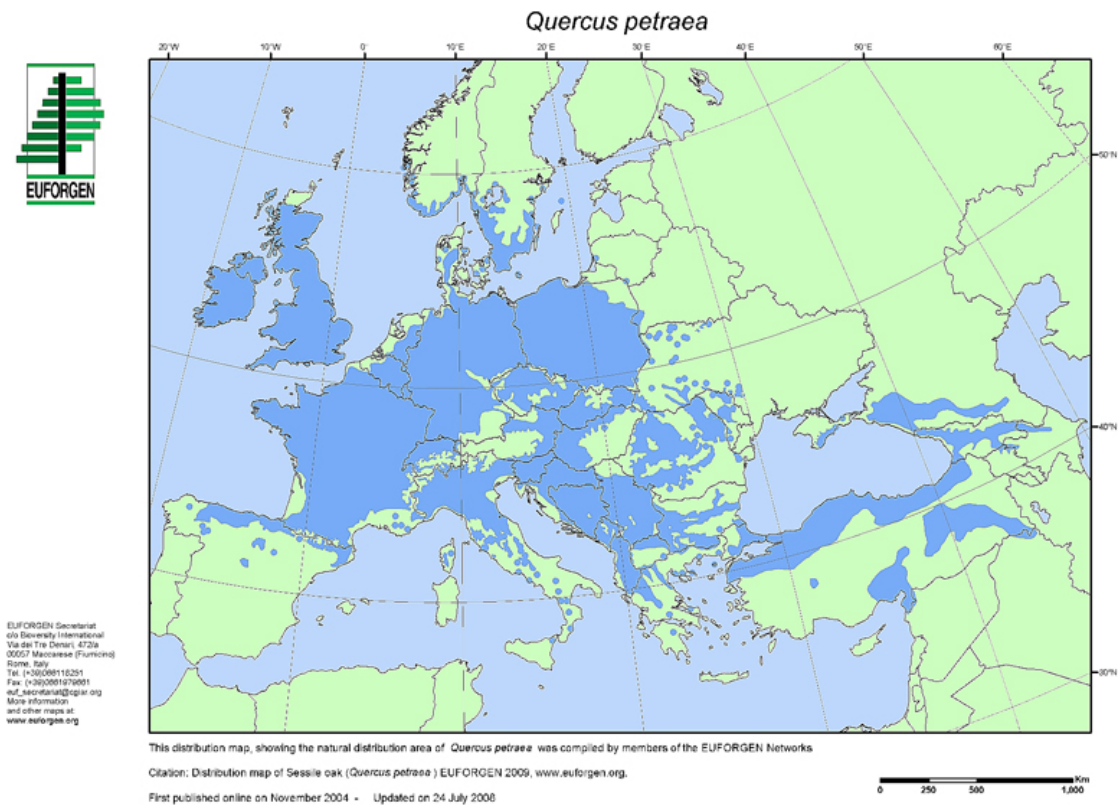


Figure 4: Native range of *Quercus petraea* (map prepared by Euforgen in 2006). Blue dots represent isolated occurrences of the species

3.4.3.2. Climatic conditions affecting establishment

The distribution of *B. fagacearum* in North America (Figure 1; Section 3.2) covers areas with cold, temperate and arid Köppen–Geiger climate types (Peel et al., 2007). These climate types overlap to a large extent with the distributions of the native *Quercus* species in Europe. Therefore, the Panel assumes climate will not be a limiting factor for the establishment of the pathogen in most of the EU.

3.4.4. Spread

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

Yes, by means of root grafts, vectors and movement of infected wood (including wood packaging material), plants for planting, and cut branches.

In many parts of the pathogens current range, the most important means of spread is transmission from tree to tree via root grafts (Gibbs and French, 1980; Appel et al., 1989). Disease transmission via root grafts has also been observed between inoculated trees of European white oaks (*Q. robur*, *Q. petraea*, *Q. pubescens*; Pinon et al., 1997). Disease transmission through root grafts in woodland will be most likely in pure stands of *Quercus* spp. *Quercus*-dominated woodlands are found in several EU regions. For example, in Galicia, Spain, about 27% of the total woodland area (about 376,000 ha) is covered by native hardwoods; of this area, about half is covered by pure stands of *Q. robur* (Diaz-Maroto and Vila-Lameiro, 2007). In Italy, about 700,000 ha are covered by oak woodland, of which about 10% are estimated to be pure stands of *Quercus* spp. (Ducci, 2007).

In the US, in areas where oaks do not form root grafts, dispersal occurs through the activity of sap-feeding nitidulid beetles (e.g. *Colopterus truncatus*, *Carpophilus sayi*) spreading spores from sporulating mats to fresh wounds (Appel et al., 1989; Ambourn et al., 2005). Oak bark beetles *P. minutissimus* and *P. pruinosis* are also thought to be vectors in some US areas but are considered to be of less importance (Sinclair and Lyon, 2005; Harrington, 2009, 2013). If the association between these beetles and the fungus is mostly mechanical, it would not be species-specific and new vector associations could easily be found in Europe should the fungus be introduced.

Fungal mats are mainly found in red oaks and are not produced in dry conditions (Sinclair and Lyon, 2005). Considering the importance of the sporulating mats as the source of inoculum for the vectors, the distribution of red oak species and the climate in some areas of the EU territory could affect the spread capacity (Webber, 2015). All red oak species are native to North America; the most commonly planted red oak species in Europe are *Q. rubra* and *Q. palustris*.

Longer distance spread may be due to transport of wood from infected trees as sporulating mats can be produced on logs from diseased trees (EPPO, 1997). In a pathway model, transportation of wood across Europe had a large contribution to the estimated exposure of oak trees to the fungus in Europe (Robinet et al., 2016).

Given that plants for planting (including large trees for ornamental purposes), as well as wood packaging material and cut branches are considered to be a potential pathway of entry (see Section 3.4.2), these commodities could also be a means of spread within the EU.

3.4.4.1. Vectors and their distribution in the EU

The main vectors in the current range, *C. sayi* and *C. truncatus*, are not found in Europe (de Jong et al., 2014; <http://www.fauna-eu.org>). Other species of both genera are found and some of them are widespread, but their potential as vectors of the oak wilt fungus is not known. However, novel associations between ophiostomatoid fungi, insect vectors and host trees are increasingly reported (Wingfield et al., 2017).

None of the *Pseudopityophthorus* species are present in Europe (de Jong et al., 2014).

The oak bark beetle *Scolytus intricatus* which is native in Europe has been suggested to possess the properties necessary to be a vector of *B. fagacearum* (Webber, 2015). The beetle is present in almost all European countries (de Jong et al., 2014).

3.5. Impacts

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

Yes, the pest introduction would have impacts in woodlands and plantations.

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

Yes, the presence of the pest on plants for planting would have an impact on their intended use.

B. fagacearum causes a true vascular wilt disease, very often lethal in a short period of time to oak species, especially in the case of red oaks. Death of trees may be preceded by chlorosis of foliage, bronzing of leaf tips or striking necrosis and chlorosis along the leaf veins, depending on the host species (Appel, 1995; Juzwik et al., 2011) and by a characteristic wilt appearance to the crown (McCracken and Burkhardt, 1979; Houston, 1993; Harrington, 2013) (Figure 5).

In the upper midwest of USA, loss of timber value due to oak wilt can be heavy (Haugen et al., 2009), but losses of amenity trees are of greater economic importance (Harrington, 2013).

In the sandiest soils of Michigan, mortality of 8–11 red oaks per hectare and year has been documented (Bruhn and Heyd, 1992; Juzwik, 2009). The mortality rate is lower in Pennsylvania (1–3 oaks per disease centre and year) and West Virginia (0.2–0.4 oaks per disease centre and year) (Jones, 1971; Mielke et al., 1983).

Oak wilt is very important in central Texas, where at least 2,500 hectares are affected by the disease (Harrington, 2013). In this region, thousands of oak trees are killed each year – probably millions of trees in total (Appel, 1995; Juzwik et al., 2011), resulting in a loss of property values and of historically and aesthetically significant trees (Harrington, 2013). The disease also implies ecological impacts (Sakalidis et al., 2017). For instance, the loss of oak habitat is a further threat to the endangered animals associated with oaks (Greene and Reemts, 2009).

Impacts can be expected in the EU, should the pathogen be introduced (Moricca et al., 2018). Three of the oak species native to Europe (*Q. robur*, *Q. petraea* and *Q. pubescens*) have been shown to be highly susceptible to *B. fagacearum* in inoculation trials (Webber, 2015). *Q. robur* and *Q. petraea* are among the most economically and ecologically important deciduous forest tree species in Europe. However, red oaks are not as widespread in the EU as they are in the USA.

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



Figure 5: *Quercus* spp. in Texas, USA, showing symptoms of oak wilt disease due to *B. fagacearum* (photo by William M. Ciesla, Bugwood.org, available online at: <https://www.ipmimages.org/browse/detail.cfm?imgnum=0758073>)

3.6. Availability and limits of mitigation measures

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

Yes. Please see Section 3.6.1.

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

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

3.6.1. Phytosanitary measures

Phytosanitary measures are currently applied to *Quercus* spp. and *Castanea* spp. (see Section 3.3.2). However, pathways exist via other hosts (*Lithocarpus*, *Malus*) (see Section 3.4.1). For these hosts, pest-free area for the production of clean nursery stock is an available phytosanitary measure.

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

- Long-distance spread through infected wood (with or without bark) or plants for planting can make local containment efforts (e.g. by means of root graft barriers) ineffective.
- The efficacy of control measures can vary markedly, for example from 54% to 100% for root graft barriers (Koch et al., 2010).
- The fungus usually disappears from the above-ground parts of its host within a year of death of the tree. Survival in underground parts, however, can be considerably longer (Anon, 2016).
- Educational programmes are needed to increase the efficacy of prevention efforts, detection and compliance with recommended management methods (Koch et al., 2010).

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

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

3.6.2. Control methods

Control methods have been reviewed by Harrington (2013).

- To avoid or reduce the risk of pathogen introduction and spread through infected wood, three options are available: (1) removal of all bark and natural rounded surface; (2) kiln drying; (3) fumigation (EPPO, 1997).
- Harvesting should be curtailed during spring and early summer because of the risk of infections through wounds in these periods (Cummings-Carlson and Martin, 2001; Haugen et al., 2009). The same also applies to pruning (Gleason and Mueller, 2005). If pruning is done during the summer, e.g. removing broken branches, all wounds should be sealed immediately with a tree wound dressing or latex paint (French and Juzwik, 1999).
- Prompt removal of all symptomatic and recently killed trees before mats form (Harrington, 2013). The same applies to portions of diseased trees greater than 5 cm diameter (Haugen et al., 2009).
- While fungicide treatment of symptomatic red oaks is not recommended, therapeutic treatments of white oaks with propiconazole are effective in delaying symptom development and mortality (Osterbauer et al., 1994; Eggers et al., 2005).
- Reduction in the root graft transmission of the oak wilt pathogen by the use of root-free zones has been practised for many years and can be effective in reducing losses (Bretz, 1951; Gehring, 1995; Cummings-Carlson and Martin, 2001; Gleason and Mueller, 2005; Juzwik et al., 2011). Usually, a trench is made to delimit infected from healthy trees.

3.7. Uncertainty

The origin of the pathogen is still unknown. Juzwik et al. (2008) claimed that the pathogen was introduced to the USA most likely from Mexico, Central or South America. If so, the distribution of the pathogen could be wider than currently reported.

There is uncertainty about the survival of the fungus in wood during transport and the association with propagation material. However, *B. fagacearum* can be isolated from sawn lumber up to 24 weeks after sawing (Gibbs and French, 1980).

A knowledge gap is the presence of suitable vectors in Europe. Similarly, there is a lack of knowledge on mycelial mat formation in European oak species affecting the spread. Moreover, the relative susceptibility of the various oak species native to Europe is uncertain. It is not known to what extent the limited (compared to the USA) distribution of red oak species in Europe would restrict the spread rate of the disease.

The susceptibility of oak species native to Europe (*Q. robur*, *Q. petraea* and *Q. pubescens*) was demonstrated using inoculation trials, but the vulnerability under natural conditions in European locations is uncertain (Webber, 2015).

4. Conclusions

B. fagacearum meets the criteria assessed by EFSA for consideration as a potential quarantine pest (Table 4).

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

Criterion of pest categorisation	Panel's conclusions against criterion in Regulation (EU) 2016/2031 regarding Union quarantine pest	Panel's conclusions against criterion in Regulation (EU) 2016/2031 regarding Union regulated non-quarantine pest	Key uncertainties
Identity of the pest (Section 3.1)	The identity of the pest as a species is clear	The identity of the pest as a species is clear	The recent change in name from <i>Ceratocystis fagacearum</i> to <i>Bretziella fagacearum</i> may take time for acceptance by the scientific community
Absence/presence of the pest in the EU territory (Section 3.2)	The pest is not reported to be present in the EU	The pest is not reported to be present in the EU	There are no records from EU MSs available to the Panel of the absence of the pathogen other than from Lithuania, the Netherlands and Slovenia
Regulatory status (Section 3.3)	<i>B. fagacearum</i> is regulated by Council Directive 2000/29/EC (Annex IAI, as <i>Ceratocystis fagacearum</i>) as a harmful organism whose introduction into and spread within all Member States shall be banned	<i>B. fagacearum</i> is regulated by Council Directive 2000/29/EC (Annex IAI, as <i>Ceratocystis fagacearum</i>) as a harmful organism whose introduction into and spread within all Member States shall be banned	None
Pest potential for entry, establishment and spread in the EU territory (Section 3.4)	<p>Entry: the pest could enter the EU via wood (with and without bark), isolated bark, plants for planting and cut branches.</p> <p>Establishment: hosts and favourable climatic conditions are widespread in the risk assessment (RA) area.</p> <p>Spread: the pest would be able to spread following establishment by various means, i.e. insects, root grafts and movement of infected wood and plants for planting.</p>	<p>Entry: the pest could enter the EU via wood (with and without bark), isolated bark, plants for planting and cut branches.</p> <p>Establishment: hosts and favourable climatic conditions are widespread in the RA area.</p> <p>Spread: the pest would be able to spread following establishment by various means, i.e. insects, root grafts and movement of infected wood and plants for planting.</p>	<p>There is uncertainty about the survival of the fungus in wood during transport and the association with propagation material.</p> <p>A knowledge gap is the presence of suitable vectors in Europe.</p> <p>There is a lack of knowledge on mycelial mat formation in European oak species affecting the spread.</p> <p>It is not known to what extent the limited (compared to the USA) distribution of red oak species in Europe would restrict the spread rate of the disease.</p>
Potential for consequences in the EU territory (Section 3.5)	The pest introduction would have economic and environmental impacts in woodlands and plantations.	The pest introduction would have an impact on the intended use of plants for planting.	There is uncertainty about the relative susceptibility level under natural conditions in European locations of the various oak species native to Europe

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
Available measures (Section 3.6)	Wood treatment (debarking, kiln drying, fumigation), prompt removal of affected trees and creating root-free zones between affected and healthy stands are available measures to reduce the risk of entry, establishment and spread	Production of plants for planting in pest-free areas can prevent pest presence on plants for planting	It is uncertain how effective chemical control in nurseries could be and whether it might just mask symptoms, hence allowing the movement of the pathogen via the trade in plants for planting The effectiveness of debarking as wood treatment is uncertain, given that <i>B. fagacearum</i> can be isolated from sawn lumber up to 24 weeks after sawing
Conclusion on pest categorisation (Section 4)	The criteria assessed by the Panel for consideration as a potential quarantine pest are met	The criterion on the pest presence in the EU is not met	
Aspects of assessment to focus on/ scenarios to address in future if appropriate	The main knowledge gaps concern (i) the survival of the fungus in wood (with and without bark) during transport and the association with propagation material, (ii) the presence of suitable vectors in Europe and (iii) the relative susceptibility level under natural conditions in European locations of the oak species native to Europe.		

References

- Ambourn AK, Juzwik J and Moon RD, 2005. Seasonal dispersal of the oak wilt fungus by *Colopterus truncatus* and *Carpophilus sayi* in Minnesota. *Plant Disease*, 89, 1067–1076.
- Anon, 2016. *Ceratocystis fagacearum* (oak wilt) - fact sheet. Canadian Food Inspection Agency. Available online: <http://www.inspection.gc.ca/plants/plant-pests-invasive-species/diseases/oak-wilt/fact-sheet/eng/1325629194844/1325632464641>
- Anon, 2017. Contingency plan for oak wilt (*Ceratocystis fagacearum*). Forestry Commission, UK, 35 pp. Available online: [https://www.forestry.gov.uk/pdf/ContingencyplanoakwiltFINAL30-01-17.pdf/\\$FILE/ContingencyplanoakwiltFINAL30-01-17.pdf](https://www.forestry.gov.uk/pdf/ContingencyplanoakwiltFINAL30-01-17.pdf/$FILE/ContingencyplanoakwiltFINAL30-01-17.pdf)
- Appel DN, 1995. The oak wilt enigma: perspectives from the Texas epidemic. *Annual Review of Phytopathology*, 33, 103–118.
- Appel DN, Maggio RC, Nelson EL and Jeger MJ, 1989. Measurement of expanding oak wilt centers in live oak. *Phytopathology*, 79, 1318–1322.
- de Beer ZW, Marincowitz S, Duong TA and Wingfield MJ, 2017. *Bretziella*, a new genus to accommodate the oak wilt fungus, *Ceratocystis fagacearum* (Microascales, Ascomycota). *Mycology*, 27, 1–19.
- Bossard M, Feranec J and Otahel J, 2000. CORINE land cover technical guide - Addendum 2000. Tech. Rep. 40, European Environment Agency. Available online: https://www.eea.europa.eu/ds_resolveuid/032TFUPGVR
- Boyras N and Bastas KK, 2001. A new fungal disease on oaks of Turkey: oak wilt (*Ceratocystis fagacearum* (Bretz) Hunt = *Chalara quercina*) first report. *Journal of the Faculty of Agriculture, Selçuk Üniversitesi*, 15, 147–152 (in Turkish).
- Bretz TW, 1951. Oak wilt. *Journal of Forestry*, 49, 169–171.
- Bretz TW and Buchanan WD, 1957. Oak wilt not found in acorns from diseased tree. *Plant Disease Reporter*, 41, 546.
- Bretz T and Long WG, 1950. Oak wilt fungus isolated from Chinese chestnut. *Plant Disease Reporter*, 34, 291.
- Bruhn JN and Heyd RL, 1992. Biology and control of oak wilt in Michigan red oak stands. *Northern Journal of Applied Forestry*, 9, 47–51.

- Bruhn JN, Pickens JB and Stanfield DB, 1991. Probit analysis of oak wilt transmission through root grafts in red oak stands. *Forest Science*, 37, 28–44.
- Buchanan WD, 1957. Brentids may be vectors of the oak wilt disease. *Plant Disease Reporter*, 41, 707–708.
- Büttner G, Kosztra B, Maucha G and Pataki R, 2012. Implementation and achievements of CLC2006. Tech. rep., European Environment Agency. Available online: http://www.eea.europa.eu/ds_resolveuid/GQ4JECM8TB
- Campbell RN and French DW, 1955. Moisture content of oaks and mat formation by the oak wilt fungus. *Forest Science*, 1, 265–270.
- Chirici G, Bertini R, Travaglini D, Puletti N and Chiavetta U, 2011a. The common nfi database. In: Chirici G, Winter S and McRoberts RE (eds.). *National Forest Inventories: Contributions to Forest Biodiversity Assessments*. Springer, Berlin. pp. 99–119.
- Chirici G, McRoberts RE, Winter S, Barbati A, Brändli U-B, Abegg M, Beranova J, Rondeux J, Bertini R, Alberdi Asensio I and Condés S, 2011b. Harmonization tests. In: Chirici G, Winter S and McRoberts RE (eds.). *National Forest Inventories: Contributions to Forest Biodiversity Assessments*. Springer, Berlin. pp. 121–190.
- Cummings-Carlson J and Martin AJ, 2001. *Oak wilt management: what are the options?*. University of Wisconsin, Madison, USA, Cooperative Extension Publications G3590, 6 pp.
- Diaz-Maroto IJ and Vila-Lameiro P, 2007. Natural forests of *Quercus robur* L. in Northwest Spain - main properties of soils. *Polish Journal of Ecology*, 55, 401–404.
- Ducci F (ed.), 2007. *Le risorse genetiche della farnia della Val Padana - tutela e gestione*. Consiglio per la Ricerca e la Sperimentazione in Agricoltura, Arezzo, Italy. p. 73.
- EFSA PLH Panel (EFSA Panel on Plant Health), 2010. PLH Guidance on a harmonised framework for pest risk assessment and the identification and evaluation of pest risk management options by EFSA. *EFSA Journal* 2010;8(2):1495, 66 pp. <https://doi.org/10.2093/j.efsa.2010.1495>
- Eggers J, Juzwik J, Bernick S and Mordaunt L, 2005. Evaluation of propiconazole operational treatments of oaks for wilt control. Research Note NC-390 of the USDA Forest Service, North Central Research Station, St. Paul, USA, 6 pp.
- EPPO (European and Mediterranean Plant Protection Organization), 1997. Data sheets on quarantine pests: *Ceratocystis fagacearum*. In: Smith IM, McNamara DG, Scott PR, Holderness M (eds.). *Quarantine Pests for Europe*, 2nd ed. CABI/EPPO, Wallingford, 1425 pp.
- EPPO (European and Mediterranean Plant Protection Organization), 2001. Diagnostic protocols for regulated pests: *Ceratocystis fagacearum*. *EPPO Bulletin*, 31, 41–44.
- EPPO (European and Mediterranean Plant Protection Organization), 2017. EPPO Global Database . Available online: <https://gd.eppo.int>
- Eschen R, Douma JC, Grégoire JC, Mayer F, Rigaux L and Potting RP, 2017. A risk categorisation and analysis of the geographic and temporal dynamics of the European import of plants for planting. *Biological Invasions*, 19, 3243–3257.
- FAO (Food and Agriculture Organization of the United Nations), 2004. ISPM (International Standards for Phytosanitary Measures) 21—Pest risk analysis of regulated non-quarantine pests. FAO, Rome, 30 pp. Available online: https://www.ippc.int/sites/default/files/documents//1323945746_ISPM_21_2004_En_2011-11-29_Refor.pdf
- FAO (Food and Agriculture Organization of the United Nations), 2013. ISPM (International Standards for Phytosanitary Measures) 11—Pest risk analysis for quarantine pests. FAO, Rome, 36 pp. Available online: https://www.ippc.int/sites/default/files/documents/20140512/ispm_11_2013_en_2014-04-30_201405121523-494.65%20KB.pdf
- French DW and Juzwik J, 1999. *Oak wilt in Minnesota*. University of Minnesota, Extension Service, St. Paul, USA. p. 4.
- Gehring EH, 1995. Evaluation of suppression project treatments. In: Appel DN and Billings RF (eds.). *Oak Wilt Perspectives: The Proceedings of the National Oak Wilt Symposium, 1992*. Houston, Texas, USA, pp. 147–154.
- Gibbs JN and French DW, 1980. The transmission of oak wilt. Research Paper NC-185, North Central Forest Experiment Station, USDA Forest Service, St. Paul, USA, 22 pp. Available online: https://www.fs.usda.gov/tree_search/pubs/10706
- Gibbs JN, Liese W and Pinon J, 1984. Oak wilt for Europe. *Outlook on Agriculture*, 13, 203–207.
- Gleason M and Mueller D, 2005. *Oak wilt - identification and management*. Iowa State University, University Extension, Ames, USA, 8pp.
- Greene TA and Reemts CM, 2009. Oak wilt research at Fort Hood: inoculum sources at landscape scale. In: Appel DN and Billings RF (eds.). *Proceedings of the 2nd National Oak Wilt Symposium 2007*. USDA Forest Service, Forest Health Protection, Austin, Texas, USA, pp. 86–107.
- Harrington TC, 2009. The genus *Ceratocystis*. Where does the oak wilt fungus fit. In: Appel DN and Billings RF (eds.). *Proceedings of the 2nd National Oak Wilt Symposium 2007*. USDA Forest Service, Forest Health Protection, Austin, USA, pp. 21–35.
- Harrington TC, 2013. *Ceratocystis* diseases. In: Gonthier P and Nicolotti G (eds.). *Infectious Forest Diseases*. CAB International, Wallingford, UK. pp. 230–255.
- Haugen L, O'Brien J, Pokorny J, Mielke M and Juzwik J, 2009. Oak wilt in the North Central region. In: Appel DN and Billings RF (eds.). *Proceedings of the 2nd National Oak Wilt Symposium 2007*. USDA Forest Service, Forest Health Protection, Austin, USA, pp. 155–163.

- Hepting GH, Toole ER and Boyce JS, 1952. Sexuality in the oak wilt fungus. *Phytopathology*, 42, 438–442.
- Hiederer R, Houston Durrant T, Granke O, Lambotte M, Lorenz M, Mignon B and Mues V, 2007. Forest focus monitoring database system - validation methodology. Vol. EUR 23020 EN of EUR – Scientific and Technical Research. Office for Official Publications of the European Communities. <https://doi.org/10.2788/51364>
- Hiederer R, Houston Durrant T and Micheli E, 2011. Evaluation of BioSoil demonstration project - Soil data analysis. Vol. 24729 of EUR - Scientific and Technical Research. Publications Office of the European Union. <https://doi.org/10.2788/56105>
- Houston DR, 1993. Recognizing and managing sapstreak disease of sugar maple. USDA, Forest Service. Research Paper NE-675. North-eastern Forest Experiment Station, Radnor, Pennsylvania, USA. 15 pp.
- Houston Durrant T and Hiederer R, 2009. Applying quality assurance procedures to environmental monitoring data: a case study. *Journal of Environmental Monitoring*, 11, 774–781.
- Houston Durrant T, San-Miguel-Ayanz J, Schulte E and Suarez Meyer A, 2011. Evaluation of BioSoil demonstration project: forest biodiversity - Analysis of biodiversity module. Vol. 24777 of EUR – Scientific and Technical Research. Publications Office of the European Union. <https://doi.org/10.2788/84823>
- Jones TW, 1971. An appraisal of oak wilt control programs in Pennsylvania and West Virginia. USDA Forest Service, Research Paper NE-204, North-Eastern Forest Experiment Station, Upper Darby, Pennsylvania, USA, 18 pp.
- de Jong Y, Verbeek M, Michelsen V, Bjørn Pde P, Los W, Steeman F, Bailly N, Basire C, Chylarecki P, Stloukal E, Hagedorn G, Hagedorn G, Wetzell FT, Glöckler F, Kroupa A, Korb G, Hoffmann A, Häuser C, Kohlbecker A, Müller A, Güntsch A, Stoev P, Penev L, 2014. Fauna Europaea - all European animal species on the web. *Biodiversity Data Journal*, 2, e4034.
- Juzwik J, 2009. Epidemiology and occurrence of oak wilt in Midwestern, middle, and south Atlantic states. In: Appel DN and Billings RF (eds.). *Proceedings of the National Oak Wilt Symposium, 2007*. USDA Forest Service, Forest Health Protection, Austin, USA, pp. 49–60.
- Juzwik J and French DW, 1983. *Ceratocystis fagacearum* and *C. piceae* on the surfaces of free-flying and fungus-mat-inhabiting nitidulids. *Phytopathology*, 73, 1164–1168.
- Juzwik J, Harrington TC, MacDonald WL and Appel DN, 2008. The origin of *Ceratocystis fagacearum*, the oak wilt fungus. *Annual Review of Phytopathology*, 46, 13–26.
- Juzwik J, Appel DN, MacDonald WL and Burks S, 2011. Challenges and successes in managing oak wilt in the United States. *Plant Disease*, 95, 888–900.
- Koch KA, Quiram GL and Venette RC, 2010. A review of oak wilt management: a summary of treatment options and their efficacy. *Urban Forestry & Urban Greening*, 9, 1–8.
- Lamarche J, Potvin A, Pelletier G, Stewart D, Feau N, Alayon DI, Dale AL, Coelho A, Uzunovic A, Bilodeau GJ and Brière SC, 2015. Molecular detection of 10 of the most unwanted alien forest pathogens in Canada using real-time PCR. *PLoS ONE*, 10, e0134265.
- MacDonald WL, Pinon J, Tainter FH and Double ML, 2001. European oaks – susceptible to oak wilt? In: Ash CL (ed). *Shade Tree Wilt Diseases*. APS Press, St Paul, USA. pp. 131–137.
- McCracken FI and Burkhardt EC, 1979. Limiting canker disease losses of sycamore in the mid-south. *Southern Journal of Applied Forestry*, 3, 26–28.
- Mielke ME, Haynes C and Rexrode CO, 1983. Local spread of oak wilt in north-eastern West Virginia during 1970–1982. *Plant Disease*, 67, 1222–1223.
- Miller RB, Quirk JT and Christensen DJ, 1985. Identifying white oak logs with sodium nitrite. *Forest Products Journal*, 35, 33–38.
- Moricca S, Bracalini M, Croci F, Corsinovi S, Tiberi R, Ragazzi A and Panzavolta T, 2018. Biotic factors affecting ecosystem services in urban and peri-urban Forests in Italy: the role of introduced and impending pathogens and pests. *Forests*, 9, 65.
- Osterbauer NK, Salisbury T and French DW, 1994. Propiconazole as a treatment for oak wilt in *Quercus alba* and *Q. macrocarpa*. *Journal of Arboriculture*, 20, 202–203.
- Peel MC, Finlayson BL and McMahon TA, 2007. Updated world map of the Köppen-Geiger climate classification. *Hydrology and Earth System Sciences Discussions*, 4, 439–473.
- Pinon J, Irwin H, MacDonald W and Tainter H, 1997. The susceptibility of European oaks to oak wilt. *Phytopathology*, 87, S114.
- Rexrode CO and Brown D, 1983. Oak wilt. Forest Insect & Disease Leaflet 29, USDA, Forest Service. Available online: <https://www.na.fs.fed.us/spfo/pubs/fids/oakwilt/oakwilt.htm>
- de Rigo D, 2012. Semantic Array Programming for environmental modelling: application of the Mastrave library. In: Seppelt R, Voinov AA, Lange S and Bankamp D (eds.). *International Environmental Modelling and Software Society (iEMSS) 2012 International Congress on Environmental Modelling and Software - Managing Resources of a Limited Planet: Pathways and Visions under Uncertainty, Sixth Biennial Meeting*. pp. 1167–1176.
- de Rigo D, Caudullo G, Busetto L and San-Miguel-Ayanz J, 2014. Supporting EFSA assessment of the EU environmental suitability for exotic forestry pests: final report. *EFSA Supporting Publications*, 11(3), EN-434.
- de Rigo D, Caudullo G, Houston Durrant T and San-Miguel-Ayanz J, 2016. The European Atlas of Forest Tree Species: modelling, data and information on forest tree species. In: San-Miguel-Ayanz J, de Rigo D, Caudullo G, Houston Durrant T, Mauri A (eds.). *European Atlas of Forest Tree Species*. Publ. Off. EU, Luxembourg, pp. e01aa69+.

- de Rigo D, Caudullo G, San-Miguel-Ayanz J and Barredo JI, 2017. Robust modelling of the impacts of climate change on the habitat suitability of forest tree species. Publication Office of the European Union, 58 pp.
- Robinet C, Douma JC, Piou D and van der Werf W, 2016. Application of a wood pathway model to assess the effectiveness of options for reducing risk of entry of oak wilt into Europe. *Forestry*, 89, 456–472.
- Sakalidis ML, Bhakta B and Bohling M, 2017. National Invasive Species Awareness Week: Oak wilt. Michigan State University. Available online: http://msue.anr.msu.edu/news/national_invasive_species_awareness_week_oak_wilt_msg17_bohling17
- San-Miguel-Ayanz J, 2016. The European union forest strategy and the forest information system for europe. In: San-Miguel-Ayanz J, de Rigo D, Caudullo G, Houston Durrant T, Mauri A (eds.). *European Atlas of Forest Tree Species*. Publ. Off. EU, Luxembourg, pp. e012228+
- San-Miguel-Ayanz J, de Rigo D, Caudullo G, Houston Durrant T and Mauri A (eds.). 2016. *European Atlas of Forest Tree Species*. Publication Office of the European Union, Luxembourg.
- Sinclair WA and Lyon HH, 2005. *Diseases of Trees and Shrubs, 2nd Edition*. Comstock Publishing Associates, a division of Cornell University Press, Ithaca, USA. 660 pp.
- True RP, Barnett HL, Dorsey CK and Leach JG. 1960. Oak wilt in West Virginia. West Virginia Agricultural Experimental Station Bulletin 448T, West Virginia University, Morgantown, USA.
- Webber J, 2015. Rapid pest risk analysis (PRA) for *Ceratocystis fagacearum*. Forest Research, Alice Holt, UK, 23 pp. Available online: <https://secure.fera.defra.gov.uk/phiw/riskRegister/downloadExternalPra.cfm?id=4097>
- Wingfield MJ, Barnes I, de Beer ZW, Roux J, Wingfield BD and Taerum SJ, 2017. Novel associations between ophiostomatoid fungi, insects and tree hosts: current status—future prospects. *Biological Invasions*, 19, 3215–3228.
- Wu CP, Chen GY, Li B, Su H, An YL, Zhen SZ and Ye JR, 2011. Rapid and accurate detection of *Ceratocystis fagacearum* from stained wood and soil by nested and real-time PCR. *Forest Pathology*, 41, 15–21.

Abbreviations

CLC	Corine Land Cover
C-SMFA	constrained spatial multiscale frequency analysis
EPPO	European and Mediterranean Plant Protection Organization
EUFGIS	European Information System on Forest Genetic Resources
FAO	Food and Agriculture Organization
GD ²	Georeferenced Data on Genetic Diversity
IPPC	International Plant Protection Convention
MS	Member State
PCR	Polymerase chain reaction
PLH	EFSA Panel on Plant Health
RNQP	Regulated Non-Quarantine Pest
RPP	Relative probability of presence
TFEU	Treaty on the Functioning of the European Union
ToR	Terms of Reference

Appendix A – Methodological notes on Figure 2

The relative probability of presence (RPP) reported here for *Quercus* 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 multiscale 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/etrs89-etrs-laea/>).

A.1.1. European National Forestry Inventories database

This data set was derived from National Forest Inventory data and provides information on the presence/absence of forest tree species in approximately 375,000 sample points with a spatial resolution of 1 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.

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 dataset with the largest geographic extent.

A.2. Modelling methodology

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

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

C-SMFA performs spatial frequency analysis of the geolocated plot data to create preliminary RPP maps (de Rigo et al., 2014). For each 1km² 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 multiscale 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 multiscale 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 the presence of all the broadleaved species combined. Thus, to improve the accuracy of the maps, the preliminary RPP values were constrained so as not to exceed the local forest-type cover fraction with an iterative refinement (de Rigo et al., 2014). The forest-type cover fraction was estimated from the classes of the Corine Land Cover (CLC) maps which contain a component of forest trees (Bossard et al., 2000; Büttner et al., 2012).

The resulting probability of presence is relative to the specific tree taxon, irrespective of the potential co-occurrence of other tree taxa with the measured plots, and should not be confused with the absolute abundance or proportion of each taxon in the plots. RPP represents the probability of finding at least one individual of the taxon in a plot placed randomly within the grid cell, assuming that the plot has negligible area compared with the cell. As a consequence, the sum of the RPP associated

with different taxa in the same area is not constrained to be 100%. For example, in a forest with two codominant tree species which are homogeneously mixed, the RPP of both may be 100% (see e.g. the Glossary in San-Miguel-Ayanz et al. (2016), <http://forest.jrc.ec.europa.eu/media/atlas/Glossary.pdf>).

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

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