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Risk assessment and reduction options for *Cryphonectria parasitica* in the EU

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Abstract

Following a request from the European Commission, the EFSA Plant Health (PLH) Panel performed a risk assessment for *Cryphonectria parasitica* in the EU with the aim to assess the current EU phytosanitary requirements and identify the risk reduction options (RROs), which would preserve the protected zone (PZ) status in some parts of the EU, where the pathogen is not known to occur. *C. parasitica*, a bark-inhabiting fungus causing blight of chestnut trees (*Castanea* spp.), has a wide distribution in the EU (non-PZs). Three regulatory scenarios were considered for the whole risk assessment (RA) area: the current situation in non-PZs (scenario A_0), the situation in the EU without measures (A_1) and the current situation in PZs with additional RROs (A_2). The Panel considered both the risk of potential spread to PZs of *C. parasitica* strains currently present in the non-PZs and the risk of introduction from Third Countries and spread in non-PZs of new, virulent strains that would be able to jeopardise the currently effective hypovirulence and cause severe impact. The number of new introductions of *C. parasitica* into the EU is reduced by approximately a factor 5,000 (median values) in scenario A_2 compared to scenario A_0. Under the A_0, A_1 and A_2 scenarios, 2, 3.5 and 0.5 (median values) EU Member States, respectively, are expected to be affected in the next 10 years due to spread of *C. parasitica* strains. The estimated relative impact on ecosystem services, due to the introduction and spread in the EU of new, virulent strains, is higher for scenario A_1 compared to scenarios A_0 and A_2. The current EU requirements and the additional RROs considered in scenario A_2 were assessed to be effective in reducing the risk of introduction and spread of *C. parasitica*, thus preserving the PZ status in some parts of the EU.

Keywords: *Castanea sativa*, chestnut blight, forest pathology, hypovirulence, phytosanitary, plants for planting, wood trade

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Summary

Following a request from the European Commission, the EFSA Plant Health (PLH) Panel performed a quantitative risk assessment of the risk to plant health in the European Union (EU) posed by *Cryphonectria parasitica* (Murrill) Barr. This pathogen is a bark-inhabiting fungus causing blight of chestnut trees (Castanea spp.). The most susceptible *Castanea* species are *Castanea dentata* (American chestnut) and *Castanea sativa* (European chestnut). The pathogen has a wide distribution in the EU, with the exception of some Member States (the Czech Republic, Ireland, Sweden, and the UK) with protected zone (PZ) status, where the pathogen is not known to occur.

The Panel interpreted the Terms of Reference (ToR) as a request for conducting a full Pest Risk Assessment (PRA) for *C. parasitica*, following the already published pest categorisation (EFSA PLH Panel, 2014) with the aim to assess the effectiveness of the current EU phytosanitary requirements and identify the risk reduction options (RROs), which may be considered to preserve the PZ status in some parts of the EU.

In this PRA, the Panel considers that the risk assessment (RA) area (i.e. the EU territory) is currently split in two areas:

1) the areas in which the pathogen is present and widespread (see pest categorisation, EFSA PLH Panel, 2014), for which regulations exist in Council Directive 2000/29/EC[1] for the pest and its hosts (non-protected zones, non-PZs); and
2) the PZs, in which the pathogen is not known to occur and for which measures are in place according to Council Directive 2000/29/EC Annex IV, Part B.

The assessment of introduction and spread was performed for those pathogen strains not yet present in the EU (or in parts of the EU, i.e. the PZs). These strains may be different in virulence and ability to spread. The assessment of impact was carried out for virulent strains only, because hypovirulent strains do not generally cause relevant damage to plants.

The Panel is also aware that the movement of *C. parasitica* strains within affected areas of the EU (e.g. from France to Italy, from Italy to Greece, etc.) could potentially reduce the effectiveness of biological control through deployment of hypovirulent isolates. However, since there is no evidence for the movement of *C. parasitica* strains from already affected NUTS1 regions to other already affected NUTS1 regions so far, this risk assessment does not consider the potential consequences of the movement of strains within the already affected areas of the EU.

A literature search was performed following the strategy described in the pest categorisation, so as to retrieve relevant papers that appeared since the time the pest categorisation was published (2014). The content of these publications was considered in the risk assessment wherever relevant. Information already provided in the pest categorisation on *C. parasitica* was not repeated here.

The quantitative risk assessment template, currently developed by the EFSA PLH Panel, was followed. The assessment model is described in detail by means of flow charts and formulas in Appendix A.

Data on which to base many of the quantitative estimations used in this Risk Assessment were either missing or incomplete. Expert judgment was, thus, used in most cases. The quantitative estimations provided by the experts should be taken with caution, as different experts might provide different figures in such a situation where evidence is lacking.

The risk assessment was carried out with the EU as RA area for the following three scenarios:

- The A_0 scenario describes the current regulatory situation in non-PZs with respect to the EU legislation (Council Directive 2000/29/EC). This scenario makes it possible to assess the effectiveness of the current EU phytosanitary requirements in reducing the risk of introduction into and spread within the RA area of new, virulent *C. parasitica* strains originating from Third Countries.
- The A_1 scenario describes a situation without RROs.
- The A_2 scenario describes the current regulatory situation in the PZs, with some measures being already in place (Council Directive 2000/29/EC) and additional RROs to be applied for all the EU Member States (MSs). This scenario makes it possible to assess the effectiveness of RROs which may be considered to: (i) preserve the PZ status, as requested in the ToR and

[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. Official Journal of the European Communities L 169, consolidated version of 30.6.2014, p. 1–181.

(ii) reduce the risk of introduction and spread of new virulent *C. parasitica* strains not currently present in the RA area.

All the scenarios also include the current agricultural practices commonly used in the RA area.

All three scenarios refer to *Castanea* spp. (chestnut), which is considered the main host and not to *Quercus* spp. (oak) because the presence of *C. parasitica* on *Quercus* spp. is rare. The conclusions on the effectiveness of the RROs for chestnut are in the view of the Panel also applicable to oak, but no further analysis was undertaken to support this assertion.

The host plants for planting and the wood with bark pathways were considered by the Panel as major pathways for the entry of the pathogen into the RA area.

The risk of new introductions of *C. parasitica* strains into the RA area by means of the main pathways of entry is relatively high with about 100 (median value; for all values, please see the main text for the 50% prediction intervals as a proxy for uncertainty) new potential established populations predicted in a 10-year period under scenario A_0; in case all relevant EU regulations are removed (scenario A_1), the number of new potential established populations increases to more than 30,000, whereas in case the current EU regulations are maintained for the PZs and the additional RROs of scenario A_2 are implemented, the number decreases to 0.02. The number of established populations is expected to be about 5,000 times higher for the A_0 scenario compared to the A_2 scenario. Under the A_1 scenario in the 99th percentile (the worst case), the expected number of established populations becomes about 23,000 per year.

The entry assessment highlighted important differences among the two major pathways of entry, with plants for planting as the most important pathway. The number of potential founder populations (median values) due to the plants for planting pathway is expected to be about eight times higher than that for the pathway wood with bark under the current situation in PZs (scenario A_0) and about 600 times higher without measures (scenario A_1).

The estimated distribution for the number of established populations in scenario A_1 has a range of about 400 times between the 99th percentile and the 1st percentile value, implying relatively limited uncertainty. The uncertainty is higher under scenarios A_0 and A_2 compared to the A_1 scenario.

In scenario A_2, the additional RROs for reducing the risk of entry include: (i) a certification scheme for the production of *Castanea* plants intended for planting; and (ii) visual inspection of consignments at the EU point of entry, and in case of suspect symptoms, sampling and lab testing. Additional RROs for reducing the risk of establishment include surveillance and use of enhanced eradication programmes, which should also be effective in decreasing the number of potential founder populations by reducing the transfer of the pathogen to a suitable host in the RA area.

Many factors influence the assessment of entry and establishment, and their relative contribution to the overall uncertainty varies between scenarios. However, there are no dominant factors contributing to the overall uncertainty. With respect to entry, the pest abundance at the origin and the number of pathway units are key factors contributing to uncertainty in the plants for planting and the wood with bark pathways, respectively. For establishment and for all scenarios, the number of pathway units is a key factor. Future risk assessment would benefit from data on trade volumes of chestnut plants for planting and wood with bark and on the pest abundance in the affected Third Countries.

Under the conditions of the three scenarios considered in this Risk Assessment, two (median value) EU Member States (EU MSs) in the RA area are expected to be newly affected due to spread of populations of *C. parasitica* over the next 10 years under scenario A_0; in case all relevant EU requirements are removed (scenario A_1) the number of EU MSs newly occupied by the pathogen increases to 3.5 (median value), whereas, if the current EU regulations are maintained in the PZs and the additional RROs of scenario A_2 are implemented, the number decreases to 0.5 (median value).

The RROs considered in scenario A_2 are expected to reduce by about four times the expected number of newly affected EU MSs compared to scenario A_0 (median values). The ratio between the expected number of newly affected EU MSs for scenarios A_1 and A_0 scenario is 1.75, whereas the ratio comparing this number for scenarios A_1 and A_2 is about 7 (median values).

The range of the estimated distribution for the number of newly affected EU MSs is narrower for scenario A_0 (about 23 times) compared to scenario A_2 (about 34 times), and for scenario A_2 compared to scenario A_1 (about 50 times), implying relatively larger uncertainty for scenario A_1 compared to scenarios A_0 and A_2.

With respect to the assessment of the risk of impacts due to *C. parasitica* under scenarios A_0, A_1 and A_2, the Panel focused only on the new, virulent strains of the pathogen, which are able to overcome hypovirulence and cause damage. Based on expert judgment, the proportion of these virulent strains in the newly established *C. parasitica* populations was the same for all scenarios and ranged from 0.1% (1st percentile value) to 0.5% (99th percentile value).

Focusing on the median values, the estimated area with presence of the main host (*C. sativa*) affected by new virulent strains of *C. parasitica* is about two times higher for scenario A_1 compared to scenario A_0 and about three times lower for scenario A_2 compared to scenario A_0.

Under the A_0 and A_1 scenarios, it is expected that, if new virulent strains will appear in the EU, the pathogen will spread across most of the RA area in a limited period (10–20 years). The spread could be faster in case of an important contribution of human-assisted spread (e.g. movement of infected chestnut saplings).

The values in scenario A_1 indicate that, in case of introduction and spread of new virulent strains of the pathogen, thereby jeopardising the currently effective hypovirulence, the impacts would be huge.

The estimated relative impact on ecosystem services (per service providing unit), as a result of the introduction into and spread within the RA area of new virulent strains of *C. parasitica,* is rather consistent for the three types of ecosystem services ((i) provisioning, (ii) regulating and supporting, and (iii) cultural services) within each scenario. Nonetheless, in absolute terms, the expected impacts on ecosystem services are higher for scenario A_1 compared to scenarios A_0 and A_2, as the proportion of the area with the presence of the main host, where new virulent strains will be present, is larger for scenario A_1 compared to scenarios A_0 and A_2.

Although damage caused by new virulent strains of *C. parasitica* could affect the ecosystem services provided by chestnut trees, some ecosystem services could be recovered by the recolonisation by new tree species. However, there are important cultural values associated with chestnut.

C. sativa is an iconic, widespread and locally abundant tree species in forest ecosystems in the EU, particularly in Mediterranean countries. The loss of this tree species would lead not only to a reduction in ecosystem services, but also to a loss in the biodiversity associated with this tree species, although there is lack of knowledge to quantify such a biodiversity reduction. It is also possible that, by replacing homogeneous chestnut woodlands with more diverse forest ecosystems, the biodiversity of some taxa present in those ecosystems could increase. But it would take a long time to replace ancient and majestic chestnut trees.

The width of the estimated distributions related to the proportion of the area with the presence of the main host where new virulent strains of *C. parasitica* will be present is wider under scenario A_1 compared to scenarios A_0 and A_2, which implies that the uncertainty on impacts is lower for the A_0 and A_2 scenarios compared to the A_1 scenario. The most important factor contributing to the overall uncertainty related to impacts is the initial proportion of new virulent strains of *C. parasitica*.

The current EU phytosanitary requirements and the additional RROs considered in the A_2 scenario were assessed to be effective (quantitative details about magnitude and uncertainty of this effectiveness can be found in the RA) in reducing the risk of introduction and spread of *C. parasitica,* thus preserving the PZ status in those parts of the Union where the pathogen is not known to occur.

The Panel considered that it is also important to prevent the introduction and spread of new virulent strains of the pathogen in those parts of the Union which are currently affected by the old strains of *C. parasitica*, so as to avoid the risk that hypovirulence will stop working. Even if the introduction of new virulent strains is not expected to be a frequent event, if it occurs, it would have dramatic consequences on crop production and ecosystem services related to chestnut.

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1. Introduction

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

The European Food Safety Authority (EFSA) is requested, pursuant to Article 22(5.b) and Article 29 (1) of Regulation (EC) No 178/2002[2], to provide a scientific opinion in the field of plant health. Specifically, as a follow up to the request of 29 March 2014 (Ares(2014)970361) and the pest categorisations (step 1) delivered in the meantime for 38 regulated pests, EFSA is requested to complete the pest risk assessment (PRA), to identify risk reduction options (RROs) and to provide an assessment of the effectiveness of current European Union (EU) phytosanitary requirements (step 2) for (1) *Ceratocystis platani* (Walter) Engelbrecht et Harrington, (2) *Cryphonectria parasitica* (Murrill) Barr, (3) *Diaporthe vaccinii* Shaer, (4) *Ditylenchus destructor* Thorne, (5) *Eotetranychus lewisi* (McGregor), (6) grapevine flavescence dorée and (7) *Radopholus similis* (Cobb) Thorne.

During the preparation of these opinions, EFSA is requested to take into account the recommendations, which have been prepared on the basis of the EFSA pest categorisations and discussed with the Member States (MSs) in the relevant Standing Committee. In order to gain time and resources, the recommendations highlight, where possible, some elements which require further work during the completion of the PRA process.

Recommendation of the Working Group on the Annexes of the Council Directive 2000/29/EC – Section II – Listing of Harmful Organisms as regards the future listing of *Cryphonectria parasitica* (Murrill) Barr.

Current regulatory status

Cryphonectria parasitica (Murrill) Barr is regulated in Annex IIAII (c).3 of Council Directive 2000/29/EC on plants of *Castanea* Mill and *Quercus* L., intended for planting, other than seeds.

Specific requirements are laid down in Annex III (Part A) as regards prohibition of introduction of plants of *Castanea* Mill., and *Quercus* L., with leaves, other than fruit and seeds, from non-European countries; Annex IV as regards special requirements which must be laid down by all the MSs for the introduction and movement of plants, plant products and other objects into and within all the MSs; Annex V as regards plant health inspection before certain host plants can enter the European territory.

Supplementary requirements are laid down for Protected Zones (PZs) (the CZ, IE, SE and the UK) as part of Annex IIB and Annex IVB.

Identify of the pest

The fungus can be identified either from its characteristics fruiting structures formed *in situ*, after incubation under damp conditions, or by isolation in culture. A DNA-based identification is possible to identify the specific strain. *C. parasitica* is a clear taxonomic entity and sensitive and reliable methods exist for its detection and identification, as well as for its discrimination from other related fungal plant pathogens.

Distribution of the pest

C. parasitica is reported in the 15 EU MSs. In the six MSs (Croatia, Hungary, Italy, Portugal, Slovenia and France), the pathogen is present in all (or almost all) of the areas where the host plants occur; in the seven MSs (Austria, Belgium, Bulgaria, Germany, Greece, Slovak Republic and Spain) with a restricted distribution, and in the two MSs, it is under eradication (the Netherlands and the UK). In the Czech Republic, the pathogen was eradicated. Literature confirms the presence of *C. parasitica* also in Romania and Greece.

No information is available in the literature or in the European and Mediterranean Plant Protection Organization (EPPO) Plant Quarantine Retrieval (PQR) database on the pest status in Cyprus, Latvia, Lithuania, Luxembourg, Iceland or Norway. *C. parasitica* is already well spread within the PRA area, except in restricted area.

Potential for establishment and spread in the PRA area

The three main hosts of *C. parasitica* are American sweet chestnut (*Castanea dentata*), European sweet chestnut (*Castanea sativa*) and durmast oak (*Quercus petrea*). The main host species are

[2] 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, 1.2.2002, p. 1–24.

present in the risk assessment (RA) area. The fungus seems to be present in most of the countries where sweet chestnut *C. sativa* is present in large quantities (except the UK).

There are no obvious ecological or climatic factors limiting the establishment and spread of the pathogen in the EU MSs where the pest is known to occur.

C. parasitica can be spread locally by wind and/or rain, but might also occasionally be carried by other agents, such as arthropods and birds. *C. parasitica* can spread over long distances via the movement of infected host plants for planting (rootstocks, scions, grafted plants, self-rooted plants, etc.), particularly asymptomatic (i.e. either latently infected or tolerant to infection) and infected wood with bark.

Potential for consequences in the PRA area

No or very little impact is noted on *Quercus* in some MSs (e.g. FR). Regulation on *Quercus* seems only justified in order to prevent introduction in non-contaminated areas.

C. parasitica causes cankers, wilt and diebacks, resulting sometimes in the death of its hosts (when on *Castanea*). Disease prevalence ranges from less than 1% in the recently infested areas (such as Germany) to more than 90% in the countries where the pathogen has existed for a long time (e.g. Italy, France, Switzerland, Portugal, etc.). However, there is no direct relationship between disease prevalence and impact.

Overall, *C. parasitica* can have considerable direct or indirect impacts in the EU, including economic and environmental effects.

Recommendation

Considering the wide distribution of this pest, and the fact that eradication and containment measures are not effective any longer in the MSs where the pathogen has existed for a long time, the Working Group suggests listing this organism as a Regulated Non-Quarantine Pest (RNQP).

However, the protected zone (PZ) status should be maintained as a possibility for those MSs that have proved to be still free from *C. parasitica*. Also Annex III (Part A) as regards prohibition of introduction of plants of *Castanea* Mill., and *Quercus* L., with leaves, other than fruit and seeds, from non-European countries, should remain. Equivalent requirements for movement of host plants have to be set in order to retain the same level of protection.

The Working Group highlights that the classification as a RNQP would promote the development of the use of hypovirulence (through inoculation).

Given the RNQP status proposed and the presence of some PZs in the EU, the Standing Committee requested to complete the PRA for this pest in order to assess the current EU phytosanitary requirements and identify the risk reduction options which may be considered to preserve the PZ status in some parts of the Union.

1.2. Interpretation of the Terms of Reference

The Panel interprets the Terms of Reference (ToR) as a request for conducting a full PRA for *C. parasitica*, following the pest categorisation already delivered by the Panel (EFSA PLH Panel, 2014). In fact, the PZ status in some parts of the Union can be broken by: (i) introduction and subsequent spread of *C. parasitica* from Third Countries and (ii) spread of *C. parasitica* from the EU areas in which the pathogen is present and widespread (hereinafter named non-protected zones, non-PZs).

In this PRA, the Panel considers that the RA area (i.e. the EU territory) is currently split in two areas:

1) the areas in which the pathogen is present and widespread (see pest categorisation, EFSA PLH Panel, 2014), for which requirements exist in Council Directive 2000/29/EC for the pest and its hosts (non-PZs);
2) the protected zones (the Czech Republic, Ireland, Sweden and the UK), in which the pathogen is not known to occur and for which measures are in place according to Annex IV, Part B of Directive 2000/29/EC.

In the non-PZs, hypovirulence has reduced the impact of chestnut blight disease (Robin and Heiniger, 2001); the unencapsidated RNA virus *Cryphonectria hypovirus 1* (CHV1) reduces the virulence of the fungal strains so that they produce non-lethal cankers, thus allowing chestnut trees to overcome the disease (Newhouse et al., 1990; Nuss, 1992; Heiniger and Rigling, 1994; Milgroom and Cortesi, 2004). Reasons why the virus has established itself and perseveres in large populations across Europe were recently reviewed by Zamora et al. (2017).

Introduction from Third Countries and consequent spread of new, virulent strains of *C. parasitica* able to jeopardise the currently effective hypovirulence and potentially cause severe impact cannot be excluded. Therefore, the Panel decided to address this risk in this Risk Assessment. The movement of *C. parasitica* strains within affected areas of the EU (e.g. from France to Italy, from Italy to Greece, etc.) could also potentially reduce the effectiveness of hypovirulence by increasing the genetic diversity of the pathogen. However, since there is no evidence for this reduction so far, the Panel did not consider the potential consequences of the movement of strains within the already affected areas of the EU.

The additional risk of potential spread to the PZs of *C. parasitica* strains currently present in the EU non-PZs has also to be considered.

Information already provided in the pest categorisation (EFSA PLH Panel, 2014) is not repeated here.

1.3. Specification of the scenarios

Three main scenarios (with the whole of the EU as the RA area) were defined in this risk assessment:

- The A_0 scenario describes the current regulatory situation in non-PZs with respect to the EU legislation (Council Directive 2000/29/EC). This scenario makes it possible to assess the effectiveness of the current EU phytosanitary requirements in reducing the risk of introduction into and spread within the RA area of new, virulent *C. parasitica* strains originating from Third Countries.
- The A_1 scenario describes a regulatory situation without RROs.
- The A_2 scenario describes the current regulatory situation in the PZs (the Czech Republic, Ireland, Sweden and the UK), with some measures being already in place (Annex IV, Part B of Directive 2000/29/EC) and additional RROs (to be applied in all the EU MSs). This scenario makes it possible to assess the effectiveness of the RROs which may be considered to: (i) preserve the PZ status in some parts of the Union, as requested in the ToR; and (ii) reduce the risk of introduction and spread in the RA area of new, virulent *C. parasitica* strains originating from Third Countries.

A summary of the RROs considered in scenarios A_0 and A_2 is reported in Appendix C. All the scenarios also include the current agricultural practices (Good Agricultural Practices) commonly adopted in the RA area.

All three scenarios refer to *Castanea* spp. (chestnut), which is considered the main host, and not to *Quercus* spp. (oak) because the presence of *C. parasitica* on *Quercus* spp. is rare. The conclusions on the effectiveness of the RROs for chestnut are in the view of the Panel also applicable to oak, but no further analysis was undertaken to support this assertion.

In all the three scenarios, the assessment of introduction and spread was performed for those pathogen strains not yet present in the EU (or in parts of the EU, i.e. the protected zones). These strains may be different in virulence and ability to spread; they can also generate new strains, with different virulence. The assessment of impact was carried out for virulent strains only, because hypovirulent strains do not generally cause relevant damage to plants.

1.3.1. Definitions specific for the assessment

1.3.1.1. Pathways of entry

The Panel identified the following pathways for the entry of *C. parasitica* into the RA area:

- plants for planting (including seedlings, scions, rootstocks, ornamental plants)
- wood with bark (including chips, wood for tannin production, hoops for barrels)
- fruit (nuts)
- soil and growing media (including isolated chestnut bark)
- natural spread of airborne inoculum
- biological agents able to mechanically transfer the fungus (e.g. birds, mammals, insects, mites, etc.)
- machinery (construction, terracing, etc.) and pruning/cutting tools.

Of the above-mentioned pathways, only the plants for planting and the wood with bark pathways are considered as major pathways for the entry of the pathogen into the RA area.

Plants for planting

Young *Castanea* spp. plants used for new plantations may carry cankers due to *C. parasitica*. Even if healing or healed such cankers could potentially introduce new strains of the fungus, causing a risk of new epidemic outbreaks. To avoid this risk, plants need to be carefully inspected and infected ones have to be destroyed.

Different species of *Quercus* can host the parasite (see EFSA PLH Panel, 2014). However, until now *C. parasitica* has affected mainly or exclusively chestnuts. Where the fungus is established in Europe (e.g. Italy, France, Switzerland), no epidemic has been recorded on other hosts. Similarly, in nurseries, infections of *C. parasitica* on young oaks are not reported, even when the pathogen is present on chestnuts. Infections of oaks can be considered rare and limited, mainly related to the first stages of the epidemic.

Wood with bark

C. parasitica is a bark pathogen, able not only to colonise the bark causing cankers but also to survive as endophyte and as spores in the bark. It is supposed that the first introduction of the pathogen into Europe was due to infected chestnut wood.

Debarking can remove almost all the potential inoculum of *C. parasitica*. Consequently, this measure can significantly reduce the risk of introduction of new fungal strains. However, fungal mycelium (typical pale brown-yellow, flat fans) sometimes may survive on the wood under the bark. Its presence can be detected by visual inspection of the wood after debarking. Potentially, mycelia can be killed by heat treatment of the wood.

Nuts

Chestnut nuts are considered a minor pathway of entry. Although *C. parasitica* may occasionally colonise the external part of the nuts (Collins, 1915; Jaynes and DePalma, 1984), the colonisation rate is generally very low. Even if the number of imported nuts from areas where chestnut blight is present (mainly China and Turkey) has drastically increased in the last decade (following the introduction of the chestnut gall wasp into Europe), nuts go directly to the market, without any contact with chestnut orchards. Moreover, most of the times the nuts are treated to improve conservation. For these reasons, this pathway can be considered of minor importance.

Soil and growing media

There is no evidence that *C. parasitica* was introduced into a new country or area through infested soil. Thus, soil can be considered as a minor pathway. Chestnut bark may theoretically harbour *C. parasitica* inoculum, e.g. stromata on the bark pieces, mycelium attached to the bark or infected wood chips mixed with the bark. However, the use of loose bark is limited to ornamental plants in nurseries and it is very unlikely that this material is used in chestnut orchards. Moreover, the import of isolated chestnut bark from Third Countries is prohibited in the EU (see Council directive 2000/29/EC, annex III, part A, point 5). Therefore, it can be considered a minor pathway of entry.

Natural spread of airborne inoculum and spread by biological agents

Both pathways are probably fundamental for the spread of *C. parasitica* within the chestnut distribution range in the three continents (Asia, Europe and North America) where species of chestnut (*Castanea*) occur (e.g. ascospores, Heald et al., 1915; birds, Heald and Studhalter, 1914). However, there is no evidence that these two pathways played a role in the introduction of new strains of the fungus into the RA area. Thus, natural spread of airborne inoculum and spread by biological agents can be considered as mechanisms of minor importance.

Machinery (construction, terracing, logging, etc.)

Machinery is not considered to pose a risk for the introduction of the pathogen into the RA area because such machinery is generally not used in chestnut orchards or plantations. There are no studies showing that *C. parasitica* can be introduced with pruning tools. Grafting knives may transmit the disease, but this is more a local issue potentially relevant for the spread and not for the entry of the pathogen.

1.3.1.2. Mechanisms of spread

The main mechanisms of spread of the pathogen, in addition to those mentioned as pathways of entry, are:

- human activities (grafting, pruning, transport of firewood and poles)
- natural spread of waterborne inoculum.

The Panel considers three mechanisms as relevant for the spread of *C. parasitica* in the RA area: (1) human activities; (2) natural spread; and (3) biological agents able to mechanically transfer the fungus (birds, mammals, insects, mites, etc.).

For a detailed description of the mechanisms of spread of *C. parasitica* in the RA area, the reader should refer to the pest categorisation of the pathogen (EFSA PLH Panel, 2014).

1.3.1.3. Unit definitions

Pathway units

For the plants for planting pathway, a single *Castanea* plant was chosen as a pathway unit.

For the wood pathway, 1 m^3 of wood was chosen as a pathway unit, as this is the unit used in the Eurostat database.

1.3.1.4. Definition of abundance of the pest

Pest abundance is defined similarly for the two pathways of entry. More specifically, for the plants for planting pathway, pest abundance (prevalence) is defined as the percentage of infected plants for planting, and for the wood pathway, the percentage of infected m^3 of wood. In the impact section (3.4), pest abundance (prevalence) is defined as percentage of plants carrying new virulent strains.

1.3.1.5. Definitions relevant to the Risk Reduction Options (RROs)

The RROs are defined according to the guidance provided by the EFSA PLH working group on the methodology for quantitative risk assessment. Details on RROs are provided in Appendix C.

1.3.1.6. Ecological factors and conditions

The assessment was performed considering the current ecological conditions. No additional scenarios were defined in relation to ecological factors and conditions in the RA area.

1.3.2. Temporal and spatial scales

See Section 1.3.3.

1.3.3. Summary of the different scenarios

Table 1 provides a summary of the key elements for the three scenarios considered in the Risk Assessment.

Table 1: Summary of the key elements of the scenarios of this Risk Assessment

Scenarios A_0, A_1 and A_2		
Definitions	Pathways	**ENTRY** 1) Host plants for planting 2) Wood with bark
	Mechanisms	**SPREAD** Human activities, natural spread and biological agents (i.e. the most important mechanisms of spread) were assessed altogether
	Pathway unit a) Entry b) Establishment	**a) Entry** 1) Plants for planting: one single *Castanea* plant 2) Wood: 1 m^3 (Eurostat unit of measure)

Scenarios A_0, A_1 and A_2		
	c) Spread	**b) Establishment** For both pathways of entry (see above): one living infected *Castanea* plant (founder population) **c) Spread** One single EU MS
	Pathway subunit a) Entry b) Establishment c) Spread	Not considered
	Abundance of the pest in the a) Production/growing area b) Pathway unit c) Pathway subunit d) Transfer unit	a) % infected host plants b) and d) for pathway 1: % infected host plants for pathway 2: % of infected m^3 of wood
	Production unit	Single plants
	Service providing unit	Chestnut orchard or stand
	Critical value economically important losses: quantity	No threshold because the assessment is for virulent strains which cause severe damage on plants
	Critical value economically important losses: quality	As above for quantity
	Critical value environmentally important losses	As above for quantity

Assessment		**Steps**			
		Entry	**Establishment**	**Spread**	**Impact**
Scenario	All pathways	No change is expected with regard to the pathways of entry in the time horizon (10 years)	No change is expected with regard to the establishment in the time horizon (10 years)	No change is expected with regard to the mechanisms of spread in the time horizon (10 years)	No change is expected with regard to the impact in the time horizon (10 years)
	RROs	See Appendix C	See Appendix C	See Appendix C	See Appendix C
	Ecological factors and conditions	Current situation	Current situation	Current situation	Current situation
Scales	Temporal horizon	10 years	10 years	10 years	10 years
	Temporal resolution	1 year	1 year	1 year	1 year
	Spatial extent	RA area	RA area	RA area	RA area
	Spatial resolution	RA area	RA area	EU MSs	RA area

RA: risk assessment; NUTS: Nomenclature of Territorial Units for Statistics.

2. Data and methodologies

2.1. Data

The literature search (up to August 2016) followed the strategy described in the pest categorisation, so as to retrieve relevant papers that appeared since 2014, when the pest categorisation was published (EFSA PLH Panel, 2014). The content of these publications is considered in the risk assessment wherever relevant.

Data on which to base most of the quantitative estimations presented here were either missing or incomplete. Expert judgment was thus used in most cases. The quantitative estimations provided by the experts should thus be taken with caution, as different experts might provide different figures in such a situation of lack of evidence. One exception was the historical spread of the pathogen through

Europe, for which the dates of first report were available at the level of MSs, thanks to previous literature compilations (Robin and Heiniger, 2001).

2.2. Methodologies

The Panel performed the pest risk assessment for *C. parasitica* following the guiding principles presented in the EFSA Guidance on a harmonised framework for risk assessment (EFSA PLH Panel, 2010) and as defined in the International Standard for Phytosanitary Measures (ISPM) No. 11 (FAO, 2013).

When conducting this pest risk assessment, the Panel took into consideration the following EFSA horizontal guidance documents:

- Guidance of the Scientific Committee on Transparency in the Scientific Aspects of risk assessments carried out by EFSA. Part 2: General Principles (EFSA, 2009),
- Guidance on Statistical Reporting (EFSA, 2014),
- Guidance on the structure and content of EFSA's scientific opinions and statements (EFSA Scientific Committee, 2014),
- Guidance on uncertainty (EFSA Scientific Committee, 2016).

The assessment follows a quantitative approach, in which the steps of entry, establishment, spread and impact are elaborated quantitatively for the three pathways identified under three RRO scenarios, identified as A_0, A_1 and A_2, according to the ToR. Within each step, substeps are distinguished to quantitatively assess the underlying component processes. An overall summary description of the steps is provided in Appendix B which describes the overall risk assessment model without mathematical equations.

Uncertainty involved in estimating entry, establishment, spread and impact, is represented using a probability distribution which expresses the best estimates of the variables provided by the experts considering both available data and judgement. The distribution is characterised by a median value and four additional percentiles of the distribution. The median is the value for which the probability of over- or underestimation of the actual true value is judged as equal. Calculations with the model are made by stochastic simulation, whereby values are drawn randomly from the distribution specified for each parameter. The stochastic simulations are repeated 20,000 times to generate a probability distribution of outcomes, i.e. the outcome of the entry, establishment, spread and impact process in a given time period in the future.

In the model calculation, the uncertainty of each component is passed through the model equation, in a way that its contribution to the uncertainty of the final result can be shown. The decomposition of uncertainty calculates the relative contribution (as a proportion) of each individual input to the overall uncertainty of the result (sum to 1).

Section 3 of the assessment reports the outcomes of scenario calculations. The distributions given in this section characterise the possible range of outcomes at the time horizon of the opinion under a certain scenario.

The distributions of the uncertain components are characterised by different values and ranges:

The median is a central value with equal probability of over- or underestimating the actual value. In the opinion, the median is also referred as 'best estimate'.

The interquartile range is an interval around the median, where it is as likely that the actual value is inside as it is likely that the actual value is outside that range. The interquartile range is bounded by the 1st and 3rd quartile (the 25th and 75th percentile) of the distribution. This range expresses the precision of the estimation of interest. The wider the interquartile range, the greater is the uncertainty on the estimate. In this opinion, we refer to the interquartile range using the term 'uncertainty interval'.

For experimental designs, it is common to report the mean (m) and the standard error ($\pm$ s) for the precision of the estimate of a measured parameter. The interval: $m \pm s$ ($[m - s, m + s]$) is used to express an interval of likely values. This estimation concept is based on replicated measurements. In the context of uncertainty, it is not reasonable to assume replicated judgements. Therefore, the median and interquartile range are used instead of the mean and the interval $m \pm s$, but the interpretation as the precision of judgements is similar.

In addition to the median and interquartile range, a second range is reported: the credibility range. The credibility range is formally defined as the range between the 1st and 99th percentile of the distribution allowing the interpretation that it is extremely unlikely that the actual value is above the range, and it is extremely unlikely that it is below the range.

Further intervals with different levels of coverage could be calculated from the probability distribution, but these are not reported as standard in this opinion.

Please note that the number of significant figures used to report the characteristics of the distribution does not imply the precision of the estimation. For example, the precision of a variable with a median of 13 could be reported using the associated interquartile range, perhaps 3–38, which means that the actual value is below a few tens. In the opinion, an effort was made to present all results both as a statement on the model outcome in numerical expressions, and as an interpretation in verbal terms.

Nevertheless, the distributions of one variable under different scenarios can be compared via the corresponding median values, e.g. consider a variable with a median value of 13 within scenario 1 and the same variable with a median value of 6 within scenario 2. This can be interpreted as the variable in scenario 2 being about half of scenario 1 in terms of its central value. The same principle is also valid for other characteristics of the distribution of a variable under different scenarios, such as comparisons of quartiles or percentiles.

2.3. Integration of risk reduction options

A quantitative assessment (mostly based on expert judgment, due to lack of evidence) was provided for the effectiveness of the combined RROs in scenarios A_0 and A_2. Details on RROs are shown in Appendix C.

3. Summary of the assessment

The Panel assessed the risk of entry, establishment, and spread as well as the impact of *C. parasitica* for the three scenarios (A_0, A_1 and A_2) described in Section 1.3.

3.1. Entry

The model of entry shown in Appendix A was used for the assessment of the various substeps of the entry process. The main characteristics of the three scenarios considered (A_0, A_1 and A_2) and of the two pathways of entry (host plants for planting and wood with bark) are described in Section 1.3. The differences between scenarios are obtained from a multiplication factor specific to scenarios A_1 and A_2 expressing in quantitative terms the effectiveness of the RROs.

3.1.1. Presentation of the results

The results of the entry assessment (described in detail in Appendix B.1) are shown in Table 2 (all pathways combined) and Figure 1 (by individual pathway and for all pathways combined). The end point of the entry model is the number of potential founder populations across the EU territory. Not all potential founder populations will result in an actual founder population as this requires establishment. Establishment is assessed in Section 3.2. Table 2 reports five quantile values (1st, 25th, 50th, 75th and 99th) of the number of potential founder populations of *C. parasitica* expected per year due to new entries in the EU in the next 10 years for scenarios A_0, A_1 and A_2, whereas Figure 1 shows the estimated continuous probability distribution associated to the values of the number of potential founder populations.

Table 2: Quantile values of the distribution of the number of potential founder populations of *C. parasitica* expected per year due to new entries in the EU in the next 10 years for scenarios A_0, A_1 and A_2 (all pathways combined)

Overall assessment Quantile	Low (1%)	1st quartile (25%)	Median (50%)	3rd quartile (75%)	High (99%)
Number of potential founder populations for scenario A_0	0.1	4.3	15	41	322
Number of potential founder populations for scenario A_1	82	2,100	4,500	8,500	32,000
Number of potential founder populations for scenario A_2	0.00001	0.001	0.004	0.014	0.32

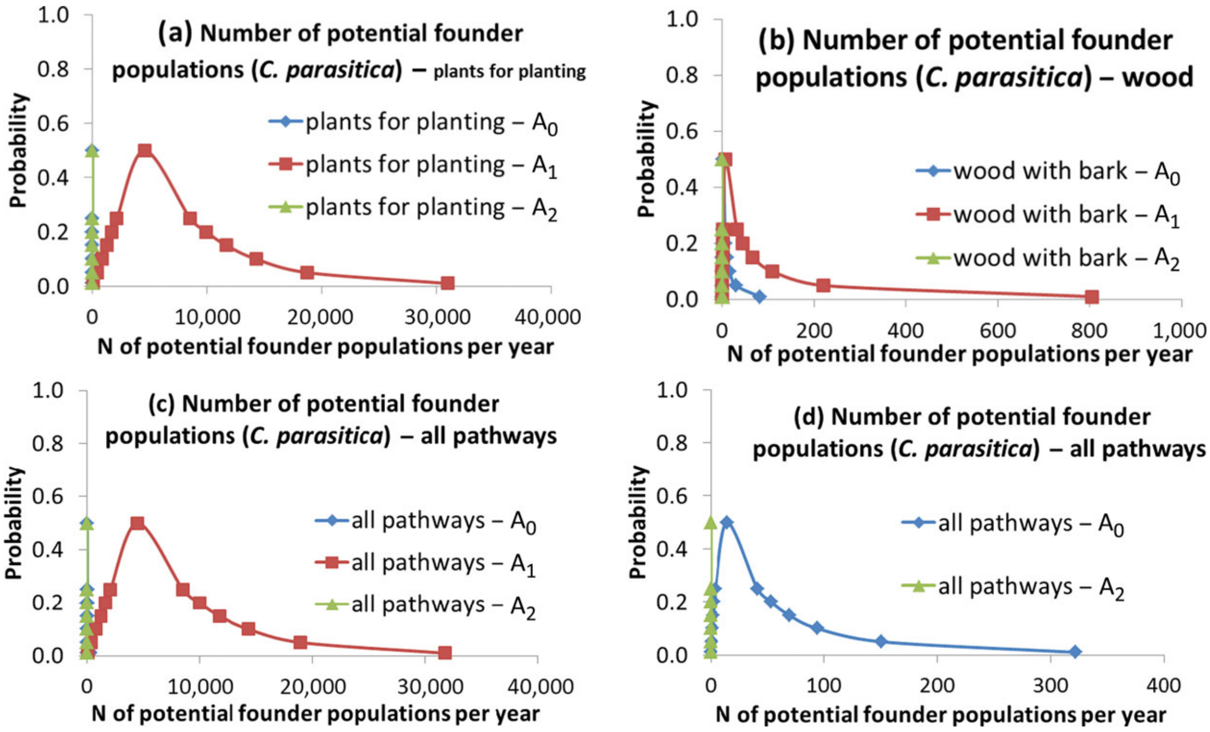

Figure 1: Graphs showing the outcomes of the assessment for entry with regard to the number of potential founder populations of *C. parasitica* per year for the three scenarios (A_0, A_1 and A_2) and the two different pathways, (a, b) individually and (c) combined. As in graph (c) the much higher number of founder populations resulting from scenario A_1 makes it difficult to notice the differences between scenarios A_0 and A_2, an additional graph (d) with just the two latter scenarios is included for all pathways together

Two main points can be highlighted:

1) Most of the potential founder populations are due to the plants for planting pathway (Figure 1a), while the number of expected entries due to the wood with bark pathway is two orders of magnitude lower (Figure 1b).
2) For the wood with bark pathway (Figure 1b), the A_0 scenario and the A_1 scenario are overlapping; this is because there are no measures in place for the chestnut wood with bark. The measures considered in scenario A_2 would be able to remove most of the risk of further entries of the pathogen into the RA area due to this pathway.

3.1.2. Uncertainty

The uncertainty associated with the different scenarios is given by the range in the predicted number of potential founder populations per year as shown in Table 2 and Figure 1. The contribution to the overall uncertainty of the various factors considered in the entry assessment is shown in Figure 2.

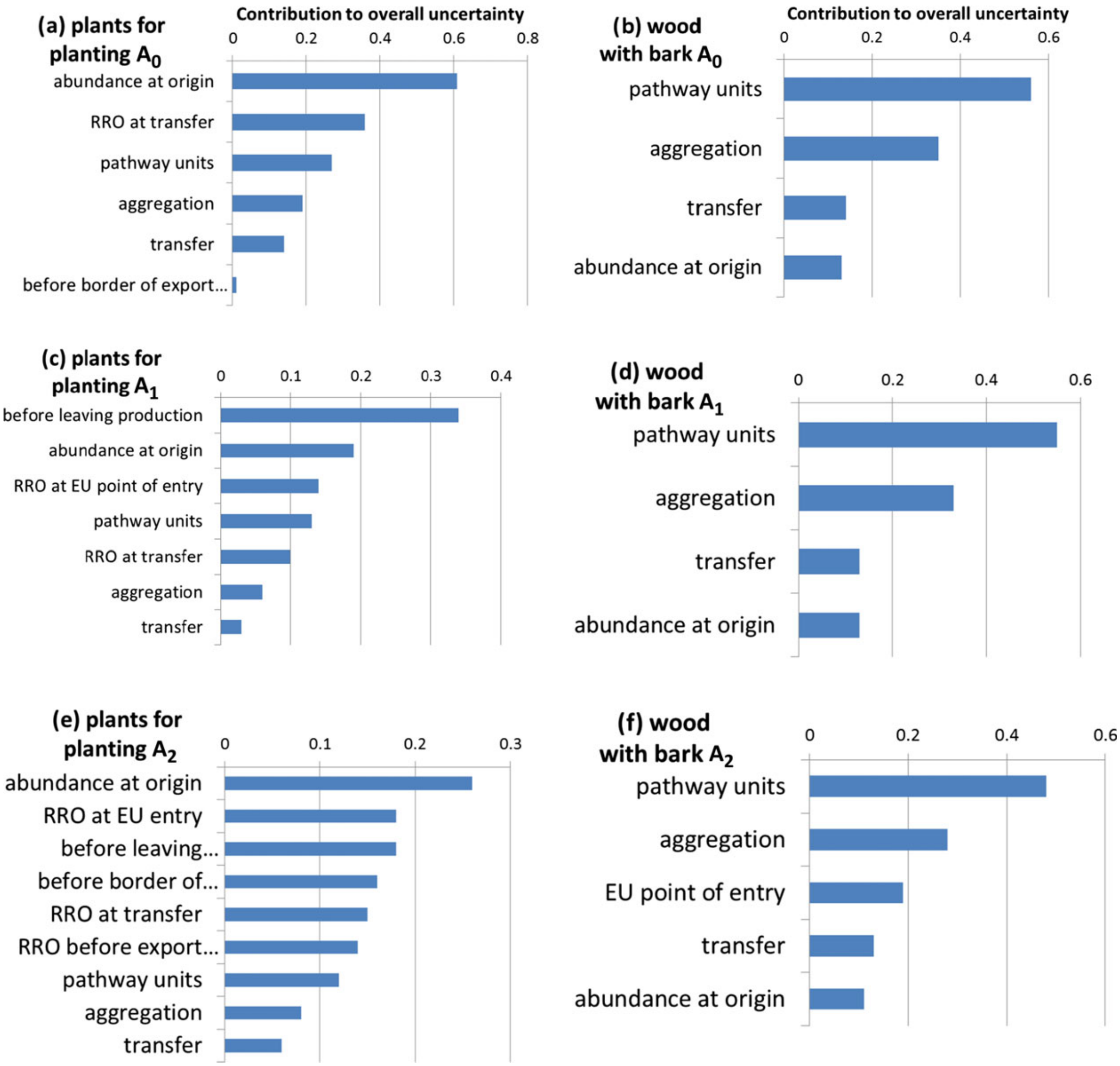

Figure 2: Bar charts showing an index for the uncertainty associated with parameter estimates for factors influencing the entry of *C. parasitica* into the risk assessment area for the two pathways (a, c, e) host plants for planting and (b, d, f) wood with bark, and the three scenarios: (a, b) A_0, (c, d) A_1 and (e, f) A_2)

3.1.3. Discussion on the entry assessment

- Under the conditions of the scenarios of this Risk Assessment, the entry of about 150 potential founder populations (median value) of *C. parasitica* is expected in 10 years in the RA area in scenario A_0. In scenario A_1, the number of potential founder populations (median values) increases to 45,000, whereas in scenario A_2 this number decreases to 0.04.
- The number of potential founder populations (median values) due to both pathways is thus expected to be about 300 times higher under scenario A_1 compared to scenario A_0. The number of potential founder populations (median values) due to both pathways is expected to be about 4,000 times higher under scenario A_0 compared to scenario A_2. As the additional RROs are expected to be particularly effective, the difference in the expected values of potential founder populations (median values) between the A_1 and A_2 scenario is of 6 orders of magnitude.
- Under the A_1 scenario in the 99th percentile (the worst case), the expected number of founder populations becomes even more considerable. This value considers that there might be additional affected Third Countries which may not currently be recognised as having the disease.

- The entry assessment highlighted important differences among the various entry pathways, with plants for planting as the most important pathway. The number of potential founder populations (median values) due to the plants for planting pathway is expected to be about eight times higher than that for the pathway wood with bark for scenario A_0 and about 600 times higher for scenario A_1. In the A_2 scenario, there would be limited remaining risk of entry for both pathways, which makes it not meaningful to compare the number of potential founder populations for the two pathways.
- The uncertainty associated with the estimated numbers of potential founder populations is evaluated in terms of the width of the distribution. The estimated distribution for the number of potential founder populations in scenario A_1 has a range of about 400 times between the 99th percentile and the 1st percentile value, implying relatively limited uncertainty. The uncertainty for the A_0 (ratio of 99th and 1st percentile values = 5,000) and A_2 (ratio of 99th and 1st percentile values = 30,000) scenarios is higher compared to the A_1 scenario.
- The relative contribution of the considered factors influencing entry to the overall uncertainty varies between pathways and scenarios. In general, there are no dominant factors to which a major contribution to the overall uncertainty regarding entry can be attributed.
- For all scenarios, the pathogen abundance at the origin and the number of pathway units are key factors contributing to uncertainty in the plants for planting and the wood with bark pathways, respectively. Further work would thus be required to improve the data availability about trade volumes of chestnut plants for planting and wood with bark.

3.2. Establishment

The assessment of the establishment process followed the model of establishment described in Appendix A. In the model, the contribution of various factors affecting establishment was considered, with only host presence assessed to be a relevant factor affecting establishment. The differences between scenarios are obtained from a multiplication factor specific to scenarios A_1 and A_2 expressing in quantitative terms the effectiveness of the RROs.

3.2.1. Presentation of the results

The results of the establishment assessment (described in detail in Appendix B.2) are shown in Table 3 and Figure 3. Table 3 reports five quantile values (1st, 25th, 50th, 75th and 99th) of the number of established populations per year of *C. parasitica* due to new entries expected for scenarios A_0, A_1 and A_2 in the next 10 years, whereas Figure 3 shows the estimated continuous probability distribution associated with the values of established populations.

Table 3: Quantile values of the distribution of the number of established populations of *C. parasitica* due to new entries per year in the EU for scenarios A_0, A_1 and A_2 (time horizon = 10 years)

Overall assessment Quantile	Low (1%)	1st quartile (25%)	Median (50%)	3rd quartile (75%)	High (99%)
Number of established pathogen populations in the risk assessment area in scenario A_0	0.04	3	10	28	223
Number of established pathogen populations in the risk assessment area in scenario A_1	58	1,500	3,220	6,200	23,400
Number of established pathogen populations in the risk assessment area in scenario A_2	0.000005	0.00004	0.002	0.008	0.17

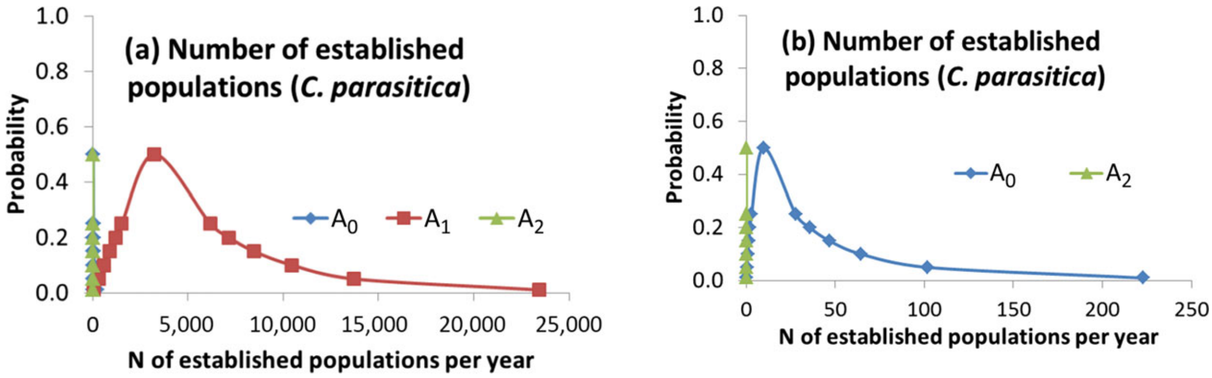

Figure 3: Graphs showing the outcome of the assessment for establishment with regard to the number of established populations of *C. parasitica* per year under the three scenarios (A_0, A_1 and A_2), for all the pathways combined. As in graph (a) the much higher number of established populations resulting from scenario A_1 makes it difficult to notice the differences between scenario A_0 and A_2, an additional graph (b) with just the two latter scenarios is included

The area of potential establishment is essentially the distribution range of the host (*C. sativa*). For more information, the reader is referred to the pest categorisation (EFSA PLH Panel, 2014).

3.2.2. Uncertainty

The uncertainty associated with the different scenarios is given by the range in the predicted number of established populations per year as shown in Table 3 and Figure 3. The contribution to the overall uncertainty of the various factors considered in the entry assessment is shown in Figure 4.

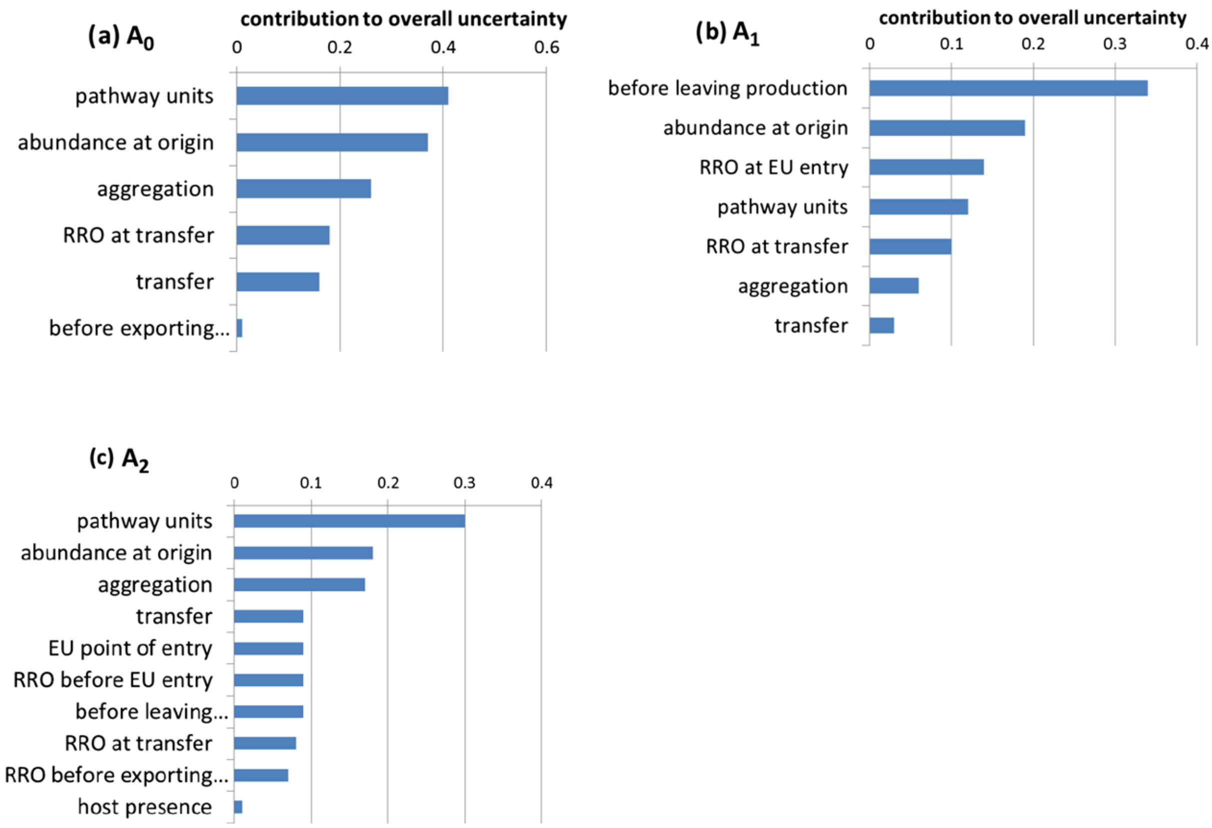

Figure 4: Bar charts showing an index expressing the contribution of the factors considered in the establishment to the overall uncertainty in the assessment of the number of established populations of *C. parasitica* in the RA area for the three scenarios considered

3.2.3. Discussion on the establishment assessment

- Under the conditions of the scenarios of this Risk Assessment, the establishment of about 100 (median value) new established populations of *C. parasitica* is expected over the next 10 years in the RA area under scenario A_0; in case all the relevant EU requirements are removed (scenario A_1), the number of new potential founder populations increases to 33,200, whereas in case the current EU regulations are maintained for the PZs and the additional RROs of scenario A_2 are implemented, the number decreases to 0.02.
- The ratios between the expected numbers of established populations in the different scenarios reflect the situation in the entry assessment. The number of established populations is expected to be about 300 times higher for the A_1 scenario compared to the A_0 scenario. In turn, the number of established populations is expected to be about 5,000 times higher for the A_0 scenario compared to the A_2 scenario. There is a difference of 6 orders of magnitude between the expected number of established populations for the A_1 scenario compared to the A_2 scenario.
- Under the A_1 scenario in the 99th percentile (the worst case), the expected number of established populations (about 23,000 per year) becomes even more considerable.
- The uncertainty associated with the estimated numbers of established populations is evaluated in terms of the width of the distribution. The estimated distribution for the number of established populations in scenario A_1 has a range of about 400 times between the 99th percentile and the 1st percentile value, implying relatively limited uncertainty. The uncertainty is higher under scenarios A_0 and A_2, as the width of the distribution is larger for the A_0 (ratio of 99th and 1st percentile values = 5,000) and A_2 (ratio of 99th and 1st percentile values = 38,000) scenarios compared to the A_1 scenario.
- The relative contribution to the overall uncertainty of the factors considered for the establishment assessment varies between scenarios (Figure 4), but for all scenarios, the number of pathway units is a key factor. Further work would thus be required to improve the data availability on trade volumes.

3.3. Spread

The assessment of the spread process followed the model of spread described in Appendix A. A simplified approach was used because the pathogen is already present in almost all EU MSs (see Appendices B.3.1 and B.3.2). Instead of using an exponential or logistic model, the Panel simply estimated the number of newly occupied EU MSs due to spread over the 10 years considered in the risk assessment. In scenario A_0, the contribution of newly established populations is limited and can be disregarded, as the pathogen is already present in almost all EU MSs and it can be expected that newly established populations will appear in already occupied spatial units. The same applies to scenario A_2. In the A_1 scenario, the contribution of spread was instead disregarded. This is because the high numbers of new established populations (under the assumption that they are randomly distributed) are able to occupy all EU MSs with presence of the host, without having to consider spread.

3.3.1. Presentation and interpretation of the results

The results of the spread assessment (described in detail in Appendix B.3) are shown in Table 4 and Figure 5. Table 5 reports five quantile values (1st, 25th, 50th, 75th and 99th) of numbers of EU MSs newly occupied by *C. parasitica* in 10 years for scenarios A_0, A_1 and A_2, whereas Figure 5 shows the estimated probability distribution associated to the number of EU MSs newly occupied by *C. parasitica*. The initial conditions consider the number of EU MSs currently occupied by the pathogen (see Appendix B.3). The quantiles for the A_1 scenario were obtained by subtracting from the estimated number of EU MSs with presence of the host the estimated number of EU MSs with the presence of the host but without the pathogen.

Table 4: Quantile values of the distribution of the number of EU MSs newly occupied by *C. parasitica* over the next 10 years for scenarios A_0, A_1 and A_2 (all mechanisms of spread)

Overall assessment Quantile	Low (1%)	1st quartile (25%)	Median (50%)	3rd quartile (75%)	High (99%)
Number of EU MSs newly occupied by the pathogen for scenario A_0	0.1	1.5	2.0	2.1	2.1
Number of EU MSs newly occupied by the pathogen for scenario A_1	0.1	2.4	3.5	4.6	7.3
Number of EU MSs newly occupied by the pathogen for scenario A_2	0.02	0.3	0.5	0.6	0.8

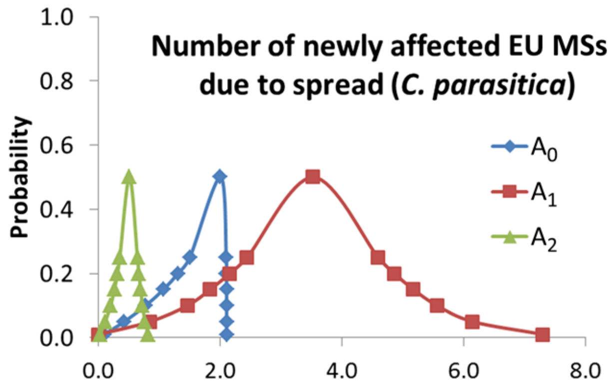

Figure 5: Graph showing the outcome of the assessment for spread with regard to the number of EU MSs newly affected by *C. parasitica* under scenarios A_0, A_1 and A_2 and for all the mechanisms of spread combined, i.e. human activities (grafting, pruning, transport of firewood and poles), natural spread of airborne & waterborne inoculum, biological agents able to mechanically transfer the fungus (e.g. birds, mammals, insects, mites, etc.)

3.3.2. Uncertainty

The uncertainty associated with the different scenarios for spread (A_0 and A_2) is given by the range in the predicted number of newly affected EU MSs as shown in Table 4 and Figure 5.

The uncertainty in scenario A_1 follows from the uncertainty in the estimation of the initial conditions (number of EU MSs already occupied by the pathogen) and in the estimation of the carrying capacity (number of EU MSs with the presence of the host).

The uncertainty breakdown is not provided as a graph for spread, as the only relevant factor is the estimated spread rate of the pathogen per year (1.00 in all cases) with the exception of the A_2 scenario, where also the RROs applied to spread contribute to the uncertainty of the scenario, with a value of 0.19.

3.3.3. Discussion on the spread assessment

- Under the conditions of the scenarios of this Risk Assessment, two (median value) EU MSs in the RA area are expected to be affected due to spread of populations of *C. parasitica* over the next 10 years under scenario A_0; in case all the relevant EU regulations are removed (scenario A_1), the number of EU MSs newly occupied by the pathogen increases to 3.5 (median value), whereas, if the current EU regulations are maintained in the PZs and the additional RROs of scenario A_2 are implemented, the number decreases to 0.5 (median value).
- The RROs considered in scenario A_2 are expected to reduce by about four times the expected number of newly affected EU MSs compared to scenario A_0 (median values). The ratio between the expected number of newly affected EU MSs for the A_1 scenario compared to the A_0 scenario is 1.75, whereas the ratio comparing this number for scenarios A_1 and A_2 is about 7 (median values).
- The uncertainty associated with the estimated numbers of newly affected EU MSs is evaluated in terms of the width of the distribution. The range of the estimated distribution for the

number of newly affected EU MSs is narrower for scenario A_0 compared to scenario A_2, and for scenario A_2 compared to scenario A_1.
- Most EU MSs are now affected by *C. parasitica*, but it is important to prevent the entry, establishment and spread of new strains of the pathogen, so as to reduce the risk that hypovirulence will stop working in the RA area.

3.4. Impact

The Panel assessed the risk of impacts due to *C. parasitica* under scenarios A_0, A_1 and A_2, as defined above. The assessment of the impact process followed the model of impact (see Appendix A). The impact assessment (described in detail in Appendix B.4) focused on the virulent strains of the pathogen, able to overcome hypovirulence. The main issues considered are: the proportion of new strains of *C. parasitica* that are virulent; the proportion of the area with presence of the main host *C. sativa* affected by new virulent strains; and the impact on ecosystem services.

3.4.1. Presentation and interpretation of the results

The proportion of new strains of *C. parasitica* that are virulent (Table 5) was estimated based on expert judgment, taking into account the historical number of entries between the first introduction in the EU and the present time. The estimation was obtained assuming that this proportion is the same for all the scenarios and does not change through time over the 10-year period of the risk assessment.

Table 5: Quantile values of the distribution of the estimated proportion of new virulent strains of *C. parasitica* (the proportion ranges from 0 (no new strains are virulent) to 1 (100% of new strains are virulent)) in the relevant crops/habitats for scenarios A_0, A_1 and A_2

Overall assessment Quantile	**Low (1%)**	**1st quartile (25%)**	**Median (50%)**	**3rd quartile (75%)**	**High (99%)**
Estimated proportion of new virulent strains of the pathogen in the relevant crops/habitats for scenarios A_0, A_1 and A_2	0.0010	0.0025	0.0030	0.0035	0.0050

The impact is estimated considering the proportion of area with presence of the main host *C. sativa* affected by new virulent strains at the end of the assessment period (10 years). The proportion is derived from a simple epidemiological model based on by a logistic growth curve which describes the disease dispersal dynamics (Table 6) (see Appendix A).

Table 6: Quantile values of the distribution of the proportion of area with presence of the main host *C. sativa* affected by new virulent strains of *C. parasitica* in the relevant crops/habitats for scenarios A_0, A_1 and A_2 at the end of the assessment period (10 years)

Overall assessment Quantile	**Low (1%)**	**1st quartile (25%)**	**Median (50%)**	**3rd quartile (75%)**	**High (99%)**
Estimated proportion of the area with presence of *Castanea sativa* affected by new virulent strains (in %) for scenario A_0	14.3%	24.8%	30.6%	37.2%	56.1%
Estimated proportion of the area with presence of *C. sativa* affected by new virulent strains (in %) for scenario A_1	9.6%	39.2%	57.6%	78.9%	100%
Estimated proportion of the area with presence of *C. sativa* affected by new virulent strains (in %) for scenario A_2	2.9%	6.5%	8.6%	11.1%	18.7%

The estimated impact on ecosystem services (as a proportion expressing the reduction in the level of service provision) is shown in Table 7 (for provisioning as well as regulating and supporting ecosystem services) and Table 8 (for cultural ecosystem services). The assessment is done referring to the proportion of the area with presence of the main host where new virulent strains will be present at the end of the assessment period (Table 6).

Table 7: Quantile values of the distribution of estimated impact (as a proportion expressing the reduction in the level of service provision; ranging between 0 (no change) and 1 (100% reduction)) of *C. parasitica* on both (a) provisioning and (b) regulating and supporting ecosystem services in the relevant habitats for scenarios A_0, A_1 and A_2

Overall assessment Quantile	Low (1%)	1st quartile (25%)	Median (50%)	3rd quartile (75%)	High (99%)
Estimated impact on provisioning ecosystem services in the relevant habitats for scenarios A_0, A_1 and A_2	0.80	0.94	1.00	1.06	1.20

Table 8: Quantile values of the distribution of estimated impact (as a proportion expressing the reduction in the level of service provision; ranging between 0 (no change) and 1 (100% reduction)) of *C. parasitica* on cultural ecosystem services in the relevant habitats for scenarios A_0, A_1 and A_2

Overall assessment Quantile	Low (1%)	1st quartile (25%)	Median (50%)	3rd quartile (75%)	High (99%)
Estimated impact on cultural ecosystem services in the relevant habitats for scenario A_0, A_1 and A_2	0.60	0.85	1.00	1.10	1.25

3.4.2. Uncertainty

The uncertainty associated with the different scenarios for the various estimated impacts is given by the range in the values provided in Tables 6–8.

The only factors contributing to the overall uncertainty in the impact assessment is the initial proportion of new strains that are virulent (initial conditions), the estimated disease dispersal rate of the pathogen and the multiplication factor associated to the effectiveness of the RROs.

In all cases, the most important factor in terms of contribution to the overall uncertainty related to impacts is the initial abundance of the pathogen. The dispersal rate of the pathogen and the multiplication factor associated to the effectiveness of the RROs have a limited contribution to the overall uncertainty.

3.4.3. Discussion on the impact assessment

- The estimated proportion of new strains of *C. parasitica* that are virulent is expected to be the same for all scenarios and to range from 0.1% to 0.5%, with a median value of 0.3%.
- Focusing on the median values, the estimated area with presence of the main host *C. sativa* affected by new virulent strains of *C. parasitica* is about two times higher for scenario A_1 (about 58%) compared to scenario A_0 (about 31%), and about three times lower for scenario A_2 (about 9%) compared to scenario A_0.
- The values in scenario A_1 indicate that, in case of introduction, establishment and spread of new virulent strains of the pathogen, thereby jeopardising the currently effective hypovirulence, the impacts would be huge.
- The estimated relative impact on ecosystem services (per service providing unit) as a result of the introduction into and spread within the RA area of new virulent strains of *C. parasitica* is rather consistent for the three types of ecosystem services within each scenario (Tables 7 and 8). Nonetheless, in absolute terms, the expected impacts on ecosystem services are higher for scenario A_1 compared to scenarios A_0 and A_2, as the proportion of the area with presence of the main host where new virulent strains will be present is larger for scenario A_1 compared to scenarios A_0 and A_2.
- Although damages caused by new virulent strains of *C. parasitica* could affect the ecosystem services provided by chestnut trees, some ecosystem services could be recovered by the recolonisation by new tree species (Boyd et al., 2013). However, there are some cultural values associated with chestnut which are irreplaceable.
- *C. sativa* is an iconic, widespread and locally abundant tree species in forest ecosystems in the EU, particularly in Mediterranean countries. The loss of this tree species would lead not only to a reduction in ecosystem services, but also to a loss in the biodiversity associated with this tree species, although there is lack of knowledge to quantify such a biodiversity reduction. It is also possible that, by replacing homogeneous chestnut woodlands with more diverse forest

ecosystems, the biodiversity of some taxa present in those ecosystems could increase. But it would take a long time to replace ancient and majestic chestnut trees.

- The width of the estimated distributions related to the proportion of the area with the presence of the main host where new virulent strains of *C. parasitica* will be present is wider under scenario A_1 compared to scenarios A_0 and A_2, which implies that the uncertainty on impacts is lower for the A_0 and A_2 scenarios compared to the A_1 scenario.
- The most important factor in terms of contribution to the overall uncertainty related to impacts is the initial proportion of new virulent strains of *C. parasitica*.

4. Conclusions

C. parasitica is a bark-inhabiting fungal pathogen causing blight of *Castanea* spp. and other susceptible tree genera and species, among which *Quercus* spp. The most susceptible *Castanea* species are *C. dentata* (American chestnut) and *C. sativa* (European chestnut). The pathogen has a wide distribution in the RA area where hosts are present.

Following the pest categorisation carried out by EFSA PLH Panel (2014), in which it was proposed to list the pathogen as a RNQP, and given that there are some PZs in the EU, the European Commission asked for a full pest risk assessment with the aim to assess the current EU phytosanitary requirements and identify the RROs which may be considered to preserve the PZ status in some parts of the Union.

The Panel carried out the PRA by considering:

1) that the risk assessment area (i.e. the EU territory) is currently split in two areas: (i) the non-PZs areas in which the pathogen is present and widespread (see Pest Categorisation, EFSA PLH Panel, 2014), and for which some requirements exist in Council Directive 2000/29/EC for the pest and its hosts, and (ii) the PZs areas (the Czech Republic, Ireland, Sweden and the UK), in which the pathogen is either not known to occur or under eradication and for which some measures are in place according to Annex IV, Part B of Directive 2000/29/EC., and
2) three scenarios (with the whole of the EU as RA area): (i) The A_0 scenario which describes the current regulatory situation in non-PZs with respect to the EU legislation (Council Directive 2000/29/EC) on the pathogen and its hosts. This scenario makes it possible to assess the effectiveness of the current EU phytosanitary requirements in reducing the risk of introduction into and spread within the RA area of new, virulent *C. parasitica* strains originating from Third Countries, (ii) The A_1 scenario which describes a situation without RROs, and (iii) The A_2 scenario, which describes the current regulatory situation in the PZs, with some measures being already in place (Annex IV, Part B of Directive 2000/29/EC) and additional RROs to be applied to the whole RA area. This scenario makes it possible to assess the effectiveness of RROs which may be considered to: (i) preserve the PZ status in some parts of the Union, as requested in the terms of reference; and (ii) reduce the risk of introduction and spread of new virulent *C. parasitica* genotypes not currently present in the RA area.

All three scenarios refer to *Castanea* spp. (chestnut), which is considered the main host, and not to *Quercus* spp. (oak) because the presence of *C. parasitica* on *Quercus* spp. is rare. The conclusions on the effectiveness of the RROs for chestnut are in the view of the Panel also applicable to oak, but no further analysis was undertaken to support this assertion.

Based on the results of the PRA, the Panel draws the following conclusions:

- The risk of new introductions of *C. parasitica* strains into the RA area by means of the main pathways of entry (i.e. plants for planting and wood with bark) is relatively high with about 100 (median value) new potential established populations predicted in a 10-year period under scenario A_0; in case all the relevant EU regulations are removed (scenario A_1), the number of new potential founder populations increases to more than 30,000, whereas in case the current EU regulations are maintained for the PZs and the additional RROs of scenario A_2 are implemented, the number decreases to 0.02. The number of established populations is expected to be about 300 times higher for the A_1 scenario compared to the A_0 scenario. In turn, the number of established populations is expected to be about 5,000 times higher for the A_0 scenario compared to the A_2 scenario. There is a difference of 6 orders of magnitude between the expected number of established populations for the A_1 compared to the

A_2 scenario. Under the A_1 scenario in the 99th percentile (the worst case), the expected number of established populations becomes even more considerable (about 23,000 per year).

- The entry assessment highlighted important differences among the various entry pathways, with plants for planting as the most important pathway. The number of potential founder populations (median values) due to the plants for planting pathway is expected to be about eight times higher than that for the pathway wood with bark under the current situation in PZs (scenario A_0) and about 600 times higher without measures (scenario A_1).
- The estimated distribution for the number of established populations in scenario A_1 has a range of about 400 times between the 99th percentile and the 1st percentile value, implying relatively limited uncertainty. The uncertainty is higher under scenarios A_0 and A_2, as the width of the distribution is larger for the A_0 (ratio of 99th and 1st percentile values = 5,000) and A_2 (ratio of 99th and 1st percentile values = 38,000) compared to the A_1 scenario.
- Many factors (not all considered here) influence the assessment of entry and establishment, and their relative contribution to the overall uncertainty varies between scenarios. In general, there are no dominant factors to which a major contribution to the overall uncertainty can be attributed. With respect to entry, the pest abundance at the origin and the number of pathway units are key factors contributing to uncertainty in the plants for planting and the wood with bark pathways, respectively. However, for establishment assessment and for all scenarios, the number of pathway units is a key factor. Therefore, future risk assessment would benefit from data on trade volumes of chestnut plants for planting and wood with bark.
- Under the conditions of the scenarios of this Risk Assessment, two (median value) EU MSs in the RA area are expected to be affected due to spread of populations of *C. parasitica* over the next 10 years under scenario A_0; in case all the relevant EU regulations are removed (scenario A_1), the number of EU MSs newly occupied by the pathogen increases to 3.5 (median value), whereas, if the current EU regulations are maintained in the PZs and the additional RROs of scenario A_2 are implemented, the number decreases to 0.5 (median value).
- The RROs considered in scenario A_2 are expected to reduce by about four times the expected number of newly affected EU MSs compared to scenario A_0 (median values). The ratio between the expected number of newly affected EU MSs for the A_1 scenario compared to the A_0 scenario is 1.75, whereas the ratio comparing this number for scenarios A_1 and A_2 is about 7 (median values).
- The range of the estimated distribution for the number of newly affected EU MSs is narrower for scenario A_0 compared to scenario A_2, and for scenario A_2 compared to scenario A_1, implying relatively larger uncertainty for scenario A_1 compared to scenarios A_0 and A_2.
- With respect to the assessment of the risk of impacts due to *C. parasitica* under scenarios A_0, A_1 and A_2, the Panel focused on the virulent strains of the pathogen, able to overcome hypovirulence and thus causing damage, and reached the following conclusions:
- Based on expert judgement, the estimated proportion of new strains of *C. parasitica* that are virulent was assessed to be the same for all scenarios and ranges from 0.1% to 0.5%.
- Focusing on the median values, the estimated area with the presence of the main host (*C. sativa*) affected by new virulent strains of *C. parasitica* is about two times higher for scenario A_1 (about 58%) compared to scenario A_0 (about 31%), and about three times lower for scenario A_2 (about 9%) compared to scenario A_0.
- It is expected that, if new virulent strains will appear in the EU, the pathogen will spread across most of the risk assessment area in a limited period (10–20 years), unless hypovirulence results in a slowing down of the spread. The spread could be faster in case of an important contribution of human-assisted spread (e.g. trade of infected chestnut saplings).
- The values in scenario A_1 indicate that, in case of introduction, establishment and spread of new virulent strains of the pathogen, thereby jeopardising the currently effective hypovirulence, the impacts would be huge.
- The estimated relative impact on ecosystem services (per service providing unit) as a result of the introduction into and spread within the RA area of new virulent strains of *C. parasitica* is rather consistent for the three types of ecosystem services within each scenario. Nonetheless, in absolute terms, the expected impacts on ecosystem services are higher for scenario A_1 compared to scenarios A_0 and A_2, as the proportion of the area with the presence of the main host, where new virulent strains will be present, is larger for scenario A_1 compared to scenarios A_0 and A_2.

- Although damages caused by new virulent strains of *C. parasitica* could affect the ecosystem services provided by chestnut trees, some ecosystem services could be recovered by the recolonisation by new tree species. However, there are important cultural values associated with chestnut.
- *C. sativa* is an iconic, widespread and locally abundant tree species in forest ecosystems in the EU, particularly in Mediterranean countries. The loss of this tree species would lead not only to a reduction in ecosystem services, but also to a loss in the biodiversity associated with this tree species, although there is lack of knowledge to quantify such a biodiversity reduction. It is also possible that, by replacing homogeneous chestnut woodlands with more diverse forest ecosystems, the biodiversity of some taxa present in those ecosystems could increase. But it would take a long time to replace ancient and majestic chestnut trees.
- The width of the estimated distributions related to the proportion of the area with the presence of the main host where new virulent strains of *C. parasitica* will be present is wider under scenario A_1 compared to scenarios A_0 and A_2, which implies that the uncertainty on impacts is lower for the A_0 and A_2 scenarios compared to the A_1 scenario.
- The most important factor in terms of contribution to the overall uncertainty related to impacts is the initial proportion of new virulent strains of *C. parasitica*.
- The current EU phytosanitary requirements and the additional RROs considered in the A_2 scenario were assessed to be effective in reducing the risk of introduction and spread of *C. parasitica*, thus preserving the PZ status in those parts of the Union where the pathogen is not known to occur.
- The Panel considered that it is also important to prevent the introduction and spread of new virulent strains of the pathogen in the parts of the EU currently affected by *C. parasitica*, so as to avoid the risk that hypovirulence will stop working. Even if the introduction of new virulent strains is not expected to be a frequent event, if it occurs, it would have dramatic consequences on crop production and ecosystem services related to chestnut.

The current EU requirements (Annex III, Part A of Council Directive 2000/29/EC) as regards the prohibition of import of (i) plants of *Castanea* Mill., and *Quercus* L., with leaves, other than fruit and seeds, from non-European countries, and (ii) isolated bark from Third Countries, should be maintained.

The current EU requirements (Annex IV, Part B of Council Directive 2000/29/EC) for the prohibition of introduction of *C. parasitica* into the PZs on host plants for planting could be improved by introducing additional measures, among which, the production of plants for planting in a pest free area under a certification scheme and a plant health inspection at the country of origin for issuing a phytosanitary certificate or plant passport for the PZs.

The current measures (Annex IV, Part B) for the prohibition of entry of *C. parasitica* into the PZs on host wood with bark (i.e. requirements for debarking or pest free area in the country of origin or kiln-drying) should be maintained and no additional measures are recommended.

For the prohibition of introduction from Third Countries into the affected EU MSs of new, virulent strains of *C. parasitica*, which could jeopardise the currently effective hypovirulence and potentially cause severe impact, the current EU regulations on host plants for planting could be further improved by introducing additional measures, among which, the production of plants for planting in a pest-free area under a certification scheme for issuing a phytosanitary certificate. With respect to the wood with bark, which is not currently regulated in the non-PZs, the current EU requirements relevant for the PZs need to be extended to the affected EU MSs.

In case new virulent strains are introduced into the RA area, to avoid their spread within the EU, the current EU measures for avoiding spread of *C. parasitica* from the non-PZs to the PZs (Annex IV, Part B of Directive 2000/29/EC) would need to be extended to all the EU. This would also be effective in case new virulent strains appear within the RA area due to recombination of currently existing strains.

References

Biraghi A, 1946. Il cancro del castagno causato da *Endothia parasitica*. Agricoltura Italiana, 7, 1–9.

Bissegger M and Sieber TN, 1994. Assemblages of endophytic fungi coppice shoots of *Castanea sativa*. Mycologia, 86, 648–655.

Bounous G, 2014. *Il castagno: risorsa multifunzionale in Italia e nel mondo*. Edagricole, Bologna, Italy.

Boyd IL, Freer-Smith PH, Gilligan CA and Godfray HCJ, 2013. The consequence of tree pests and diseases for ecosystem services. Science, 342, 1235773.

Bragança H, Simoes S, Onofre N, Tenreiro R and Rigling D, 2007. *Cryphonectria parasitica* in Portugal: diversity of vegetative compatibility types, mating types, and occurrence of hypovirulence. Forest Pathology, 37, 391–402.

Colinas C and Uscuplic M, 1999. Studies on chestnut blight (*Cryphonectria parasitica* (Murr.) Barr) in north-east Spain. Acta Horticulturae, 494, 495–500.

Collins JF, 1915. The chestnut bark disease on freshly fallen nuts. Phytopathology, 5, 233–235.

Conedera M, Manetti MC, Giudici F and Amorini E, 2004. Distribution and economic potential of the sweet chestnut (*Castanea sativa* Mill.) in Europe. Ecologia Mediterranea, 30, 179–193.

Cunnington JH and Pascoe IG, 2003. Post entry quarantine interception of chestnut blight in Victoria. Australasian Plant Pathology, 32, 569–570.

Diamandis S, Perlerou C, Tziros GT, Christopoulos V and Topalidou E, 2015. Establishment and dissemination of hypovirulent strains of *Cryphonectria parasitica* in Greece. Forest Pathology, 45, 408–414.

Dutech C, Barres B, Bridier J, Robin C, Milgroom MG and Ravigne V, 2012. The chestnut blight fungus world tour: successive introduction events from diverse origins in an invasive plant fungal pathogen. Molecular Ecology, 21, 3931–3946.

EFSA (European Food Safety Authority), 2009. Guidance of the Scientific Committee on Transparency in the Scientific Aspects of risk assessments carried out by EFSA. Part 2: general principles. EFSA Journal 2009;7(5):1051, 22 pp. doi:10.2903/j.efsa.2009.1051

EFSA (European Food Safety Authority), 2014. Guidance on Statistical Reporting. EFSA Journal 2014;12(12):3908, 18 pp. doi:10.2903/j.efsa.2014.3908

EFSA PLH Panel (EFSA Panel on Plant Health), 2010. 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, 68 pp. doi:10.2903/j.efsa.2010.1495

EFSA PLH Panel (EFSA Panel on Plant Health), 2014. Scientific Opinion on the pest categorisation of *Cryphonectria parasitica* (Murrill) Barr. EFSA Journal 2014;12(10):3859, 42 pp. doi:10.2903/j.efsa.2014.3859

EFSA Scientific Committee, 2014. Guidance on the structure and content of EFSA's scientific opinions and statements. EFSA Journal 2014;12(9)3808, 10 pp. doi:10.2903/j.efsa.2014.3808

EFSA Scientific Committee, 2016. Guidance on Uncertainty in EFSA Scientific Assessment. Working draft. Available online: https://www.efsa.europa.eu/sites/default/files/consultation/150618.pdf [Accessed: September 2016].

EPPO (European and Mediterranean Plant Protection Organization), 2005. Normes OEPP. EPPO Bulletin, 35, 271–273.

Eschen R, Rigaux L, Sukovata L, Vettraino AM, Marzano M and Grégoire JC, 2015. Phytosanitary inspection of woody plants for planting at European Union entry points - a practical enquiry. Biological Invasions, 17, 2403–2413.

FAO, 2008. ISPM No. 31, Methodologies for Sampling of Consignments. IPPC Secretariat, Rome, Italy.

FAO (Food and Agriculture Organization of the United Nations), 2013. ISPM (International standards for phytosanitary measures) No 11. Pest risk analysis for quarantine pests. FAO, Rome, 36 pp. Available online: https://www.ippc.int/en/publications/639/.

Giltrap N, Eyre D and Reed P, 2009. Internet sales of plants for planting—an increasing trend and threat? EPPO Bulletin, 39, 168–170.

Griffin GJ, 1986. Chestnut blight and its control. Horticultural Reviews, 8, 291–335.

Guérin L and Robin C, 2003. Seasonal effect on infection and development of lesions caused by *Cryphonectria parasitica* in *Castanea sativa*. Forest Pathology, 33, 223–235.

Heald FD and Studhalter RA, 1914. Birds as carriers of the chestnut blight fungus. Journal of Agriculture Research, 2, 405–422.

Heald FD, Gardner MW and Studhalter RA, 1915. Air and wind dissemination of ascospores of the chestnut blight fungus. Journal of Agriculture Research, 3, 493–526.

Heiniger U and Rigling D, 1994. Biological control of chestnut blight in Europe. Annual Review of Phytopathology, 32, 581–599.

Heiniger U and Rigling D, 2009. Application of the Cryphonectria hypovirus (CHV-1) to control the chestnut blight, experience from Switzerland. Acta Horticulturae, 815, 233–245.

Jaynes RA and DePalma NK, 1984. Natural infection of nuts of *Castanea dentata*. Phytopathology, 74, 296–299.

Ježić M, Krstin L, Rigling D and Ćurković-Perica M, 2012. High diversity in populations of the introduced plant pathogen, *Cryphonectria parasitica*, due to encounters of genetically divergent genotypes. Molecular Ecology, 21, 87–99.

Liu Y-C and Milgroom MG, 2007. High diversity of vegetative compatibility types in *Cryphonectria parasitica* in Japan and China. Mycologia, 99, 279–284.

Milgroom MG and Cortesi P, 2004. Biological control of chestnut blight with hypovirulence: a critical analysis. Annual Review of Phytopathology, 42, 311–338.

Milgroom MG and Lipari SE, 1995. Spatial analysis of nuclear and mitochondrial RFLP genotypes in populations of the chestnut blight fungus, Cryphonectria parasitica. Molecular Ecology, 4, 633–642.

Milgroom MG, Lipari S and Wang KR, 1992. Comparison of genetic diversity in the chestnut blight fungus, *Cryphonectria (Endothia) parasitica*, from China and the United States. Mycological Research, 96, 1114–1120.

Newhouse JR, MacDonald WL and Hoch HC, 1990. Virus-like particles in hyphae and conidia of European hypovirulent (dsRNA-containing) strains of *Cryphonectria parasitica*. Canadian Journal of Botany, 68, 90–101.

Nuss DL, 1992. Biological control of chestnut blight: an example of virus-mediated attenuation of fungal pathogenesis. Microbiological Reviews, 56, 561–576.

Prospero S and Rigling D, 2013. Chestnut blight. In: Gonthier P and Nicolotti G (eds.). *Infectious Forest Diseases*. CAB International, Wallingford, UK. pp. 318–339.

Prospero S and Rigling D, 2016. Using molecular markers to assess the establishment and spread of a mycovirus applied as a biological control agent against chestnut blight. BioControl, 61, 313–323.

Prospero S, Conedera M, Heiniger U and Rigling D, 2006. Saprophytic activity and sporulation of *Cryphonectria parasitica* on dead chestnut wood in forests with naturally established hypovirulence. Phytopathology, 96, 1337–1344.

Rigling D, Schütz-Bryner S, Heiniger U and Prospero S, 2014. Der Kastanienrindenkrebs. Schadsymptome, Biologie und Gegenmassnahmen. WSL Merkblatt für die Praxis Nr 54, Birmensdorf, Switzerland. 8 pp.

Roane MK, Griffin GJ and Elkins JR, 1986. Chestnut Blight, other Endothia diseases and the genus *Endothia*. American Phytopathological Society Monograph Series.

Robin C and Heiniger U, 2001. Chestnut blight in Europe: diversity of *Cryphonectria parasitica*, hypovirulence and biocontrol. Forest Snow and Landscape Research, 76, 361–367.

Shain L, 1982. Strategies for enhancing dissemination of hypovirulence in *Endothia parasitica*: state of the art. In: Smith HC and MacDonald WC (eds.). *Proceedings of the US Forestry Service American Chestnut Cooperators' Meeting in Morgantown*, West Virginia. pp. 175–183.

Smith KF, Behrens MD and Sax DF, 2009. Local scale effects of disease on biodiversity. EcoHealth, 6, 287–295.

Turchetti T and Marinelli A, 1980. Preliminary observations on *Endothia parasitica* canker of chestnut in some coppice stands of Pistoia province. L'Italia Forestale e Montana, 35, 80–90.

Turchetti T and Maresi G, 2008. Biological control and management of chestnut diseases. In: Ciancio A and Mukerji KG (eds.). *Integrated Management of Diseases Caused by Fungi, Phytoplasma and Bacteria*. pp. 85–118.

Zamora P, González Casas A, Dueñas M, San Martin R and Diez JJ, 2017. Factors influencing growth, sporulation and virus transfer in *Cryphonectria parasitica* isolates from Castilla and León (Spain). European Journal of Plant Pathology, in press. doi:10.1007/s10658-016-1069-5

Abbreviations

CHV1	*Cryphonectria hypovirus 1*
EPPO	European and Mediterranean Plant Protection Organization
EU MS	European Union Member State
FAO	Food and Agriculture Organization
GAP	Good Agricultural Practices
ISEFOR	Increasing Sustainability of European Forests (FP7 research project)
ISPM	International Standards for Phytosanitary Measures
NPPO	National Plant Protection Organization
NUTS	Nomenclature of Territorial Units for Statistics
PLH	Plant Health
PQR	Plant Quarantine Retrieval
PRA	pest risk assessment
PZ	protected zone
RA	risk assessment
RNQP	Regulated Non-quarantine Pest
RRO	risk reduction option
ToR	Terms of Reference

Appendix A – Description of the model used for the assessment

A.1. Introduction

The modelling approach used to quantify the risk posed by *C. parasitica* combines individual distributions of the possible values of variables relevant to the assessment (e.g. population abundance, multiplication factors, trade volume). These distributions represent the best estimation of state variables (e.g. the trade volume) or the effect of processes modifying these state variables (e.g. the increase in the population in a pathway unit) characterising the substep in each of the four main component or steps of the assessment, which are: entry, establishment, spread and impact. The efficacy of combination of RROs is also expressed in terms of distributions. The combination of individual distribution results in a final distribution which allows comparisons to be made between different pathways and different scenarios considering all the pathways together for the four main components to the risk assessment.

The model here presented is a simplified version of the model considered in the assessment. For sake of simplicity, only the deterministic version is given. The extension considering the random variables estimated by the experts or calculated is reported in the *C. parasitica* @Risk file (Annex A).

A.2. Entry

The objective of the entry model is to estimate the total number of new potential founder populations N_1 within the EU territory as a result of entry of the pest from Third Countries for the selected temporal and spatial scales. All the different pathways are considered together and different scenarios based on combination of RROs are compared.

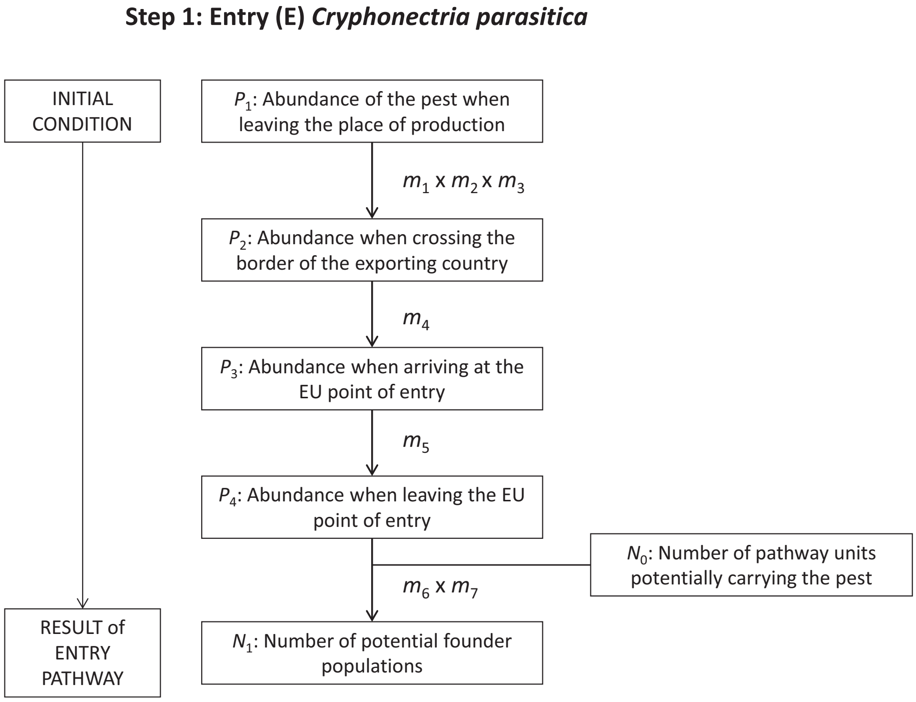

Figure A.1: Diagram that defines the series of substeps or nodes of the entry

The number of potential founder populations is estimated for the scenario *i* and the pathway *j* throughout a network of nodes or substeps in which the population abundance changes due to natural processes (e.g. population growth) or the implementation of RROs (see Figure A.1). The change in population abundance is obtained considering multiplication factors taking into account the result of natural processes of RROs.

Where

P_{1ij} the population abundance of the pest when leaving the place of production in the export country/countries for the scenario *i* and the pathway *j* in the substep E_1 of Entry (E);

P_{2ij} the population abundance of the pest when crossing the border of the exporting country of the export country/countries for the scenario i and the pathway j in the substep E_2 of Entry (E);
P_{3ij} the population abundance of the pest when arriving at the EU point of entry for the scenario i and the pathway j in the substep E_3 of Entry (E);
P_{4ij} the population abundance of the pest when leaving the EU point of entry for the scenario i and the pathway j in the substep E_4 of Entry (E);
N_{0ij} the number of pathway units potentially carrying the pest from the place of production to the risk assessment area for the scenario i and the pathway j;
N_{1ij} the total number of new potential founder populations within the EU territory as a result of entry of the pest from Third Countries for the selected temporal and spatial scales and for the scenario i and the pathway j;
and
m_{1ij} the multiplication factor changing the abundance of the pest before leaving the place of production for the scenario i and the pathway j;
m_{2ij} the units conversion coefficient for the scenario i and the pathway j;
m_{3ij} the multiplication factor changing the abundance from substep E_1 (after having left the place of production) to substep E_2 (before crossing the border of the export country) for the scenario i, and the pathway j;
m_{4ij} the multiplication factor changing the abundance from substep E_2 (after having left the border of the export country) to substep E_3 (before arriving at the EU point of entry) for the scenario i and the pathway j;
m_{5ij} the multiplication factor changing the abundance from substep E_3 (after arriving at the EU point of entry) to substep E_4 (before leaving the EU point of entry) for the scenario i, and the pathway j;
m_{6ij} the aggregation/disaggregation coefficient transforming the pathway units into the transfer units for the scenario i, and the pathway j;
m_{7ij} the multiplication factor changing the abundance from substep E_4 (after leaving the point of entry) to substep E_5 (transferring to the host) in the different scenarios for the scenario i, and the pathway j.
Then, the following population abundance are calculated

$$P_{2ij} = P_{1ij} \times m_{1ij} \times m_{2ij} \times m_{3ij}$$
$$P_{3ij} = P_{2ij} \times m_{4ij}$$
$$P_{4ij} = P_{3ij} \times m_{5ij}$$

Finally, the number of potential founder populations for each scenario is obtained as

$$N_{1i} = \sum_j P_{4ij} \times N_{0ij} \times m_{6ij} \times m_{7ij}.$$

A.3. Establishment

The number of established populations N_{2i} for the scenario i derives from the number of potential founder populations N_{1i} calculated in the entry step multiplied by the probability of establishment m_{8i} (see Figure A.2). In the case of *C. parasitica*, only the presence of the host plant is considered as a factor influencing the establishment. The probability of establishment is also dependent on the combination of RROs considered for the scenario i.

Step 2: Establishment (T) *Cryphonectria parasitica*

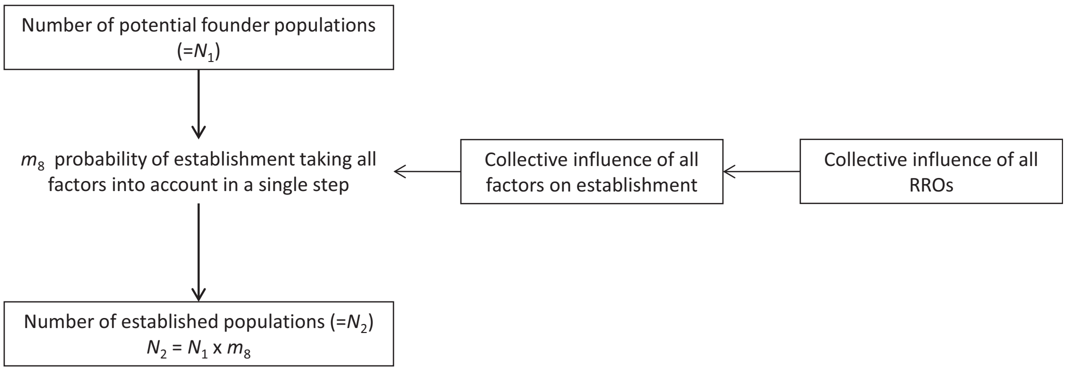

Figure A.2: Diagram that defines variables and factors influencing the establishment

From m_{8i}, the number of established populations N_{2i} for the scenario i is obtained as

$$N_{2i} = N_{1i} \times m_{8i}.$$

A.4. Spread

The spread is assessed at the EU MS level because of lack of detailed data atthe level of NUTS regions. Due to the widespread distribution of the pest and the low the spatial resolution of the assessment, a linear model was considered the best option to estimate the increase in the number of occupied spatial units in the assessment area for the selected time horizon (10 years).

The total number of occupied spatial units N_{5i} at the end of the time horizon for the different scenario i, that derive from number of spatial units representing the initial condition for the spread, is calculated as

$$N_{5i} = N_3 + T \times m_{9i}$$

where:

N_3 is the number of spatial units representing the initial condition for the spread, this corresponds to the distribution of pest at the level of the EU MSs when the assessment is performed (the year 2016);
T represents the time horizon used for the assessment, that is 10 years;
m_{9i} is the multiplication factor used to derive the number of spatial units occupied by the pest at the end of the time horizon (10 years) for the different scenarios i;
The multiplication factor m_{9i} represents the number of newly occupied spatial units per year due to the spread. It changes according to scenario and it is calculated based on the effectiveness of RROs (see Appendix C).

The maximum number of spatial units N_4 at the EU MS level in the RA area for the relevant crops/habitats has also been estimated even if it is not considered in the linear model. It is also useful to define the area of potential establishment of the pest.

In this risk assessment, the increase in the spread due to new entries is not consider (see Appendix B.3.4).

A.5. Impact

The impact assessment is carried out for virulent strains only (see Appendix B.4 for further details) and considers the calculation of: (i) the number of established *C. parasitica* (new virulent strains) populations, (ii) the relative impact on crop production and on the environment in terms of the percentage of change in the crop production outputs and in the provision of ecosystem services and in the biodiversity, and (iii) the absolute impact on crop production and on the environment at the EU level.

A.5.1. Number of established *C. parasitica* (new virulent strains) populations

The proportion of plants P_5 carrying new virulent strains of *C. parasitica* in the new established populations of the pest is estimated assuming that this proportion is the same for all the scenarios and does not change through time over the 10-year period of the risk assessment. From P_5, the number of established C. *parasitica* (new virulent strains) populations P_{5i*} for scenario *i* per year (time horizon = 10 years) is calculated as

$$P_{5i^*} = N_{2i} \times P_5.$$

A.5.2. Relative impact on crop production and on the environment

The following multiplication factors are estimated:

m_{11ih} is the multiplication factor changing crop production outputs (h = chestnut nuts or wood) in relation to virulent strain of *C. parasitica* in the scenario *i*;
m_{13i} is the multiplication factor changing the provision of provisioning ecosystem services in relation to virulent strains of *C. parasitica* in the scenario *i*;
m_{13i*} is the multiplication factor changing the provision of regulating and supporting ecosystem services in relation to virulent strains of *C. parasitica* in the scenario *i*;
m_{13i**} is the multiplication factor changing the provision of cultural ecosystem services in relation to virulent strains of *C. parasitica* in the scenario *i*;
m_{14i} is the multiplication factor changing the biodiversity in relation to virulent strains of *C. parasitica* in the scenario *i*.

A.5.3. Assessment of the impact at the EU level

The assessment of the impact at the EU level requires the estimation of both the relative impact (see above) and the proportion of the area of the occupied spatial units where the relevant crops/habitats are present and where the pathogen can spread under the different scenarios.

To estimate this proportion, a simple epidemiological model is used to describe the stratified dispersal (i.e. long- and short-distance dispersal) of the new virulent strains across the area where the host is present. This model is based on a logistic growth curve that describes the time-variation of the percentage of the area that the new virulent strains can colonise. The model disregards the contribution to the spread due to the new entry per year.

The proportion R_{2i} (ranging from 0 to 1, where 1 = 100%) of the area of the occupied spatial units where the relevant crops/habitats are present and where the new virulent strains of *C. parasitica* are present under the different scenarios in 10 years is calculated as

$$R_{2i} = 1/(1-(1-(1/R_{0i}))exp(R_1 T))$$

where

R_{0i} is the number of established populations in 5 years in the scenario *i* and represents the initial condition of the epidemics, this parameter is calculated at the mid-point of the time horizon on the basis of the results on establishment to account for the possible underestimation of the spread as a consequence of disregarding the new entry in the epidemiological model;
R_1 is the estimated growth rate (1/year) appearing in the epidemiological model that describes the spread of the epidemics across the EU due to the stratified dispersal of new virulent strains of *C. parasitica*, this parameter does not depend on the scenario;
T is the time horizon (10 years).

In the epidemiological model, the carrying capacity expressing the maximum level of prevalence of the disease in the suitable area, given that the prevalence expressed as a proportion of the carrying capacity, is equal to 1.

To quantify the magnitude of the impact at the level of the whole RA area, the information on the relative impact (i.e. percentage of reduction) on crop production, ecosystem services provision level and biodiversity are combined with information on proportion of area with the presence of the main host *C. sativa* affected by new virulent strains of *C. parasitica* at the end of the assessment period (10 years).

Appendix B – Detailed information on the assessment

As mentioned in Section 2, most of the quantitative estimations of this RA were based on expert judgement because data were either missing or incomplete. The quantitative estimations should thus be taken with caution, as different experts might provide different figures in such a situation of lack of evidence.

B.1. Entry

B.1.1. Substep E_1: abundance of the pest when leaving the place of production in the country of origin

For background information about the distribution and biology of *C. parasitica*, the EUROPHYT interceptions, its intraspecific diversity, its hosts and the regulatory status, the reader should refer to the EFSA pest categorisation on *C. parasitica* (EFSA PLH Panel, 2014).

Table B.1: $[P_1]$ Abundance of plants for planting and wood with bark units affected by *C. parasitica* (proportion of units affected) when leaving the place of production in the countries of origin, in scenario A_0

	$[P_1]$	
Quantile	**Plants for planting**	**Wood with bark**
Lower	0.0001	0.10
Q_1	0.0007	0.40
M	0.001	0.65
Q_3	0.003	0.70
Upper	0.03	0.95
Distribution	BetaGen	BetaGen

Justifications for P_1 (Table B.1)

The abundance of *C. parasitica* when leaving the place of production in the country of origin is estimated to be higher for wood with bark than for plants for planting, mainly because *C. parasitica* is a bark-inhabiting fungus and plants for planting are generally exported very young, at a stage in which they are less susceptible to the disease.

Plants for planting

- Lower: 1–2-year-old plants for planting might not be infected yet, but 3-year-old plants are likely to be infected (Turchetti and Marinelli, 1980). No precise information exists on the age of the imported into the EU host plants for planting, but it is expected that they are generally less than 5-year-old). Chestnut propagation is usually through grafting, so as to maintain the properties of the selected varieties.
- Median, Q_1 and Q_3: Values based on expert judgement, as no evidence is available.
- Upper: The pathogen is widespread in the countries of origin mainly in association with different chestnut species. Occasionally, it has been found as a saprophyte or a weak pathogen on other species (see pest categorisation), but the estimations provided here refer to the main host *Castanea* spp. (and not to other occasional hosts as *Quercus* spp.). *C. parasitica* can be present on *Castanea* spp. as an endophyte without causing symptoms (Bissegger and Sieber, 1994; Cunnington and Pascoe, 2003; Guérin and Robin, 2003). However, the current requirement for import of plants for planting into the EU non-PZs is a pest-free area or pest-free place of production.

Wood with bark

Wood with bark poses an important risk for the introduction of new pathogen strains, because *C. parasitica* can survive and sporulate on chestnut bark (Prospero et al., 2006).

- Lower: It is expected that most bark cankers are removed from the wood before leaving the place of production. The lower value accounts for stromata present on apparently healthy bark.
- Q_1, Median and Q_3: Values based on expert judgement, as no evidence is available.
- Upper: *C. parasitica* can be present as mycelium under the bark or stromata in the cracks of the bark and in cankers.

Table B.2: [m_1] Multiplication factor changing the abundance of *C. parasitica* before leaving the place of production in the different scenarios, for the plants for planting and wood with bark pathways

Quantile	A_0	A_1	A_2
[m_1] plants for planting pathway			
Lower	1	3.3	0
Q_1	1	6.6	0.03
M	1	10	0.05
Q_3	1	20	0.08
Upper	1	100	0.20
Distribution	–	Pearson5	Gamma
[m_1] wood with bark pathway			
Lower	1	1	0
Q_1	1	1	0.03
M	1	1	0.05
Q_3	1	1	0.08
Upper	1	1	0.20
Distribution	–	–	BetaGen

Justifications for m_1 (Table B.2) (all pathways)

The multiplication factor to be applied for changing the abundance of the pathogen when leaving the place of production in the country of origin (P_1) is 1 for scenario A_0, because assessments for P_1 are conducted for this scenario.

The multiplication factors for A_1 and A_2 were calculated based on the effectiveness of RROs (see Appendix C).

Table B.3: [m_2] Unit conversion coefficient for all pathways

Quantile	A_0	A_1	A_2
[m_2] both pathways			
Lower	1	1	1
Q_1	1	1	1
M	1	1	1
Q_3	1	1	1
Upper	1	1	1

Justifications for m_2 (Table B.3) (both pathways)

No conversion is needed because there is no change in the units expressing abundance either for plants for planting or for wood with bark.

Table B.4: [m_3] Multiplication factor changing the abundance of *C. parasitica* from substep E_1 (after having left the place of production) to substep E_2 (before crossing the border of the export country) in the different scenarios, for the plants for planting pathway

Quantile	A_0	A_1	A_2
[m_3] plants for planting pathway			
Lower	1	1	1
Q_1	1.04	1	1
M	1.06	1	1
Q_3	1.08	1	1
Upper	1.10	1	1
Distribution	Weibull	–	–

Justifications for m_3 (Table B.4) (plants for planting pathway)

Sporulation on infected plants may occur during the transport, leading to new infections of healthy plants in the consignment. Temperature and humidity during transport are likely to be favourable to pathogen survival and sporulation, even though this strongly depends on the plant material (e.g. scions vs big potted plants) and transportation type (e.g. in refrigerated atmosphere vs open air).

- For the A_0 scenario:
  - Lower: scions are usually transported at low temperatures (close to 5°C). Under such temperatures, it is unlikely that the disease will spread from infected scions to neighbouring healthy ones.
  - Median, Q_1 and Q_3: at the same interval between extremes, due to lack of data.
  - Upper: most of the plants for planting are likely to be saplings, not scions for grafting. Only bare-rooted saplings may be wrapped up all together and be transported at ambient temperature. Under these conditions, the disease can spread from infected saplings to others in the batch.
- For the A_1 and A_2 scenarios: The multiplication factor was calculated based on the effectiveness of RROs (see Appendix C).

Table B.5: [m_3] Multiplication factor changing the abundance of *C. parasitica* from substep 1A (after having left the place of production) to substep 1B (before crossing the border of the export country) in the different scenarios, for the wood with bark pathway

Quantile	m_3 for A_0	m_3 for A_1	m_3 for A_2
[m_3] wood with bark pathway			
Lower	1	1	1
Q_1	1	1	1
M	1	1	1
Q_3	1	1	1
Upper	1	1	1

Justifications for m_3 (Table B.5) (wood with bark pathway)

- For the A_0 scenario: Normal transport conditions of wood are not likely to affect the abundance of the fungus. However, high humidity during transport could facilitate the sporulation of the pathogen. For simplicity, and in the absence of data, it is expected that there are no changes in the pathogen abundance at this substep.
- For the A_1 and A_2 scenarios: The multiplication factor was calculated based on the effectiveness of RROs (see Appendix C).

B.1.2. Substep E_2: abundance of the pest when crossing the border of the exporting country

Table B.6: [m_4] Multiplication factor changing the abundance of *C. parasitica* from substep E_2 (after having left the border of the export country) to substep E_3 (before arriving at the EU point of entry) in the different scenarios, for the plants for planting and the wood with bark pathways

Quantile	A_0	A_1	A_2
[m_4] both pathways			
Lower	1	1	1
Q_1	1	1	1
M	1	1	1
Q_3	1	1	1
Upper	1	1	1

Justifications for m_4 (Table B.6) (both pathways)

- For the A_0 scenario: No change in the pathogen abundance is expected to occur during this substep for scenario A_0. Although there might be some development of symptoms on latently infected plants, this does not actually change the proportion of infected plants in the consignment. Similarly, no change is expected during this substep in the pathogen abundance in the case of wood with bark pathway.
- For the A_1 and A_2 scenarios: The multiplication factor was calculated based on the effectiveness of RROs (see Appendix C).

B.1.3. Substep E_3: abundance when arriving at the EU point of entry

Table B.7: [m_5] Multiplication factor changing the abundance of *C. parasitica* from substep E_3 (after arriving at the point of entry) to substep E_4 (before leaving the EU point of entry) in the different scenarios, for the plants for planting pathway

Quantile	A_0	A_1	A_2
[m_5] plants for planting pathway			
Lower	0.96	5	0
Q_1	0.97	12.5	0.03
M	0.98	20	0.05
Q_3	0.99	33.3	0.08
Upper	1	100	0.20
Distribution	BetaGen	InvGauss	BetaGen

Justifications for m_5 (Table B.7) (plants for planting pathway)

The import of plants for planting into the EU is regulated in Council Directive 2000/29/EC. ISPM No. 31 (FAO, 2008) that provides guidance on the determination of the number of plants to be sampled in individual consignments to verify compliance with the phytosanitary requirements set by an importing country.

- For the A_0 scenario:
  - Lower: for EU points of entry with efficient inspection capacity
  - Median, Q_1 and Q_3: values based on expert judgement, as no evidence is available.
  - Upper: for EU points of entry without efficient inspection capacity, or in case of latently infected (asymptomatic) plants or presence of *C. parasitica* as an endophyte in imported into the EU plants for planting.
- For the A_1 and A_2 scenarios: The multiplication factor was calculated based on the effectiveness of RROs (see Appendix C).

Table B.8: [m_5] Multiplication factor changing the abundance of *C. parasitica* from substep E_3 (after arriving at the point of entry) to substep E_4 (before leaving the EU point of entry) in the different scenarios, for the wood with bark pathway

Quantile	A_0	A_1	A_2
[m_5] wood with bark pathway			
Lower	1	2	0
Q_1	1	2.9	0.03
M	1	4	0.05
Q_3	1	6.7	0.08
Upper	1	100	0.15
Distribution	–	Pearson5	BetaGen

Justifications for m_5 (Table B.8) (wood with bark pathway)

- For the A_0 scenario: No change is expected during this substep (scenario A_0) in the pathogen abundance in the case of wood with bark pathway, because no routine inspection of chestnut wood for the detection of *C. parasitica* is conducted at all the EU points of entry.
- For the A_1 and A_2 scenarios: The multiplication factor was calculated based on the effectiveness of RROs (see Appendix C).

B.1.4. Substep E_4: abundance when leaving the EU point of entry

Table B.9: [N_0] Number of pathway units potentially carrying *C. parasitica* from the place of production to the risk assessment area in the different scenarios, for the plants for planting pathway

Quantile	A_0	A_1	A_2
[N_0] plants for planting pathway			
Lower	2,000	3,000	20
Q_1	4,200	6,000	42
M	6,000	10,000	60
Q_3	7,800	15,000	78
Upper	30,000	50,000	300
Distribution	Gamma	InvGauss	Gamma

Justifications for N_0 (Table B.9) (plants for planting pathway)

Quantiles for the different scenarios were estimated by expert judgement, based on the following considerations.

The current EU requirements are probably decreasing the trade compared to scenario A_1 (without measures). However, as the EU production of chestnut plants for planting is large, there might not be a great increase in import if the EU regulations are removed. Nonetheless, there might be a possible market for import of Chinese chestnuts into the EU possibly due to the existing projects in Spain and Portugal for establishing major new chestnut plantations for nut production.

With respect to the number of imported host plants for planting, there is a high variability and uncertainty about these trade numbers (ISEFOR database). However, there is one record in the ISEFOR database of a large shipment of *Castanea mollissima* plants for planting originated in China and imported into the EU. This trade of plants for planting from China does not look like having a constant flow. The ISEFOR database does not include the number of host plants for planting traded through Internet; this trade is also very difficult to be tracked by the NPPOs (Giltrap et al., 2009).

In scenario A_2, the need for import of host plants for planting would most likely be similar as for the current situation. However, scenario A_2 requires import of plants for planting either originating in a pest free country (currently relevant only for EU PZs) or produced in a pest-free area under a certification scheme. This scenario reduces the possibility of affected Third Countries to produce chestnut plants for planting for export complying with the above requirements. Therefore, it is expected that the trade volume under scenario A_2 is likely to be much smaller compared to that under scenario A_0 (current situation in non-PZs).

Table B.10: [N_0] Number of pathway units potentially carrying *C. parasitica* from the place of production to the risk assessment area in the different scenarios, for the wood with bark pathway

Quantile	A_0	A_1	A_2
[N_0] wood with bark pathway			
Lower	0	0	0
Q_1	50	50	0
M	100	100	0
Q_3	300	300	0
Upper	1,000	1,000	0
Distribution	InvGauss	InvGauss	–

Justifications for N_0 (Table B.10) (wood with bark pathway)

Quantiles for the different scenarios were estimated by expert judgement, based on the following considerations.

No data were obtained on the volume of wood imported into the EU. However, based on expert judgement and information from the Italian Wood Furniture Association Federlegno (personal communication to A.M. Vettraino), the volume is considered to be very low. The low import of chestnut wood into the RA area is likely due to the EU wood production that usually covers the local needs [the current European chestnut forest surface is 1.8 millions of hectares (Conedera et al., 2004)].

It is unlikely that chestnut wood is imported by the EU MSs from affected non-European countries because the timber quality of the European chestnut (*C. sativa*) is higher than that of Asian chestnut species. In China, *C. mollissima* is cultivated mainly for nuts and not for timber (Bounous, 2014). The American chestnut (*C. dentata*), although a good timber producer, is no longer present as mature tree in the USA (due to *C. parasitica*).

In scenario A_0, a slightly higher number of wood with bark units may be expected, because the EU MSs would import chestnut wood with bark or wood that has not undergone kiln-drying, since the prohibition of import applies to isolated bark only (Annex III, part A).

In scenario A_2, the requirement of debarking for import of chestnut wood would result in no import of chestnut wood with bark.

Table B.11: [m_6] Aggregation/disaggregation coefficient* transforming the pathway units/subunits into the transfer units in the different scenarios, for the plants for planting pathway

Quantile	A_0	A_1	A_2
[m_6] plants for planting pathway			
Lower	0.001	0.001	0.001
Q_1	0.5	0.5	0.5
M	0.7	0.7	0.7
Q_3	0.8	0.8	0.8
Upper	1	1	1
Distribution	BetaGen	BetaGen	BetaGen

*: 1 means that all pathway units go separately. For all pathway units to stay together, the coefficient is 1/N of pathway units.

Justifications for m_6 (Table B.11) (plants for planting pathway)

Quantiles for the different scenarios were estimated by expert judgement, based on the following considerations.

If a batch of imported host plants for planting goes to a single new plantation or nursery, it can be considered as an individual founder population. Otherwise, if nursery plants are distributed widely in the EU, each of it can act as a founder population. Scions will probably go to a nursery and stay together. Young plants might be planted together, but could also be distributed to shops. Chestnuts for ornamental purpose are more likely to be sold to different customers.

- For all scenarios:
  - Lower: in case of distribution to a single site (e.g. a single nursery).
  - Median, Q_1 and Q_3: values based on expert judgement, as no evidence is available.
  - Upper: in case of distribution to different nurseries or in case plants are used in many plantations.

Table B.12: [m_6] Aggregation/disaggregation coefficient* transforming the pathway units/subunits into the transfer units in the different scenarios, for the wood with bark pathway

Quantile	A_0	A_1	A_2
[m_6] wood with bark pathway			
Lower	0.005	0.005	0.005
Q_1	0.017	0.017	0.017
M	0.05	0.05	0.05

Quantile	A_0	A_1	A_2
Q_3	0.1	0.1	0.1
Upper	1	1	1
Distribution	BetaGen	BetaGen	BetaGen

*: 1 means that all pathway units go separately. For all pathway units to stay together, the coefficient is 1/N of pathway units.

Justifications for m_6 (Table B.12) (wood with bark pathway)

Quantiles for the different scenarios were estimated by expert judgement, based on an estimation of the number of expected places in the RA area at which wood of *Castanea* may arrive, considering that wood of *Castanea* might be imported mainly for furniture production. Based on expert judgement, most of the furniture production using imported chestnut wood in the EU is located in a few countries.

- For all scenarios:
  - Lower: in case of distribution to a single site.
  - Median, Q_1 and Q_3: values based on expert judgement, as no evidence is available.
  - Upper: in case of distribution to different sites.

Table B.13: $[m_7]$ Multiplication factor changing the abundance from substep E_4 (after leaving the point of entry) to substep E_5 (transferring to the host) in the different scenarios, for the plants for planting pathway

Quantile	A_0	A_1	A_2
$[m_7]$ plants for planting pathway			
Lower	1	1	1
Q_1	6	6	6
M	8	8	8
Q_3	8.5	8.5	8.5
Upper	10	10	10
Distribution	Weibull	Weibull	Weibull

Justifications for m_7 (Table B.13) (plants for planting pathway)

C. parasitica inoculum can be transferred from the imported infected plants for planting to a native susceptible chestnut plant. In case no RROs are applied, infected plants can act as inoculum source for a long time and then transfer the pathogen to host plants.

- For all scenarios:
  - Lower: if an infected sapling is planted close to native susceptible hosts, infection of at least one individual native host can occur. This is based on the observation of identical genotypes of the pathogen in the same or in neighbouring chestnut trees (i.e. a few metres apart) (Milgroom and Lipari, 1995).
  - Median, Q_1 and Q_3: values based on expert judgement, as no evidence is available.
  - Upper: most chestnut trees are used for the production of nuts or wood, thus imported plants tend to be planted close to native chestnut plants (e.g. to replace chestnut trees in chestnut forests or orchards). The spatial distribution of chestnut stands could enhance the spread of the inoculum to new host plants (also see the experience from *Dryocosmus kuriphilus*). Moreover, an introduced infected plant could harbour new strains of the fungus with potential differences in virulence. Historical records show that *C. parasitica* can spread very fast (in North America: 37 km per year; in Italy: 29 km per year) (Shain, 1982; Roane et al., 1986).

Table B.14: [m_{7*}] Multiplication factor changing the abundance from substep E_4 (after leaving the point of entry) to substep E_5 (transferring to the host) in the different scenarios for the plants for planting pathway, due to the RROs

Quantile	A_0	A_1	A_2
[m_{7*}] plants for planting pathway, due to the RROs			
Lower	0.20	0.20	0.20
Q_1	0.38	0.38	0.38
M	0.50	0.50	0.50
Q_3	0.65	0.65	0.65
Upper	0.90	0.90	0.90
Distribution	Uniform	Uniform	Uniform

Justifications for m_{7*} (Table B.14) (plants for planting pathway)

Use of GAPs, which include proper removal of cankers and appropriate management of the plantation (see Appendix C) would reduce the transfer of the pest to a suitable host.

The multiplication factor was then calculated based on the estimated effectiveness of the RROs (see Appendix C).

Table B.15: [m_7] Multiplication factor changing the abundance from substep E_4 (after leaving the point of entry) to substep E_5 (transferring to the host) in the different scenarios, for the wood with bark pathway

Quantile	A_0	A_1	A_2
[m_7] wood with bark pathway			
Lower	0.01	0.01	0.01
Q_1	0.50	0.50	0.50
M	0.80	0.80	0.80
Q_3	0.95	0.95	0.95
Upper	1	1	1
Distribution	BetaGen	BetaGen	BetaGen

Justifications for m_7 (Table B.15) (wood with bark pathway)

A similar situation as for plants for planting occurs in case of the presence of cankers on wood with sporulation on the bark. However, whereas plants for planting typically are planted close to chestnut orchards and plantations, chestnut wood is not commonly disposed or used close to host plants. Many conditions have to be satisfied for infection of native host plants to occur through the inoculum provided by the imported wood with bark; they include: storage of wood with bark near chestnut trees in an open environment, suitable humidity conditions for sporulation of the fungus, appropriate wind speed and direction, the presence of wounds on the bark of the native hosts.

- For all scenarios:
  - Lower: based on expert judgement.
  - Q_1 and Q_3: relatively away from the median because of the uncertainty inherent on the lack of data on this issue.
  - Median: closer to the upper limit, because if there are cankers with sporulation on the bark, it is possible that some of the cankers will start a new infection.
  - Upper: based on expert judgment.

B.2. Establishment

Table B.16: Quantile values of the distribution of the effect of factors influencing establishment

Factors affecting establishment	Weight of the factor affecting the establishment [%]	Quantile values of the distribution of the effect of factors influencing the establishment				
		Lower	Q_1	M	Q_3	Upper
Presence of host plants	100	0.90	0.95	0.97	0.98	1.00
Distribution	BetaGen					

Justifications (Table B.16)

The Panel considers that the presence of host plants is the only relevant factor affecting the establishment of *C. parasitica* in the RA area. The historical records of first report of *C. parasitica* in the EU and the USA confirm that establishment can easily take place.

Quantiles estimations take into consideration the quite continuous natural chestnut distribution in the EU.

Table B.17: Multiplication factor changing the establishment in the different scenarios due to RROs

Quantile	Value		
	A_0	A_1	A_2
Lower	0.5	0.55	0.3
Q_1	0.6	0.68	0.4
M	0.7	0.75	0.5
Q_3	0.8	0.83	0.8
Upper	0.9	0.95	0.9
Distribution	BetaGen	BetaGen	BetaGen

Justifications (Table B.17)

The multiplication factor was calculated based on the effectiveness of RROs (see Appendix C).

B.3. Spread

B.3.1. Substep S_1: initial condition for the spread

Table B.18: [N_3] Number of spatial units representing the initial condition for the spread of *C. parasitica* in the different scenarios

	[N_3]		
Quantile	A_0	A_1	A_2
Lower	15.0	15.0	15.0
Q_1	16.0	16.0	16.0
M	18.0	18.0	18.0
Q_3	18.5	18.5	18.5
Upper	19.0	19.0	19.0
Distribution	Normal	Normal	Normal

Justifications for N_3 (Table B.18)

This step is assessed at the EU MS level because of lack of detailed data at the level of NUTS regions.

Quantiles for the different scenarios were estimated by expert judgement, based on the following considerations.

C. parasitica is already widespread within the RA area. Based on the EPPO PQR database (last accession on 20 September 2016), the EU MSs where the pathogen is currently present are: Austria, Belgium, Bulgaria, Croatia, France, Germany, Greece, Hungary, Italy, Luxembourg, the Netherlands (transient, under eradication), Poland, Portugal, Romania, Slovakia, Slovenia and Spain.

No information is included in the EPPO PQR database (last accession on 20 September 2016) on the pest status in Cyprus, Denmark, Estonia, Finland, Ireland, Malta, Latvia, Lithuania and Sweden.

B.3.2. Substep S_2: maximum number of spatial units (area of potential establishment)

Table B.19: [N_4] Distribution of the maximum number of spatial units in the risk assessment area for the relevant crops/habitats in the different scenarios

	[N_4]		
Quantile	**A_0**	**A_1**	**A_2**
Lower	20.0	20.0	20.0
Q_1	20.5	20.5	20.5
M	21.0	21.0	21.0
Q_3	21.5	21.5	21.5
Upper	22.0	22.0	22.0
Distribution	Normal	Normal	Normal

Justifications for N_4 (Table B.19)

C. sativa is not present in all the EU MSs. Twenty to twenty-two EU MSs are already colonised by the pathogen (they represent most of the continuous natural range of chestnut), the other EU MSs are physically separated or without the presence of the host.

B.3.3. Substep S_3: increase in number of occupied spatial units due to the spread

Table B.20: [m_9] Multiplication factor used to derive the number of spatial units from the initial condition for the spread in the different scenarios

	[m_9]		
Quantile	**m_9 for A_0**	**m_9 for A_1**	**m_9 for A_2**
Lower	0	0.014	0.002
Q_1	0.15	0.200	0.032
M	0.20	0.334	0.051
Q_3	0.21	0.462	0.060
Upper	0.224	0.653	0.072
Distribution	BetaGen	BetaGen	BetaGen

Justifications for m_9 (Table B.20)

- For the A_0 scenario:
  - Lower: in case of no further colonisation of additional EU MSs over the time horizon of the risk assessment (due to saturation effects).
  - Q_1: expert judgement, due to lack of data.
  - Median: the median value is based on the data about the first report of *C. parasitica* in the various EU MSs during the period 1938–2014. The Panel is aware that first reports in the RA area are not necessarily the result of the spread of the pathogen, as some of those reports might be due to new entries, although there is no evidence for this hypothesis. Nevertheless, French genotypes were found in the UK due to the spread of the pathogen. Based on the relatively low genetic variability in the current European population of *C. parasitica* compared to the native populations in Asia (Liu and Milgroom, 2007), the Panel assumes that the median value of 0.2 is mainly due to spread and not to repeated new entries.

 - Q_3: expert judgement, due to lack of data.
 - Upper: confidence intervals of 99% were used for the upper boundary. Saturation effects could lead to no additional MS being affected over the period considered.

- For the A_1 and A_2 scenarios: the multiplication factor was calculated based on the effectiveness of RROs (see Appendix C).

B.3.4. Substep S_4: increase in the spread due to the new entries

Table B.21: $[m_{10}]$ Multiplication factor taking into account the increase in number of occupied spatial units due to the new entries in the different scenarios

	$[m_{10}]$		
Quantile	A_0	A_1	A_2
Lower	1	1	1
Q_1	1	1	1
M	1	1	1
Q_3	1	1	1
Upper	1	1	1

Justification for m_{10} (Table B.21)

Genetic analyses suggest that only a few introductions of *C. parasitica* into the EU have occurred, specifically into Italy (with plant material originating from the USA), France (originating from Japan) and Spain (Dutech et al., 2012). From these introductions, the spread of the pathogen occurred by wind or through infected host plants for planting. Even if there is no evidence of further new entries in the past, this does not rule out that additional introductions might occur in the future. The trend towards importing host plants for ornamental purposes from Asia or the USA might result in further introductions of the pathogen.

In this PRA, the Panel did not consider the increase in the spread due to new entries because the new established *C. parasitica* populations will be equally distributed in the RA area. As the number of established pathogen populations from new entries is in all scenarios are high and given the spatial resolution used (EU MSs), it can be reasonably expected that all EU MSs will be affected by new introductions.

B.4. Impact

As anticipated in Section 1.3, the assessment of impact was carried out for virulent strains only because hypovirulent strains do not cause relevant damage to plants.

In estimating impacts, two situations were analysed. The first is based on the situation in some EU MSs before the appearance of hypovirulence, i.e. the damage recorded in the 1960s. The second is based on the current hypovirulence situation in the EU, in which low level of damage occurs.

The Panel is aware that the situation of hypovirulence is not uniform among the EU-affected areas (non-PZ). In some areas (e.g. Italy), hypovirulence occurs in about 90% of the chestnut stands, whereas in other areas (e.g. France and Portugal) the prevalence of hypovirulence is considerably lower (e.g. Colinas and Uscuplic, 1999; Bragança et al., 2007). Thus, both situations, i.e. with and without hypovirulence, should theoretically be considered. However, given that hypovirulent strains do not cause damage, they are not considered here.

New virulent strains of the pathogen (coming from abroad or formed within the EU population by mutation or sexual recombination (Ježić et al., 2012)), if not affected by hypovirulence, could rapidly spread, as happened in the USA, causing high damage. Until now, new strains were rarely formed within the European *C. parasitica* population and, if present, they were affected by hypovirulence, thus remaining very localised.

An increase in *C. parasitica* diversity in the EU could be worrying because of the experience in the USA, where a high vegetative compatibility (vc) type diversity of the pathogen seems to be one of the reasons for the lack of establishment of hypovirulence (Milgroom and Cortesi, 2004). Introducing new *C. parasitica* virulent strains from Third Countries into the EU represents a high risk of introducing new vc types.

In this Risk Assessment, the Panel considers that the impact caused by new virulent strains of the pathogen coming from Third Countries into the EU-affected areas (non-PZs) will be the same as that caused by the spread of the EU virulent strains of the pathogen to PZs.

The Panel also considers that each entry is probably a different strain and makes the assumption that these strains enter and spread independently from the others.

B.4.1. Assessment of impact for the different scenarios

Substep I_1: Abundance of the pest in the spatial units occupied by the pest under the different scenarios

Table B.22: [P_5] Estimated abundance of *C. parasitica* virulent strains (as percentage of plants carrying new virulent strains) in the new established populations of the pest under the different scenarios

	[P_5]		
Quantile	**A_0**	**A_1**	**A_2**
Lower	0.0010	0.0010	0.0010
Q_1	0.0025	0.0025	0.0025
M	0.0030	0.0030	0.0030
Q_3	0.0035	0.0035	0.0035
Upper	0.0050	0.0050	0.0050
Distribution	Weibull	Weibull	Weibull

Justification for P_5 (Table B.22)

- For all scenarios:
  - Lower: based on the historical experience of no new entries of virulent strains over the last decades.
  - Q_1: expert judgement, due to lack of data.
  - Median: hypovirulence is currently widespread in the EU, so it is likely that only a few of the new entries will be virulent and not controlled by hypovirulence.
  - Q_3: expert judgement, due to lack of data.
  - Upper: based on the historical experience of three introductions of the pathogen into the EU over a period of about 30 years in the middle of the last century.

As hypovirulence is not affected by regulations, it is considered to be present in all scenarios.

Table B.23: [P_{5*}] Number of established *C. parasitica* (new virulent strains) populations for scenarios A_0, A_1 and A_2, per year (time horizon = 10 years)

	[P_{5*}]		
Quantile	**A_0**	**A_1**	**A_2**
Lower	0	0.2	0.00000003
Q_1	0.008	4.2	0.000001
M	0.029	9.3	0.000005
Q_3	0.081	18.1	0.00002
Upper	0.81	59.8	0.0008
Distribution	These are results from a calculation, so no distribution was fitted to the obtained quantiles		

Justification for P_{5*} (Table B.23)

The number of established *C. parasitica* (new virulent strains) populations for scenarios A_0, A_1 and A_2 was calculated by combining establishment (as previously estimated) with P_5.

B.4.2. Assessment of impacts on host crops

Substep I_2: Estimation of the change in crop production outputs in the spatial units occupied by the pest in the different scenarios

As chestnut nuts and wood have an economic value, *Castanea* is considered as a crop, i.e. separately from the ecosystem services. Chestnut blight causes reduction in quantity and quality of nuts and wood.

Table B.24: [m_{11}] Multiplication factor changing crop production outputs (chestnut nuts and wood) in relation to virulent strain of *C. parasitica* in the different scenarios

Quantile	A_0	A_1	A_2
[m_{11}] nuts			
Lower	0.70	0.70	0.70
Q_1	0.85	0.85	0.85
M	0.90	0.90	0.90
Q_3	0.93	0.93	0.93
Upper	1.00	1.00	1.00
[m_{11}] wood			
Lower	0.70	0.70	0.70
Q_1	0.85	0.85	0.85
M	0.90	0.90	0.90
Q_3	0.93	0.93	0.93
Upper	1.00	1.00	1.00
Distribution	No distribution was fitted to these values, as they were not used for calculations reported in the summary of the risk assessment		

Justification for m_{11} (Table B.24)

When a branch dies because of a canker, the nut production of that branch is lost. For pole production, the output is reduced only in case of cankers on the main stem (this is more likely in the case of young plantations). As the cankers caused by virulent strains have similar impact on nuts and wood production, the same values are used.

- For the A_0 scenario:
  - Lower: if the canker is on a branch, the production will be reduced, but the tree might survive for a little while, until a new canker appears on the stem.
  - Q_1: intermediate value of damages between lower and median.
  - Median: most of the trees are badly damaged with strong but not total reduction in production and hypovirulence already present and spreading.
  - Q_3: intermediate value of damages between median and upper.
  - Upper: without hypovirulence, chestnut blight is a severe disease, thus, the upper value is equal one (total loss of the production is expected if the canker is on the stem).

In the A_1 scenario, no changes are expected in chestnut nut and wood production, because the RROs measures listed in Appendix C for impact do not apply to the outputs of the single plant affected.

In the A_2 scenario, introducing hypovirulence, when available, from the area in which the new virulent strains originate, as it is currently done in Portugal and Greece (Diamandis et al., 2015), could be considered as an additional RRO (mitigation measure). Although this could start working already within the time horizon considered in the present PRA (10 years), particularly for the protection of individual trees, it would be more effective in the long run (Robin and Heiniger, 2001). The same measure could be applied to pathogen strains potentially introduced/spread from the already affected non-PZs into the PZs, supposing that hypovirulence is not introduced into a new area together with the new virulent strain. For these reasons, scenario A_2 is equal to scenario A_0.

B.4.3. Assessment of impacts on the environment

Substep I_4: Estimated change in ecosystem services provision levels (for selecting provisioning, regulating and supporting services) in the spatial units occupied by the pest in the different scenarios

In this PRA, the following ecosystem services provided by chestnut plants were considered:

- provisioning ecosystem services: honey, nuts for wildlife, mushroom production, grazing, etc.,
- regulating and supporting services: water regulation, erosion avoidance, carbon sequestration, etc., and
- cultural services: cultural heritage, recreation, landscape aesthetics, tourism, etc.

Table B.25: [m_{13}] Multiplication factor changing the provision of provisioning ecosystem services in relation to virulent strains of *C. parasitica* in the different scenarios

	[m_{13}]		
Quantile	**A_0**	**A_1**	**A_2**
Lower	0.80	0.80	0.80
Q_1	0.94	0.94	0.94
M	1.00	1.00	1.00
Q_3	1.06	1.06	1.06
Upper	1.20	1.20	1.20
Distribution	Gamma	Gamma	Gamma

Justification for m_{13} (Table B.25)

Currently, the ecosystem services are completely provided by chestnut stands, where hypovirulence is predominant. The reappearance of damages due to new virulent strains could affect also some ecosystem services related to the loss of the chestnut trees (Boyd et al., 2013). Of course, the maintenance or the regrowth of a new forest cover could reduce the impact.

- For the A_0 scenario:
  - Lower: in case of host tree survival with limited mortality of branches.
  - Q_1, Median and Q_3: expert judgement, due to lack of data.
  - Upper: in case of severe damage.
- For the A_1 and A_2 scenarios: An additional multiplication factor was calculated based on the effectiveness of RROs (see Appendix C). For the A_2 scenario, introduction of new hypovirulent strains from Third Countries is estimated to be no effective in a time horizon of 10 years.

Table B.26: [m_{13*}] Multiplication factor changing the provision of regulating and supporting ecosystem services in relation to virulent strains of *C. parasitica* in the different scenarios

	[m_{13*}]		
Quantile	**A_0**	**A_1**	**A_2**
Lower	0.80	0.80	0.80
Q_1	0.94	0.94	0.94
M	1.00	1.00	1.00
Q_3	1.03	1.03	1.03
Upper	1.10	1.10	1.10
Distribution	Gamma	Gamma	Gamma

Justification for m_{13*} (Table B.26)

Chestnut is often cultivated in pure stands. Loss of the chestnut trees would thus result in a temporary reduction in regulating and supporting ecosystem services. Other tree species can take the role of chestnut, both in chestnut orchards and coppices. However, the abandonment of cultivation could cause the cessation of the maintenance of landscape and structures.

- For the A_0 scenario:
  - Lower: in case of host tree survival with limited mortality of branches.
  - Q_1, Median and Q_3: expert judgement, due to lack of data.
  - Upper: in case of severe damage.
- For the A_1 and A_2 scenarios: An additional multiplication factor was calculated based on the effectiveness of RROs (see Appendix C). For the A_2 scenario, introduction of new hypovirulent strains from Third Countries is estimated to be no effective in a time horizon of 10 years.

Table B.27: [m_{13**}] Multiplication factor changing the provision of cultural ecosystem services in relation virulent strains of *C. parasitica* in the different scenarios

	[m_{13**}]		
Quantile	**A_0**	**A_1**	**A_2**
Lower	0.60	0.60	0.60
Q_1	0.85	0.85	0.85
M	1.00	1.00	1.00
Q_3	1.10	1.10	1.10
Upper	1.25	1.25	1.25
Distribution	BetaGen	BetaGen	BetaGen

Justification for m_{13**} (Table B.27)

There is a whole civilisation associated with chestnut, but this has already declined over the last decades (partly due to the chestnut blight itself and other pathogens but mainly due to abandonment of the crop). Therefore, based on expert judgement, the reduction in cultural ecosystem services due to new virulent strains of *C. parasitica* will be further enhanced.

- For the A_0 scenario:
  - Lower: in case of host tree survival with limited mortality of branches.
  - Q_1, Median and Q_3: expert judgement, due to lack of data.
  - Upper: in case of severe damage.
- For the A_1 and A_2 scenarios: An additional multiplication factor was calculated based on the effectiveness of RROs (see Appendix C). For the A_2 scenario, introduction of new hypovirulent strains from Third Countries is estimated to be no effective in a time horizon of 10 years.

Substep I_5 Estimated change in biodiversity (e.g. percentage reduction in species richness) in the spatial units occupied by the pest as assessed in the spread step

When a chestnut orchard or coppice is lost because of *C. parasitica*, the biodiversity associated with chestnut might be lost locally, but the biodiversity at the landscape level is likely to increase, because chestnut forests tend to be homogeneous due to the artificial dominance of chestnut.

Table B.28: [m_{14}] Multiplication factor changing the biodiversity in relation to virulent strains of *C. parasitica* in the different scenarios

	[m_{14}]		
Quantile	**A_0**	**A_1**	**A_2**
Lower	1.0	1.0	1.0
Q_1	1.2	1.6	1.2
M	1.3	2.0	1.3
Q_3	1.4	3.3	1.4
Upper	1.5	5.0	1.5
Distribution	No distribution was fitted to these values, as they were not used for calculations reported in the summary of the risk assessment		

Justification for m_{14} (Table B.28)

The Panel underlines that it is difficult to estimate a single multiplication factor the potential consequences for biodiversity of the introduction and spread of new virulent strains of *C. parasitica*. It is known that the biodiversity structure of chestnut orchards and coppices would change dramatically. Drastic changes are to be expected in the community associated with chestnut species, even if it is difficult to predict which organisms will colonise the affected chestnut forests and orchards. Thus, these changes could lead to both the disappearance of certain species and the appearance of others. There are many publications on the ecological consequences of chestnut blight in North America (Smith et al., 2009). Biodiversity loss would also include the loss of local and rare chestnut varieties.

- For all scenarios and quantiles: expert judgement, due to lack of data.

B.4.4. Assessment of the impact at the EU level

In Table 32, the impact is assessed at the level of the single tree. Should the introduction of virulent strains take place, then the local impact would be great, particularly in the long run. The proportion of the area of the occupied spatial units where the relevant crops/habitats are present and where the pathogen can spread under the different scenarios is related to the distance over which the pathogen is spread per year due to both short- and long-distance dispersal.

To quantify the magnitude of the impact at the level of the whole RA area, a simple epidemiological model is used to describe the stratified dispersal (i.e. long- and short-distance dispersal) of the new virulent strains across the area where the host is present. The epidemiological model is based on a logistic growth curve that describes the time variation of the percentage of the area that the new virulent strains can colonise. The model considers: (i) the number of established populations in 5 years in the different scenarios as the initial condition of the epidemics, (ii) a population growth rate describing the rate at which the epidemics spread in the host population across the EU in the different scenarios, and (iii) a carrying capacity expressing the maximum level of prevalence of the disease in the suitable area, given that the prevalence expressed as a proportion of the carrying capacity is equal to 1 (see Appendix A).

The impact is estimated considering the proportion of area with the presence of the main host *C. sativa* affected by new virulent strains of *C. parasitica* at the end of the assessment period (10 years).

Substep I_7: Estimate the absolute impact at the EU level

Table B.29: [R_1] Estimated growth rate (1/year) appearing in the epidemiological model that describes the spread of the epidemics due to the stratified dispersal of new virulent strains of *C. parasitica*

	[R_1]		
Quantile	**A_0**	**A_1**	**A_2**
Lower	0.630	0.630	0.630
Q_1	1.324	1.324	1.324
M	1.375	1.375	1.375
Q_3	1.446	1.446	1.446
Upper	1.543	1.543	1.543
Distribution	Gamma	Gamma	Gamma

Justification for R_1 (Table B.29)

Based on historical data, the dispersal distance of new virulent strains of *C. parasitica* is estimated in a range from 1 (lower quantile) to 40 (upper quantile) km per year. Considering this range of the dispersal distance, the corresponding area of the epidemic spread is calculated for the lower and upper quantiles. The values of Q_1, M and Q_3 are estimated based on expert judgement. The growth rate in Table B.29 is calculated by fitting the exponential growth of the infected area obtained with the assumption of no carrying capacity. The growth rate is the same in all the scenarios because the Panel considers that there are no conditions or RROs considered in the different scenarios able to influence the spread of the epidemics in the considered time horizon.

Table B.30: [R_2] Proportion (ranging from 0 to 1, where 1 = 100%) of the area of the occupied spatial units where the relevant crops/habitats are present and where the new virulent strains of *C. parasitica* are present under the different scenarios in 10 years

	[R_2]		
Quantile	**A_0**	**A_1**	**A_2**
Lower	0.14	0.10	0.03
Q_1	0.25	0.39	0.06
M	0.31	0.68	0.09
Q_3	0.37	0.79	0.11
Upper	0.56	1.00	0.19
Distribution	These are results from a calculation, so no distribution was fitted to the obtained quantiles		

Justification for R_2 (Table B.30)

R_2 represents the proportion of the area of the occupied spatial units where the relevant crops/habitats are present and where the new virulent strains of *C. parasitica* can spread under the different scenarios in 10 years. This proportion was calculated based on the logistic model presented in the introductory part of Appendix B.4.4, taking into account the estimated growth rate of the pathogen per year (as reported in Table B.29). Moreover, the established populations due to the entry of new virulent strains are expected to be randomly distributed across the risk assessment area.

The endangered area corresponds to the area in R_2.

Appendix C – Detailed information on the Risk Reduction Options (RROs)

C.1. RROs in scenarios A_0 and A_2

The RROs considered in scenarios A_0 (current situation in the non-PZ of the RA area with respect to the EU legislation (Council Directive 2000/29/EC on the pest and its host as well as the emergency measures applied by the *C. parasitica*-affected EU MSs) and A_2 (current situation in PZs with some measures being already in place (Annex IV, Part B of Directive 2000/29/EC) and additional RROs for the whole RA area) are listed in Tables C.1–C.4, for entry, establishment, spread and impact.

Scenario A_1 is not included because it describes the situation without RROs (worst-case scenario).

Table C.1: Summary of the RROs in scenarios A_0 and A_2 (entry)

Plants for planting		**Wood with bark**	
Scenarios			
A_0	**A_2**	**A_0**	**A_2**
Step: Entry, Substep: E_1. Measures applied before leaving the place of production			
Prohibition of import of plants with leaves other than fruits and seeds from non-European countries (relevant for the whole EU) (*Annex III, Part A*) Plants for planting originate from a pest free area OR pest free place of production (based on visual inspection) (relevant for non-PZs) (*Annex IV, Part A, Section I*) – Requirements for introduction of plants for planting in PZ (see point 19.1 in annex IVB of the Council Directive 2000/29/EC)	Plants for planting originate from a pest free country (currently relevant for PZs, i.e. CZ, IRL, S, UK)) (*Annex IV, Part B of Directive 2000/29/EC*) OR produced in a pest free area under a certification scheme AND plant health inspection at the country of origin for issuing a plant passport	Prohibition of import of isolated bark from Third countries (relevant for the whole EU) (*Annex III, Part A*) – Requirements for introduction of wood and bark in PZ (see points 6.3 and 14.9 in annex IVB of the Council Directive 2000/29/EC)	Wood as to be bark free OR originate from a pest free area OR kiln-dried (currently relevant only for PZs) (*Annex IV, Part B*) AND plant health inspection in the country of origin-phytosanitary certificate (import) or plant passport (for PZ movement) (for wood excluding bark-free wood) (currently relevant only for PZs) (*Annex V, Part B, Section II*)
Substep: E_2. Measures applied before crossing the border of the exporting country			
No requirements in Council Directive 2000/29/EC	No additional RROs	No requirements in Council Directive 2000/29/EC	No additional RROs
Substep: E_3. Measures applied before arriving at the EU point of entry (during transport)			
No requirements in Council Directive 2000/29/EC	No additional RROs	No requirements in Council Directive 2000/29/EC	No additional RROs
Substep: E_4. Measures applied before leaving the EU point of entry			
Prohibition of movement and proper disposal of non-compliant consignments as part of the general measures applied by the phytosanitary inspectors	Visual inspection AND sampling AND lab-testing, in case of suspect symptoms (mandatory)	Prohibition of movement and proper disposal of non-compliant consignments as part of the general measures applied by the phytosanitary inspectors	Visual inspection AND sampling AND lab-testing, in case of suspect symptoms (mandatory)

Plants for planting		Wood with bark	
Scenarios			
A_0	A_2	A_0	A_2
Substep E_5. Measures applied before transferring to the host			
No requirements in Council Directive 2000/29/EC GAPs* currently in place (not mandatory)	No additional RROs GAPs currently in place (not mandatory)	No requirements in Council Directive 2000/29/EC	No requirements in Council Directive 2000/29/EC for PZs

*: GAPs – good agricultural practices include cropping practices avoiding stresses, visual inspections for cankers, roguing of branches with cankers and correct disposal of the pruning debris. It also includes IPM by using/favouring hypovirulence.

Table C.2: Summary of the RROs in scenarios A_0 and A_2 (establishment)

Step	Substep		A_0	A_2
Establishment	**T**	Measures modifying establishment	No requirements in Council Directive 2000/29/EC GAPs (not mandatory)	Surveillance AND Eradication in the whole RA area GAPs (not mandatory)

Table C.3: Summary of the RROs in scenarios A_0 and A_2 (spread)

Step	Substep		Plants for planting		Wood with bark	
			Scenarios			
			A_0	A_2	A_0	A_2
Spread	**S**	Measures modifying the spread factor	Plants for planting originate from a pest-free area OR pest free place of production (based on visual inspection) (relevant for non-PZs) (*Annex IV, Part A, Section II*). Plant health inspection at the place of production: plant passport (relevant for the whole EU) (*Annex V, Part A, Section I of Directive 2000/29/EC*). GAPs including hypovirulence (not mandatory)	Plants for planting originate from a pest-free area (currently relevant only for PZs) (*Implementing Directive 2014/78/EU to Annex IV, Part B of Directive 2000/29/EC*) GAPs AND Biological control by using hypovirulent strains active against new virulent strains to improve the natural spread of hypovirulence	No requirements in Council Directive 2000/29/EC for non-PZs	<u>Wood</u>: bark free OR originated in a pest free area OR kiln-dried (currently relevant only for PZs) Wood (excluding bark free wood) and isolated bark: plant health inspection at the place of production: plant passport (currently relevant only for PZs) (*Annex V, Part A, Section II*) <u>Isolated bark</u>: pest free area OR fumigated (or treated with other appropriate treatment) (currently relevant only for PZs) (*Annex IV, Part B*)

Table C.4: Summary of the RROs in scenarios A_0 and A_2 (impact)

Step	Substep		A_0	A_2
Impact		Measures modifying abundance in the affected areas	As for spread	As for spread

C.2. Description of the RROs in scenario A_2

C.2.1. Certification scheme for plants for planting

A certification scheme could be developed for the production of pest-free host plant propagation material. Currently, there is no official certification scheme for *Castanea* plants for planting.

C.2.2. Visual inspection, sampling and lab-testing of consignments

Plants for planting

Chestnut plants for planting should be carefully inspected for bark lesions (Turchetti et al., 2008; Prospero and Rigling, 2013; Rigling et al., 2014). At the beginning of the infection, these lesions are difficult to detect. Later on, the infected smooth bark turns from olive green to bright brown, orange brown, yellow brown or red brown, may sink inwards, and irregular margins may develop. Particular attention should be given to the grafting points which are particularly susceptible to attacks by *C. parasitica* or to the stem base where wounds are frequently located (e.g. mowing machine). A typical symptom of virulent chestnut blight is a dead branch with hanging wilted yellow or brown leaves (so-called 'flag'). On this branch below the dead leaves, a girdling canker is usually present.

A weakness of this measure is the difficulty to detect lesions at the very initial stage, i.e. before symptoms on the bark are visible (e.g. germinating spores). Anyway initial infections consist of localised reddish bark and can be detected with careful inspection. Moreover, *C. parasitica* can also be present as endophyte in the healthy bark of chestnut plants (e.g. Bissegger and Sieber, 1994). Lesions may develop when chestnut plants are stressed (e.g. during the transport). Early stage lesions could be detected by keeping the plants in quarantine for at least 2–3 months. However, the proportion of inspected plants is low and there are strong differences among the EU MSs in their sampling effort (Eschen et al., 2015). In addition, it is difficult to estimate the proportion of latently infected (asymptomatic) plants in a consignment.

A lab testing can be used to verify the presence of *C. parasitica* on the host, according to the methods described in EPPO Standard 7/45(1) (EPPO, 2005).

Wood

Wood consignments should be examined for the presence of *C. parasitica* by visual inspection, sampling and laboratory analysis according to the EPPO Standard 7/45(1) (EPPO, 2005).

C.2.3. Wood and isolated bark treatment

Debarking

Given that *C. parasitica* is a bark pathogen (Biraghi, 1946), if the bark is removed before the wood with bark is transformed into pallets, there is a significant decrease in the pathogen abundance. The fungus can survive inside the wood (small fragments of mycelium), but without being able to multiply. Although it is not easy to debark young poles and, thus, some fragments of infected cambium might remain, the Panel considers the wood pathway to be closed by a correct, complete debarking.

Kiln-drying

Kiln-drying to below 20% moisture content, expressed as a percentage of dry matter, achieved through an appropriate time-temperature schedule, is expected to reduce the risk of introducing the pathogen by importing infected wood. There appear to be no data on the effectiveness of this RRO, but it is expected that mycelium of *C. parasitica* will not survive at such moisture content of the wood.

Fumigation

According to ISPM 15, the wood packaging material must be fumigated with methyl bromide in accordance with a schedule that achieves the minimum concentration–time product (CT) over 24 h at the temperature and final residual concentration specified in Table C.5. This CT must be achieved throughout the wood, including at its core, although the concentrations would be measured in the ambient atmosphere. The minimum temperature of the wood and its surrounding atmosphere must be not less than 10°C and the minimum exposure time must be not less than 24 h. Monitoring of gas concentrations must be carried out at a minimum at 2, 4 and 24 h (in the case of longer exposure times and weaker concentrations, an additional measurement should be recorded at the end of fumigation).

No data are available in the literature with regard to the effectiveness of this RRO. Nevertheless, it is expected that the pathogen will not survive exposure to methyl bromide under the conditions described above.

Table C.5: Minimum concentration–time product (CT) over 24 h for wood packaging material fumigated with methyl bromide

Temperature	CT (g h/m^3) over 24 h	Minimum final concentration (g/m^3) after 24 h
21°C or above	650	24
16°C or above	800	28
10°C or above	900	32

C.2.4. Enhanced surveillance and eradication programmes

Surveillance

No specific data exist on how frequent newly planted chestnut plants should be visually inspected for symptoms of chestnut blight. The Panel recommends visual inspections to be performed at least once a year (preferably two inspections) during the vegetative period.

Eradication

Achieving eradication is very difficult for *C. parasitica*. Nonetheless, there are official reports of some EU MSs where *C. parasitica* is under eradication. Eradication implies collecting all infected plants and destroy them via burning. For eradication to be possible, very early detection is needed.

C.2.5. Biological control using hypovirulence

Once *C. parasitica* is established in a chestnut stand, biocontrol with hypovirulence (natural or human-assisted) is the most promising approach to reduce further impacts of the pathogen. Hypovirulence has two main advantages: (1) hypovirus-infected *C. parasitica* strains usually (if the host is not strongly stressed) do not kill the infected trees, and (2) hypovirulence is able to spread naturally and to become predominant and stable over time (Heiniger and Rigling, 1994; Turchetti et al., 2008). Currently, in the RA area hypovirulence is spreading naturally in almost all the natural range of European chestnut. Where hypovirulence is not present naturally, it may be introduced by artificial inoculation (e.g. Heiniger and Rigling, 1994, 2009; Prospero and Rigling, 2016). Therapeutic individual-canker treatment could be useful in Europe but is too expensive over large regions (Milgroom and Cortesi, 2004; Turchetti et al., 2008). Given that the hypovirus is best transmitted between fungal strains belonging to the same group of vegetative compatibility, the introduction of new virulent strains may significantly reduce chances of hypovirus transmission (Turchetti et al., 2008). In order to increase hypovirulence, new hypovirulent strains could be obtained in the lab by means of conversion of virulent strains. However, if the introduced vegetative compatibility types are genetically completely different from those already present in the EU, control by means of hypovirulence of *C. parasitica* in the field might not be effective (as is the case in North America).

Impact largely depends on hypovirulence. With no hypovirulence, the impact is expected to be considerable, as in the 1960s in Italy. With hypovirulence, the impact is contained (Biraghi, 1946; Griffin, 1986).

C.3. Assessment of the effectiveness of RROs in scenarios A_0 and A_2

The effectiveness of the RROs was assessed based on expert judgement (Tables C.6–C.9). In this assessment, 0 means no effect and 1 means 100% effect.

The RRO multiplication factors for scenario A_1 are calculated based on the estimated effectiveness of the RROs in scenario A_0 with the formula: $m(A_1) = 1/(1 - \text{eff RRO}(A_0))$. The RRO multiplication factors for scenario A_2 are instead calculated based on the estimated effectiveness of the RROs in scenario A_2 with the formula: $m(A_2) = (1 - \text{eff RRO}(A_2))$.

Table C.6: Summary of the estimated effectiveness of the RROs in scenarios A_0 and A_2 (entry)

	Plants for planting		Wood	
Quartiles	**A_0**	**A_2**	**A_0**	**A_2**
Step: Entry, Substep: E_1, Measures applied before leaving the place of production				
Lower	0.7	0.8	0	0.8
Q_1	0.85	0.92	0	0.92
M	0.9	0.95	0	0.95
Q_3	0.95	0.97	0	0.97
Upper	0.99	1	0	1
Substep: E_2, Measures applied before crossing the border of the exporting country				
Lower	0	0	0	0
Q_1	0	0	0	0
M	0	0	0	0
Q_3	0	0	0	0
Upper	0	0	0	0
Substep: E_3, Measures applied before arriving at the EU point of entry (during transport)				
Lower	0	0	0	0
Q_1	0	0	0	0
M	0	0	0	0
Q_3	0	0	0	0
Upper	0	0	0	0
Substep: E_4, Measures applied before leaving the EU point of entry				
Lower	0.8	0.85	0.5	0.85
Q_1	0.92	0.92	0.65	0.92
M	0.95	0.95	0.75	0.95
Q_3	0.97	0.97	0.85	0.97
Upper	0.99	1	0.99	1
Substep E_5, Measures applied before transferring to the host				
Lower	0.1	0.1	0	0
Q_1	0.35	0.35	0	0
M	0.5	0.5	0	0
Q_3	0.62	0.62	0	0
Upper	0.8	0.8	0	0

Table C.7: Summary of the estimated effectiveness of the RROs in scenarios A_0 and A_2 (establishment)

Step: establishment		
Quartiles	**A_0**	**A_2**
Lower	0.1	0.1
Q_1	0.2	0.2
M	0.4	0.5
Q_3	0.4	0.6
Upper	0.5	0.7

Table C.8: Summary of the estimated effectiveness of the RROs in scenarios A_0 and A_2 (spread)

Step: spread	**Plants for planting**		**Wood**	
Quartiles	**A_0**	**A_2**	**A_0**	**A_2**
Lower	0		0.60	
Q_1	0.1		0.67	
M	0.5		0.70	
Q_3	0.6		0.77	
Upper	0.7		0.90	

Table C.9: Summary of the estimated effectiveness of the RROs in scenarios A_0 and A_2 (impact)

Step: impact		
Quartiles	**A_0**	**A_2**
Lower	0	0.6
Q_1	0.1	0.67
M	0.5	0.7
Q_3	0.6	0.77
Upper	0.7	0.9