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Pest risk assessment of *Diaporthe vaccinii* for the EU territory

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Abstract

As requested by the European Commission, the EFSA Panel on Plant Health (PLH) Panel assessed the risk of *Diaporthe vaccinii* in the EU, focusing on entry, establishment, spread and impacts on cultivated and wild *Vaccinium* species, the principal hosts being American and European cranberry and blueberry. Several outbreaks occurred in the EU since 1956, but most were eradicated except in Latvia. The Panel considered entry via fruits and plants for planting. The risk of establishment from discarded infected berries is much lower than from infected plants for planting, of which, potted plants and cuttings pose the greatest risk, while plug plants, derived from tissue culture and grown in pest free structures, pose a low risk. Nine per cent of the EU is highly suitable for establishment of the pathogen, mostly in the SE and NE. Following establishment, the pathogen could spread naturally over short range, and by human assistance over long range. Calculations with an integrated model for entry, establishment and spread, indicate that with current regulations, over a period of 5 years, a few hundred cultivated *Vaccinium* plants and several thousand *Vaccinium* plants in natural ecosystems would contract the disease. The associated loss of commercial production is small, less than one tonne of berries per year. On natural vegetation, the median impact after 5 years was estimated to be negligible affecting a negligible proportion of the natural *Vaccinium* population (2×10^{-8}). However, the uncertainty of this estimate was high, due to uncertainty about the rate of spread; in a worst-case scenario (99th percentile), almost 1% of plants in natural areas would become infected. Complete deregulation (scenario A1) was predicted to increase the impact substantially, especially in natural areas, while additional measures (scenario A2) would effectively eliminate the entry of infected plants for planting, further reducing the impacts below the current situation.

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Keywords: *Diaporthe vaccinii*, *Phomopsis vaccinii*, blueberry, cranberry, plant health, quantitative risk assessment, risk reduction options

Requestor: European Commission

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Figure 11: EPPO

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Summary

Request – Following a request from the European Commission, the EFSA Panel on Plant Health (PLH) Panel performed a risk assessment for *Diaporthe vaccinii* (fungal disease) in the European Union (EU) focusing on the risk of entry and establishment, the spread from established outbreaks, and the potential impacts considering the host range. The principal hosts of *Diaporthe vaccinii* are American and European cranberries (*Vaccinium macrocarpon, Vaccinium oxycoccos*), highbush blueberry (*Vaccinium corymbosum*), lowbush blueberry (*Vaccinium angustifolium*) and rabbiteye blueberry (*Vaccinium ashei*), but the host range is thought to include all *Vaccinium* species. Several outbreaks have been recorded in the EU since 1956, but most of them were eradicated. Latvia in the only EU country where the pathogen is currently officially present. *D. vaccinii* is also present in parts of the USA, Canada, Chile and China, and possibly in Belarus and Russia where the presence of the pathogen has not been confirmed by molecular techniques, viz. DNA sequencing.

The Panel interpreted the Terms of Reference as a request to conduct a full Pest Risk Assessment (PRA) with the aim to develop risk reduction options (RROs) on the basis of the pathways of entry and spread identified in the recent Pest Categorisation (EFSA PLH Panel, 2014), namely human-assisted and natural means, including infected symptomatic or asymptomatic *Vaccinium* plants for planting intended for commercial berry production or for domestic use in home and garden, infected or contaminated berries for consumption, as well as rain and wind-dispersed spores, contaminated irrigation water, or vectoring by animals.

Data and methodology – The literature search followed the strategy described in the pest categorisation for the retrieval of additional relevant papers besides those listed in the pest categorisation. In particular, refereed publications on '*Diaporthe* or *Phomopsis*' combined with '*Vaccinium*' were searched in the Web of Science. DNA sequences for recent identifications of *D. vaccinii* worldwide were obtained from GenBank (2010–2016). Research reports and extension publications on blueberry and cranberry diseases were obtained through searches in Google. Literature on *Phomopsis* (or *Diaporthe*) *vaccinii* in the Russian language was also obtained through Google and translated into English by EFSA staff. In addition, a recent paper on the potential distribution of *Vaccinium* twig blight in Europe based on the current global distribution and global long-term climate data was used for the delineation of the potential establishment area. Epidemiological data for the prediction of natural spread of the pathogen was not available for *D. vaccinii*, and data on other *Phomopsis* species and other fungi were used for this purpose.

Quantitative information on blueberry and cranberry production, interception of *Vaccinium* plants or fruits, and findings of *D. vaccinii* used for the PRA was deduced from websites of EUROPHYT, EPPO, ISEFOR, EUROSTAT, FAOSTAT and JRC. Moreover, Member States were consulted about survey data collected in 2016, and selected berry producers and nurseries were consulted about the origin of their plants. Finally, quantitative information on the export of *Vaccinium* plants from the USA was obtained through several State Certification Agencies (USDA-APHIS, 2017).

A map of natural *Vaccinium* vegetation was made on the basis of the following data sets: (1) Maps of realised distributions of *Vaccinium myrtillus* and *Vaccinium vitis-idea* at 10 × 10 km resolution; (2) Corine Land Cover data.

Quantitative data on the diseases caused by *D. vaccinii* and their impact on yield were obtained primarily from Plant Disease Management Reports of the American Phytopathological Society and research reports from the Ministry of Agriculture in Canada. However, most of the data needed for the quantitative estimations presented here were not available in the literature or on websites. Expert judgement was thus used in many cases. The quantitative estimations provided by the experts should be taken with caution as different experts might provide different figures in such a situation of scant evidence.

Assessment – The quantitative risk assessment template, currently developed by the EFSA PLH Panel, was followed. The assessment model is presented by means of flow charts in the main text, and detailed formulas and specification and quantitative assessment of parameter values in Appendix A. Uncertainties associated with trade data and model parameters were identified and analysed with regard to their impact on the final assessment outcome in line with the Draft Guidance on Uncertainty (EFSA Scientific Committee, 2016).

The assessment was based on a quantitative model that distinguished six main pathways of entry two categories of berry fruit and four categories of plants for planting, three scenarios for RROs, and four EU regions for the assessment of the probability of establishment and the rate of spread in nurseries, production and natural areas.

The three scenarios for the use of RROs are:

A0 scenario, which describes the current situation in the RA area with respect to the EU legislation (Council Directive 2000/29/EC[1]) on the pathogen and its host.

A1 scenario, which describes the situation where *D. vaccinii is deregulated*

A2 scenario, which describes the current situation but with the application of additional RROs. In this scenario, the application of a combination of the most effective RROs is considered.

The risk of new introductions of *D. vaccinii* into the RA area by means of the main pathways for **entry** (i.e. berry fruits, plants for planting) is relatively high, but the probability of establishment is low. For the blueberry fruit pathway, the estimated number of infected fruit entering the EU (median, A0 scenario), is in the order of 200,000/year, but the probability of establishment of the pathogen from an infected berry is very small. Factors contributing to a low probability of establishment are a low probability of spore production on infected berries as *D. vaccinii* may be outcompleted by other microbes, while berries are eaten by animals, buried or destroyed, and a low probability of transfer of spores to new hosts due a low probability of encounter with hosts following spore flight. Establishment was thus calculated to be in the order of only a few infected plants/year, and often in conditions from which further spread is unlikely. Despite the fact that the estimated number of infected berries entering the EU (mainly from the USA) is quite large, the number of established populations associated to this pathway was thus estimated to be quite small and highly uncertain; uncertain with a 50% interval ranging from close to zero (0.45) to 10.

With less than 10 infected plants established per year (median, A0 scenario) from infected plants for planting, the overall risk of establishment in the form of local disease outbreaks is limited, despite uncertainty is much lower compared to the berry pathways (from 0.3 to less than 100 infected plants – 50% intervals). In contrast, under the A1 scenario (deregulation), the median number of new established populations was predicted to be substantially higher (approximately by a factor of 15). Blueberry potted plants and cranberry cuttings were the most relevant pathways.

In scenario A2, an additional RRO for reducing the risk of entry was assessed, which was to restrict trade in plants for planting so that plants could be traded only from pest-free areas or in areas where *D. vaccinii* is present, only trade in plug plants derived from tissue culture and grown in *D. vaccinii*-free enclosed structures would be permitted (i.e. this excludes potted plants and cuttings from field grown plants in pest-affected areas). Scenario A2 was predicted to result in almost no newly established infections.

The **establishment** model integrated two aspects: (a) distribution of the import of infected fruit and plants for planting (P4P) over EU countries in four main EU regions (north-west (NW), north-east (NE), south-west (SW) and south-east (SE)), and (b) establishment in production areas within those regions based on suitability of the climate for *D. vaccinii* and in natural areas based on both climate suitability and prevalence of *Vaccinium* in the EU region. The distribution of the import of blueberry and cranberry fruit, and consequently, the number of wasted fruits, was based on the import data: the NW region accounted for 52% and 93% of the import of blueberry and cranberry, respectively, followed by NE (26% and 4%), SW (22% and 3%) and SE with negligible values. The distribution of the import of blueberry and cranberry P4P was based on the scale of cultivated areas in each region combined with knowledge about import distributions in 2016: SW accounted for 56 and 50% of blueberry and cranberry, respectively, followed by NE (23 and 50%), NW (20% blueberry and negligible values for cranberry), while SE had very low values for both species. The climate suitability ranged from a minimum of 0.63 for the NW to a maximum of 0.86 for the SE.

The established plants with *D. vaccinii* infection were the starting point for predicted **spread** within the EU. *D. vaccinii* can spread by the asexually produced conidia, the sexually produced ascospores, droppings of birds that have eaten infected berries, movement of infected berries, and movement of infected plants or cuttings to new production sites. Transfer from imported berry waste to *Vaccinium* plants can take place in home gardens, production fields or natural areas. Transfer from imported P4P can take place in nurseries or production fields. Five ecological compartments were distinguished when assessing spread: nurseries, production fields, garden centres, home gardens, and natural areas. Flows of infection between these compartments were assessed, considering four regions in the EU (NW, NE, SW and SE) as separate entities, and not considering spread between those regions. Within each region, the rate of spread of the disease between compartments was assessed and calculated. The inflow of infection from outside the EU through entry and establishment was incorporated in this model as was the influence of climate on spread through its effect on establishment.

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

The natural spread is mostly by rain-splashed conidia affecting new plants within only 1–10 m from the original source. Therefore, although conidia are important to intensify or establish an infection at a site, the role of conidia contributes to spread over only short distances estimated at most to be 10–100 m extension per focus per year. The possible spread by birds was not considered because of the high uncertainty and the lack of quantitative evidence. The formation of sexual fruiting bodies in areas where *D. vaccinii* is present (Latvia and possibly Belarus and Russia) is thought to be very rare and has not been confirmed by molecular techniques. Therefore, longer distance natural spread by ascospores was not considered.

The key factor in the spread is the rate of spread in natural areas due to natural mechanisms. Over extended time (decades of years), the disease is expected to be able to spread substantially, but in the shorter term (few years) spread is rather limited. Calculations indicate that with current regulations, over a period of 5 years, a few hundred (from 99 to 608 infected plants – 50% intervals) cultivated *Vaccinium* plants would contract the disease as a result of entry into the EU territory, followed by establishment and spread, and several thousand (this estimate has high uncertainty: from less than 120 to 430,000 infected plants for the 50% intervals) *Vaccinium* plants in natural ecosystems. Stricter regulation would reduce entry to a level at which further spread would be negligible, while deregulation is expected to increase levels of spread by a factor 10–100.

The assessment of the expected **impact** was based on the potential establishment in nurseries, commercial blueberry and cranberry production areas and natural habitats combined with the actual impact observed in areas in the USA and Canada where *D. vaccinii* is endemic. Concepts were developed for a fully quantitative impact model, but the model was not implemented due to shortage of time and human resources. Instead, an assessment of impact was made by combining the information on spread with the severity of the impact at the level of the individual plant. In serious cases, individual *Vaccinium* plants can have 30% of their branches infected with the pathogen, resulting in 30% loss of berry yield as infected branches do not carry fruit.

Following this methodology, the loss of production in production areas was estimated to be very small, less than one ton of berries per year across the whole EU territory. On natural vegetation, the median impact (considering uncertainty) after 5 years was estimated to be negligible, affecting a negligible fraction of plants (2×10^{-8}) in natural areas. However, the uncertainty of this estimate was high due to uncertainty about the rate of spread and the exponential rate of spread; in a worst case scenario (99th percentile) almost 1% of plants in natural areas would become infected. Complete deregulation (scenario A1) was predicted to increase the impact significantly, especially in natural areas, while additional measures (scenario A2) would effectively eliminate the entry of infected plants for planting, further reducing the impacts below the current situation.

Conclusions – The Panel concluded that the risk of entry of *D. vaccinii* is moderate and all the pathways considered can contribute to the introduction of infected material into the EU territory. In numeric terms, blueberry and cranberry fruits represents by far the largest quantity of infected material entering EU, followed by blueberry potted plants and cranberry cuttings, while the number of infected blueberry and cranberry plugs is very small.

However, as the probability of establishment from the berries pathway is low and very uncertain, blueberry potted plants and cranberry cuttings (very limited in number) are considered to make the most relevant contribution to the risk of establishment of the disease in the EU territory. The probability of establishment is also affected by climate suitability and by the distribution of the infected material entering the EU territory. Using the model, the highest numbers of established founder plants were predicted to be in the NE and SW part of EU.

The spread is affected by the distribution of the infected founder plants and by habitat suitability. The pathway most likely to introduce *D. vaccinii* into the EU is the import of potted highbush blueberry plants for planting from third countries where *D. vaccinii* occurs. Model results indicated that it is likely that most years at least one infected plant arrives in the EU; on average between one and a few tens of infected plants are likely to enter. The number of established infected plants in the EU range from 1 every three years (0.339/year for the 1st percentile) up to more than 500 per year for the 99th percentile.

The results for the deregulation scenario (A1) show that the current measures (scenario A0) are effective in reducing the probability of introduction of the pathogen. However, due to the possibility of the introduction of the pathogen with asymptomatic plants, there is nevertheless a low risk of introduction.

The proposed strengthened measures (scenario A2) aim at improved requirements for plants for planting from infected areas (limited to plug plants derived from tissue culture and grown in *D. vaccinii*-free enclosed structures). These measures were predicted to reduce the risk of introduction and establishment to a negligible level.

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1. Introduction

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

The European Commission requested the European Food Safety Authority (EFSA), pursuant to Article 22(5.b) and Article 29(1) of Regulation (EC) No 178/2002[2], requested from EFSA, as a follow up to the request of 29 March 2014 (Ares(2014)970361) and the pest categorisations (step I) delivered in the meantime, to complete the pest risk assessment (PRA), to identify risk reduction options and to provide an assessment of the effectiveness of current EU phytosanitary requirements (step 2) for (1) *Ceratocystis platani* (Walter) Engelbrecht et Harrington, (2) *Cryphonectria parasitica* (Murrill) Barr, (3) *Diaporthe vaccinii* Shear, (4) *Ditylenchus destructor* Thome, (5) *Eotetranychus lewisi* (McGregor), (6) Grapevine Flavescence doree and (7) *Radopholus similis* (Cobb) Thome.

The current opinion answers the request for a PRA for *Diaporthe vaccinii* Shear. Based on the pest categorisation for *D. vaccinii* (EFSA, 2014), the European Commission proposed the Terms of Reference (ToR) for the risk assessment of *D. vaccinii* (see Section 1.2.1).

1.1.1. 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 *Diaporthe vaccinii*

1.1.1.1. Current regulatory status

Diaporthe vaccinii is listed in the Annex II A I of Directive 2000/29/EC[1] for plants of *Vaccinium* spp., intended for planting, other than seeds. Specific requirements on the import of fruits of the host plant are listed in Annex VBI of Directive 2000/29/EC[1]. There are some generic requirements on trees and shrubs, which relate also to *Vaccinium*, in Annex IVA I No 39 and No 40, without any specific reference to *D. vaccinii*. The host plants are also regulated under Marketing Directive 2008/90/EC.[3]

1.1.1.2. Identity of the pest

The identity of *D. vaccinii* is clearly defined. However, identification of the pest is complex as several other fungal species cause symptoms similar to those caused by *D. vaccinii*. Species of the genus *Phomopsis* with similar cultural and morphological characteristics have also been reported on *Vaccinium* spp. Guidance on diagnosis is provided by the EPPO Standard PM 7/86(1) (EPPO, 2009).

1.1.1.3. Distribution of the pest

Within the EU territory, *D. vaccinii* is present in Latvia. The pest status in the Netherlands is officially declared as transient, under surveillance. Several countries (Germany, Lithuania, Romania, Poland and the UK) have reported findings of this fungus which were subsequently eradicated. Outside the EU, the pest is present in North America (Canada and 12 States of the USA) and in Chile. The pathogen has also been identified using DNA sequencing in China (QingHua et al., 2015), but has not been included in the EPPO data base.

1.1.1.4. Potential for establishment and spread in the PRA area

EFSA pest categorisation concludes that suitable climatic conditions for *D. vaccinii* are present in several Member States (MSs) and the organism can be spread by natural and human-assisted means. In particular, the movement of contaminated but symptomless plants for planting is identified as a major pathway. Moreover, the pathogen has the potential to cause environmental consequences in the risk assessment area by unintentional spread to native plants offsite. Chemical treatments are possible.

1.1.1.5. Potential for consequences in the PRA area

The information available on damage potential of *D. vaccinii* on *Vaccinium* spp. crops in the EU is very limited. Moreover, there are no data on the potential impact on bilberry (*Vaccinium myrtillus*), as bilberry does not occur in areas where *D. vaccinii* originated from. The overall impact of the organism

[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.

[3] Commission Implementing Directive 2014/97/EU of 15 October 2014 implementing Council Directive 2008/90/EC as regards the registration of suppliers and of varieties and the common list of varieties. OJ L 298, 16.10.2014, p. 16–21.

in the EU territory has so far been very low but, it is difficult to make a longer-term assessment because of all the uncertainties.

1.1.1.6. Recommendation

Based on the information submitted by EFSA in the pest categorisation, *D. vaccinii* does not have the potential to be classified as quarantine pest as it does not fulfil one of the pest categorisation criteria defined in ISPM 11 (FAO, 2013) (having a severe impact). However, the Working Group highlights that **the pest categorisation presents several uncertainties and data gaps as regards the real distribution of the pathogen and its host plants in the EU, as well as uncertainties on the observed impact of the pest both in the EU and in non-EU countries.** At the same time, difficulties exist concerning the interpretation of data because of the possible confusion of this organism with other species in older literature. The impact is usually reported as the result of several species.

At the same time, there are no scientific arguments to prove that **effects on native plants, biodiversity and ecosystems** would be low. As regards the **impact on cultivated plants**, current data from non-EU countries has not been fully considered. The Working Group considers that there are several publications available from Universities and Organisations providing extension services in North America which emphasise the economic importance of this organism. However, further details are not available.

Given the level of uncertainly presented above, the Working Group recommends to keep this organism as Union Quarantine Pest.

If further information is available and the data gap can be addressed, the Working Group recommends that EFSA prepares full Pest Risk Analysis in order to provide, for the main pathways (natural and human assistance means, including host plants for planting), **further elements in terms of risk reduction options**, on which relevant measures can be taken.

1.2. Interpretation of the Terms of Reference

1.2.1. Pest categorisation

Information provided in the pest categorisation on *D. vaccinii*[4] is not repeated here. Here, an update of the current distribution is given. The pathogen is widely referred to its anamorphic state *P. vaccinii*, which is currently officially present in Latvia only (EPPO Global Database, https://gd.eppo.int/). Until recently, it was also identified in Lithuania, Poland and the Netherlands (Gabler et al., 2004; Kačergius and Jovaišienė, 2010; NPPO 2013, 2015; Lombard et al., 2014; EPPO 2015; Vilka and Volkova, 2015; Michalecka et al., 2017). The pathogen might be also present in Belarus (Galynskaya and Liaguskiy, 2012) and Russia (Dokukina, 2001), although proper identification using DNA technology has not been carried out on the *D. vaccinii* isolates obtained in these countries. Moreover, the colony morphology and spore dimensions provided in one report from Belarus (Galynskaya et al., 2011) did not correspond to those of *D. vaccinii* (Lorenzo Lombard, Hearing Expert on November 25, 2016). Many different *Diaporthe* species can be easily confused with *D. vaccinii*, and DNA sequence analyses of the ITS region and elongation factor 1-alpha (but preferably four different gene regions) are needed for proper identification (Udayanga et al., 2011, 2014; Lombard et al., 2014; Moore, 2016). In a small survey of commercial and wild *Vaccinium* species in Europe, *Diaporthe eres* seemed to be quite common, while *Diaporthe viticola* and two new species were also found (Lorenzo Lombard, Hearing Expert, November 25, 2016). A survey in the UK revealed the presence of *Phomopsis viticola*, *Phomopsis eres* and *Phomopsis theicola*, but not of *D. vaccinii* (Moore, 2016).

1.2.2. Interpretation of ToR and recommendations

The Panel interprets the ToR as a request to conduct a full PRA with the aim to develop risk reduction options on the basis of the pathways of spreading identified in the recent Pest Categorisation (EFSA PLH Panel, 2014), namely human-assisted and natural means, including infected or contaminated symptomatic or asymptomatic *Vaccinium* plants for planting intended for commercial berry production, infected *Vaccinium* plants for domestic use in home and garden, infected or contaminated berries for consumption, as well as rain splash, wind-driven rain, irrigation water and animals.

[4] Scientific basis for the recommendation: EFSA PLH Panel (2014). Scientific Opinion on the pest categorisation of *Diaporthe vaccinii* Shear. EFSA Journal 2014:12(7):3774. 28 pp. https://doi.org/10.2903/j.efsa.2014.3774. http://www.elsa.europa.eu/en/efsajournal/doc/3774.pdf

Questions about the ToR and the proposed scenarios were communicated by the Panel to the European Commission on 11/10/2016, and an answer was received on 25/10/2016. In summary, the European Commission would like EFSA to explore all possible scenarios: assessment of current situation (A0), deregulation (A1) and taking reinforced measures (A2) (see Section 2.3.1). All possible pathways should be considered, including natural spread from eastern Europe. The economic impact on cultivated plants and effects on native plants, biodiversity and ecosystems should get special attention (Table 1).

Table 1: Details on TOR, European Commission recommendations and Panel interpretation

TOR questions in EC recommendation	Panel interpretation and reference to section
The real distribution of the pathogen in the EU	Survey information from member states
The real distribution of the host plants in the EU	Establishment section
Observed impact of the pathogen (including the aspect of confusion with other species)	Impact section
Impact on native plants and ecosystems	Limited/no information available, not assessed
Impact on cultivated plants	Impact section
Risk assessment and analysis of risk reduction options	Three scenarios were assessed

2. Data and methodologies

2.1. Pilot phase

EFSA recommends that efforts should be made to work towards more quantitative expression of both risk and uncertainty whenever possible (EFSA Scientific Committee, 2012), i.e. where possible, the expression of the probability of the negative effect and the consequences of the effect should be reported quantitatively.

The method used in this assessment seeks to address the call for increased quantitative reporting of risk. The first iteration of the method was applied to four case study pests (EFSA PLH Panel, 2016a–d). Feedback from users has been taken into account to refine the method and the revised method is being used in a further series of tests on four more pilot case studies. This is one of these second phase pilot studies. Following feedback received from the second series of pilot case studies, it is anticipated that further refinements may be made to the method before it is published in 2018 as a new guidance document for the EFSA PLH Panel (Gilioli et al., 2017).

2.2. Data

The literature search followed the strategy described in the pest categorisation for the retrieval of additional relevant papers besides those listed in the pest categorisation (EFSA PLH Panel, 2014). In particular, refereed publications on '*Diaporthe* or *Phomopsis*' combined with '*Vaccinium*' were searched in the Web of Science. DNA sequences for recent identifications of *D. vaccinii* worldwide were obtained from GenBank (2010–2016). Research reports and extension publications on blueberry and cranberry diseases were obtained through searches in Google. Literature on *Phomopsis* (or *Diaporthe) vaccinii* in the Russian language was also obtained through Google and translated into English by EFSA staff. In addition, a recent paper on the potential distribution of *Vaccinium* twig blight in Europe based on the current global distribution and global long-term climate data (Narouei-Khandan et al., 2017) was used for the delineation of the potential establishment area. Biogeographic information on the distribution of *Vaccinium* species in the EU was obtained from several forestry books and specific websites found through Google. Epidemiological data for the prediction of natural spread of the pathogen was not available for *D. vaccinii*, and data on other *Phomopsis* species were used for this purpose. The content of all these publications was considered in the risk assessment wherever relevant.

Quantitative information on blueberry and cranberry production, interception of *Vaccinium* plants or fruits, and findings of *D. vaccinii* used for the PRA was deduced from websites of EUROPHYT (https://ec.europa.eu/food/plant/plant_health_biosecurity/europhyt_en), EPPO (Global Database (EPPO, online)), PQR (online), ISEFOR trade data (Increasing Sustainability of European Forests), EUROSTAT (online), FAOSTAT (online) and JRC (https://ec.europa.eu/jrc/en). Moreover, MSs were consulted about survey data collected in 2016, and selected berry producers and nurseries were consulted about the origin and destination of their plants. Finally, quantitative information on export of

Vaccinium plants from the USA was obtained through several State Certification Agencies (USDA-APHIS, 2017). Further details on the databases and data used in this PRA are provided in Table 2.

Table 2: Summary of the databases and of the data used in the PRA

Database	Data extracted
EUROSTAT	All berries, blueberry, cranberry production areas and quantities
FAOSTAT	Blueberry, cranberry production areas and quantities. Trade of blueberry and cranberry
USHBC (US Highbush Blueberry Council)	Blueberry production areas and quantities
Comtrade	Trade of berries fruit
ISEFOR	Trade of plants for planting
EUROPHYT	Interceptions of *D. vaccinii*
PQR	Distribution of *D. vaccinii*

A map of natural *Vaccinium* vegetation was made on the basis of the following data sets: (1) Maps of realised distributions of *Vaccinium myrtillus* and *Vaccinium vitis-idea* (Meusel et al., 1978; recompiled by Erik Welk) at 10 × 10 km resolution; (2) Corine Land Cover data (EEA, 2014). The general, large scale distribution of the two species was obtained using a Species Distribution Model (SDM) based on the coordinates of collected specimen (GBIF and other databases) and macroclimatic data at 10 × 10 arc min resolution. The refinement of the distribution was based on land cover data, assuming that natural *Vaccinium* spp. could be present only within the areas classified, at first hierarchical level of Corine Land Cover, in groups three (forest and seminatural areas) and four (wetlands). The area of natural *Vaccinium* spp. in the EU 28 is approximately 1,400,000 km^2. This value indicates all the areas where the wild species of *Vaccinium* were found and may occur, but of course the coverage can vary.

Quantitative data on the diseases caused by *D. vaccinii* and their impact on yield were obtained primarily from Plant Disease Management Reports of the American Phytopathological Society and research reports from the Ministry of Agriculture in Canada. However, most of the data needed for the quantitative estimations presented here were missing in the literature or on websites. Expert judgement was thus used in many cases. The quantitative estimations provided by the experts should thus be taken with particular caution, as different experts might provide different figures in such a situation of lack of evidence.

2.3. Methodologies

The Panel performed the pest risk assessment for *D. vaccinii* 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, 2004).

When conducting this PRA, the Panel took into consideration also 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).

A mathematical model for entry, establishment, spread and impact was used to support quantitatively the pest risk assessment. The model is presented in outline in Section 2.3, and details of the equations are parameters of the model are given in Appendix A. This model was used to carry out scenario studies which represent different options for risk reduction (Section 2.3.1).

In short, the entry step (Section 3.1; Appendix D) estimates the total amount of infested planting material that enters the EU from third countries in a year. As trade flows vary, a target year was chosen. The year 2018 was taken as the target year for estimates because risk assessment concerns the future. End point of the entry step is in terms of number of infected berries and infected plants for planting entering yearly into four geographic regions of Europe: north-west (NW), north-east (NE), south-west (SW) and south-east (SE). End point of the establishment step is in terms of the number of entries resulting in infected plants in these four zones. Intra-EU movement between the four zones is not considered. End point of the spread step is in terms of the number of infected plants in the four geographic regions if the trade flows estimated for 2018 are continued over 5 years. End point of the impact step is in terms of numbers of affected plants in natural areas and the ecological consequences of this in the four regions.

The quantitative model uses equations and parameters, but both the equations and parameters are uncertain. Uncertainty in parameters is represented by assigning each parameter a probability distribution that expresses the knowledge of experts about the parameter value. Based on available data and judgement, the distribution is characterised by a median value and four additional percentiles of the distribution (1, 25, 75 and 99 percentile). 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 period in the future.

Following the 20,000 model iterations, a statistical regression analysis is made of the contribution of uncertainty in each model parameter to the uncertainty in chosen model outcomes. The decomposition of uncertainty calculates the relative contribution (as a proportion) of each individual input to the overall uncertainty of the result. The relative contributions sum to 1.

Section 3 (‘Assessment’) reports key outcomes of these stochastic simulations. The distributions given in this section characterise the possible range of outcomes in the future, under a certain scenario.

In Appendix B, a description and analysis is reported of the relevant Risk Reducing Options (RROs). Tables with data used in this PRA are reported in Appendix C and maps that support the PRA are reported in the main text and in Appendix D. All the calculations performed using @Risk and the sensitivity analyses are provided as an @Risk file in Annex A.

2.3.1. Specification of the scenarios

We consider three scenarios:

- A0: Current regulation in place
- A1: Deregulation of *D. vaccinii*
- A2: Current regulation in place + additional enforced measures.

2.3.1.1. A0 Current regulation in place

Pest-specific measures

The pathogen *D. vaccinii* Shear is regulated as a harmful organism in the EU and is listed in Council Directive 2000/29/EC[1] under Annex II, Part A, Section I (c), with respect to contamination of plants of *Vaccinium* spp. intended for planting. Its introduction into, and spread within, all MSs is banned if found on *Vaccinium* plants or plant products. In addition, there are general import requirements for plants for planting according to Annex IV, Part A, section I, including special requirements for dwarfed plants (such as bonsai plants of *Vaccinium corymbosum*).

A full description of the current measures in place can be found in the pest categorisation (EFSA, 2014). In summary, the following measures are in place:

Current measures for plants for planting

General import requirements: plant health inspection and export certificate; plants should be dormant and free from leaves (except if they don’t shed their leaves as is the case for *Vaccinium* plants), flowers and fruits; bonsai plants must be grown in clean potting mix in registered nurseries for at least 2 years, subjected to pest control, and must be inspected regularly.

Specific requirements for *D. vaccinii*: *Vaccinium* plants should be free from *D. vaccinii*, however, there are no specific requirements how pest freedom for *D. vaccinii* should be guaranteed.

In addition, plants must originate from areas that are free from *Xylella fastidiosa,* and this requirements has also effect on trade in *Vaccinium* (see Table A.40).

EU internal trade: No plant passport requirement, marketing directive (EU/2014/98) in place.

Current measures for fruits (Berries)

Import requirements: plant health inspection and export certificate. There are no specific requirements regarding *D. vaccinii*.

EU internal trade: No requirements.

2.3.1.2. A1 Deregulation

Scenario A1 is the situation where *D. vaccinii* has no quarantine status. This implies that there is no guarantee anymore that imported *Vaccinium* plants are free from *D. vaccinii*.

The general import requirements of EC/2000/29[1] remain: plant health inspection and export certificate; plants should be free from flowers and fruits; import inspection of plants.

2.3.1.3. A2 Improved import requirements

Scenario A2 assesses the situation where specified requirements for *D. vaccinii* are in place. In this scenario, plants for planting should originate from:

- a pest-free area or
- a pest-free place of production or
- be produced and exported as tissue culture or plug plants directly derived from tissue culture.

2.3.2. Definitions for the scenarios

2.3.2.1. Definition of the pathways

Six pathways of entry of the pathogen are distinguished in this opinion. Two of those are entry with fruits for fresh consumption and four are entry with plants for planting. The Panel considers thus six pathways for entry of the pathogen with trade flows originating from countries with presence of *D. vaccinii.*

Berries

1) Fresh blueberries for consumer use
2) Fresh cranberries for consumer use

Host plants for planting

3) Blueberry plants for planting in plug trays
4) Blueberry potted plants for planting
5) Cranberry plants for planting in plug trays
6) Cranberry unrooted or potted cuttings.

2.3.2.2. Definition of different units used

Specification of temporal and spatial scales, resolution and units used in the assessment are given in Table 3

Table 3: Summary of the temporal and spatial scales, resolution and units used in the assessment

	Pathways				
	Fresh blueberry fruit	**Fresh cranberry fruit**	**Blueberry and cranberry plants for planting in plug trays**	**Blueberry potted plants for planting**	**Cranberry cuttings**
Entry	Metric tonnes/kg per number of fruit per year	Metric tonnes/kg per number of fruit per year	Number per year	Number per year	Number per year
Establishment	Number of successful transfers to host plants in EU territory per year	Number of successful transfers to host plants in EU territory per year	Number of infected plants planted in nurseries and surviving at least 2 months before detection	Number of infected plants planted in nurseries or production fields and surviving at least 2 months before detection	Number of infected plants planted in nurseries or production fields and surviving at least 2 months before detection
Spread	Number of plants infected in each of 4 regions in the EU				

	Pathways				
	Fresh blueberry fruit	**Fresh cranberry fruit**	**Blueberry and cranberry plants for planting in plug trays**	**Blueberry potted plants for planting**	**Cranberry cuttings**
Impact	Proportion of infected twigs per ha Proportion yield loss (berries) per ha; proportion of environmental impact				
Production	kg berries per ha per year				
Time step	1 year				
Time horizon	5 years				
Spatial resolution	1 infected plant				
Spatial extent	Whole EU				

Production unit in the country of origin: total number of plants per country

Production unit in the assessment area: individual plants in four regions in the EU

Pathway unit: berry or plant

Pathway subunit: none

Transfer unit: infected plant

Spatial unit: infected plants

Time unit: one year for a total of 5 years.

2.3.2.3. Definition of abundance of the pest

The opinion considers the proportion of berries infected (entry with fresh fruit), the proportion of plants infected (entry with plants for planting, establishment and spread), the proportion of area units infected (impact) and the proportion of fruit bearing branches infected (impact).

2.3.2.4. Potential RROs of the steps and identification of the RROs for the sub-steps

In Appendix B, an overview is given of the selection of relevant RROs for *D. vaccinii* for the three scenarios and for which steps in the risk assessment they are relevant.

In Table 4, a summary is given of the relevant RROs for the different scenarios. For Scenario A0 (Current regulation), eight relevant RROs are identified. For scenario A1 (deregulation), four RROs remain in place such as the certification system for *Vaccinium* plants as well as fungicidal control of fungi present in nurseries. Pruning and roguing of dead and diseased plants may continue despite the deregulation of *D. vaccinii*. The main difference between scenario A0 and scenario A2 (more stringent measures) is the restriction to import of in-vitro plant material and plug plants derived from this material for areas where *D. vaccinii* is present.

Table 4: RROs relevant for different scenarios.

RRO	A0	A1	A2
1. Certification of reproductive material	X	X	X
2. Fungicide treatments of production fields	X	X	X
3. Inspection of nurseries	X		X
4. Roguing in case of a finding of *D. vaccinii*	X	X	X
5. Laboratory testing to verify the presence of *D. vaccinii* in nursery	(X)		X
6. Restriction to *in vitro* plant material of *Vaccinium* from pest-free areas for *Xylella fastidiosa*	X	X	X
7. Rejection consignment after export inspection	X		X
8. Rejection consignment after import inspection	X		X
9. Import is restricted to tissue culture and plug plants derived from tissue culture from areas where *D. vaccinii* is present			X

2.3.2.5. Ecological factors and conditions in the chosen scenarios

The climate requirements for *D. vaccinii* range from humid continental climate to hot summer Mediterranean climate. The climate is moderately conducive in most areas where *Vaccinium* spp. grow, especially in the western half of the EU; there is a low risk of establishment in those areas (Narouei-Khandan et al., 2017). However, the climate is highly conducive in most of the eastern part of the EU. This holds particularly for the north-eastern part, but also for the south-eastern part, which are classified as high-risk areas (Narouei-Khandan et al., 2017). In addition, some areas in northern Spain, south-eastern France and northern Italy fall in the high-risk category.

The assessment is conducted assuming no change in ecological factors and conditions compared to the current situation.

2.3.2.6. Temporal and spatial scales

Although the pathogen produces asexual spores (conidia in pycnidia) throughout the spring and summer, infection is mostly limited to the time of bloom and early fruit set. Sexual spores (ascospores) have been rarely found. This means that there is essentially only one disease cycle per year, and we get a reasonable idea of the potential expansion of this disease on a 5-year horizon. Moreover, blueberry production is in a flux of uncertain expansion at this time, so that a longer horizon would result in highly uncertain predictions.

Thus, the assessment has a 5-year time horizon, and considers the entry year of import flows as well as imports in the subsequent 4 years. Establishment and spread are also considered at a yearly time scale for a total of 5 years.

The spatial scale is the whole of the EU until the moment of establishment, when individual countries are taken into account. However, the countries are then grouped into four regions (NW, NE, SW and SE), because the numbers of initial disease foci are predicted to be very low, and the countries in a particular region have similar climates and importation of *Vaccinium* plants for planting and berries.

2.3.2.7. Summary of the different scenarios

In Table 5 it is reported a synthesis of the different assessments presented by the Panel in this document.

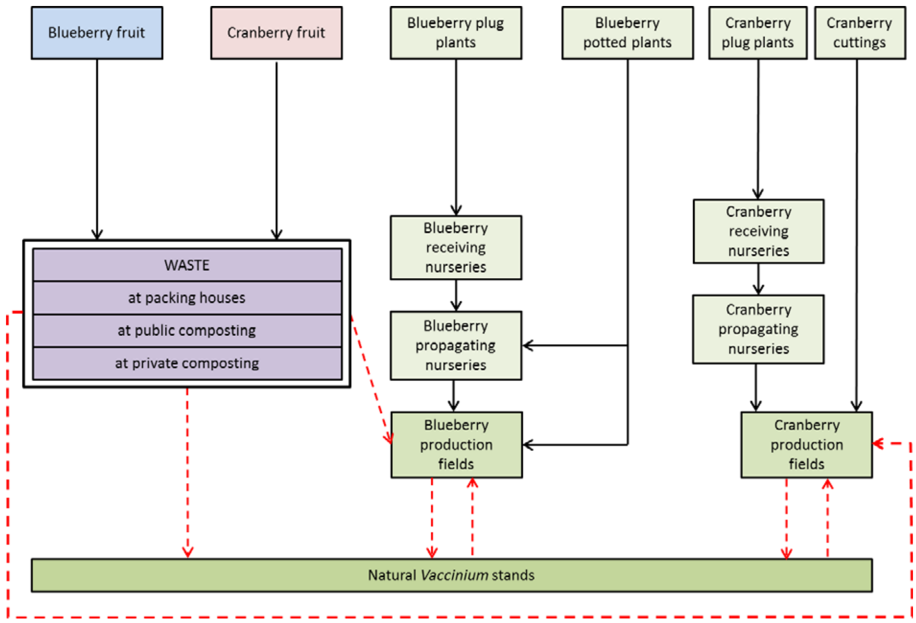
Table 5: Summary of the main pathways, steps and units considered in the RA. All elements remain the same for all three scenarios (A0, A1 and A2)

Pathways	**<u>ENTRY</u>:** **Fruit:** 1) Blueberry 2) Cranberry **Plants for planting:** 3) Blueberry plants for planting in plug trays (from tissue culture) 4) Blueberry potted plants for planting 5) Cranberry plants for planting in plug trays (from cuttings) 6) Cranberry unrooted cuttings
Units **a) Entry** **b) Establishment** **c) Spread**	**a) Entry** 1) Plants for planting: one single plant 2) Fruit: one single berry **b) Establishment** One living infected Blueberry or Cranberry plant (founder population), spatially divided over four regions (NW, NE, SW and SE) in the EU **c) Spread** Individual infected plants in production and natural areas, spatially divided over four regions (NW, NE, SW and SE) in the EU

Abundance of the pest in the a) Production/growing area b) Pathway unit c) Transfer unit	a) % infected host plants and % infected berries b) Infected host plant and infected berry c) Infected host plant and infected berry
Production unit	Single plants
Critical value economically important losses: quantity	No threshold because the twig blight incidence is linearly related to yield loss with an intercept at 0. Pest management costs would increase in production fields. *Vaccinium* plants generally do not die from *D. vaccinii* infection, and can maintain themselves in natural areas albeit at a reduced productivity level, and thus reduced ability to provide food for wildlife
Critical value economically important losses: quality	Threshold dependent on fungicide residue levels affecting fruit quality in production areas. No threshold in natural areas
Critical value environmentally important losses	Thresholds for fungicide applications are comparable to those in other fruit crops. No threshold in natural areas

2.4. Model formulation and formalisation

The six entry pathways are elaborated quantitatively to assess their absolute and relative importance. Establishment is assessed on the basis of relative importation of *Vaccinium* plants and berries combined with ecological niche modelling (Narouei-Khandan et al., 2017). Spread is assessed using an ecological compartment model with infection flows between the ecological compartments. The mathematical approach is akin to matrix modelling, in which the flows are calculated as the product of the number in a compartment and a parameter expressing the proportionality between the flow and the number in the compartment (Casswell, 1999). Finally, the impact is assessed by combining calculation results on the number of infected plants with knowledge on the yield loss per plant. Details on the models are given in Appendix A. Flow charts of the models for entry, establishment, spread and impact are given in the rest of Section 2. Parameter estimations including a description of evidence and uncertainties are given in Appendix A. Results of modelling under different scenarios for risk mitigation are given in Section 3. A flow chart for the overall risk assessment model is given in Figure 1.



The six solid boxes at the top (e.g. 'blueberry fruit' and 'blueberry plants for planting') represent the six commodities for which the risk of entry of *Diaporthe vaccinii* with trade is assessed. The other boxes represent ecological compartments in the European territory in which the pathogen may occur as a result of either entry or spread. Drawn black arrows represent trade flows. The pathogen can move internationally and within Europe with these trade flows. Red hatched arrows represent the transfer of the pathogen from one compartment to another as a result of natural pathways for spread. In the top part of the diagram, the key process is international trade driving the entry. In the lower part of the diagram, the key processes are transfer, establishment and spread. Colours indicate the kind of plant material; blue for blueberry, red for cranberry, green for plants and greener for more natural growing conditions of the plants.

Figure 1: Diagram of the overall model used in the quantitative risk assessment

2.4.1. Model for Entry

2.4.1.1. Conceptual model for Entry

Entry pathways 1 and 2: blueberries and cranberries for consumer use

Frozen fruit for processing is not considered in this PRA, because the risk of frozen fruit carrying live *D. vaccinii* is practically zero. For fresh fruit, we consider the number of infected fruit, produced in third countries, exported from Third countries and imported into Europe. Within Europe, three destinations are considered: packing house, supermarket and consumer. At each, there is a waste flow, which can result in an exposure. The waste flow from packing houses is commonly deposed of as starting material for compost (G. Savini, hearing expert). The material entering a composting facility has a small but non-zero chance of starting a founder population if the waste is in close contact with hosts (*Vaccinium* spp.) before it is composted properly (at sufficiently high temperatures to kill the pathogen). Waste generated in supermarkets is generally incinerated or put into the land-fill, and is not considered to be a risk for further spread. *Vaccinium* waste generated in households is composted at household level (where it can result in spore production of *D. vaccinii* and transfer to hosts in home gardens) or processed as municipal waste The municipal waste may be composted resulting in the same type of pathway as for the packing house waste. Fruits that are processed or eaten are not further considered. The process can be presented in a flow chart (Figure 2).

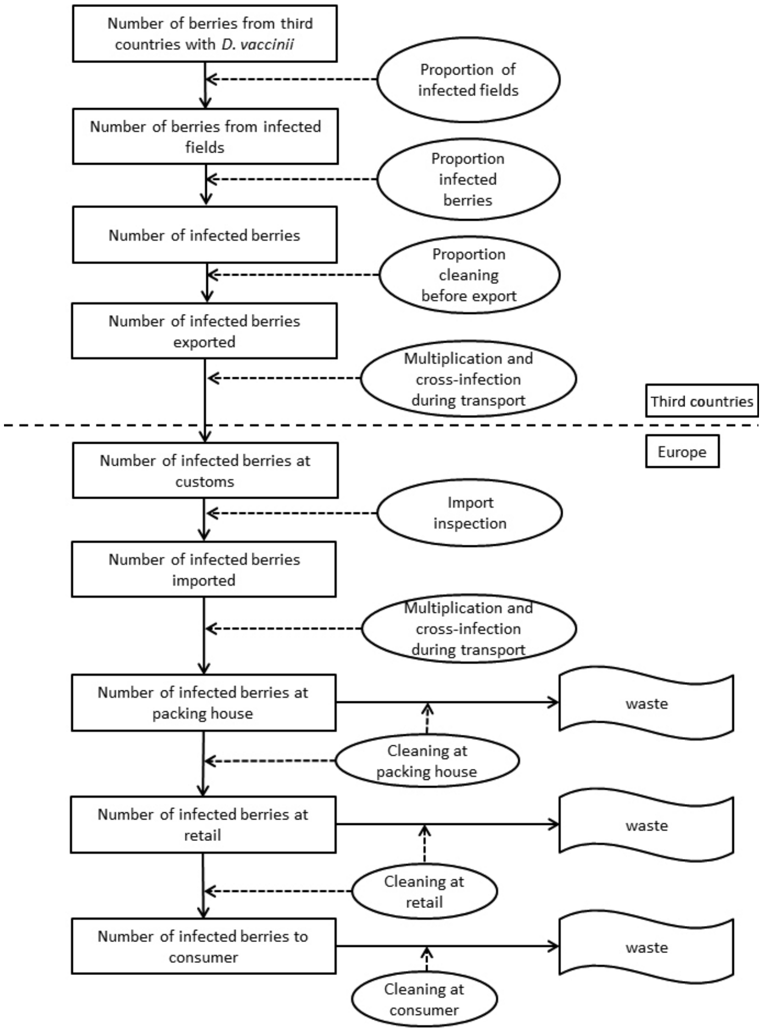


Figure 2: Flow chart of the entry model for *D. vaccinii* into the EU via the pathway of blueberry fruit for consumer use

Entry pathways 3, 4, 5 and 6: blueberry and cranberry plants for planting

For plants for planting, we consider the number plants imported from Third countries affected by *D. vaccinii*. The following types of plants for planting are considered: (1) blueberry plants for planting in plug trays (from tissue culture); (2) blueberry potted plants for planting; (3) cranberry plants for planting in plug trays; (4) cranberry unrooted cuttings or rooted cuttings in pots. After the arrival in EU 28, plants are transported to nurseries, before reaching the final destination. As final destinations, the Panel considered commercial berry plantations for berry production and domestic gardens.

A conceptual diagram for the plants for planting pathway is given in Figure 3.

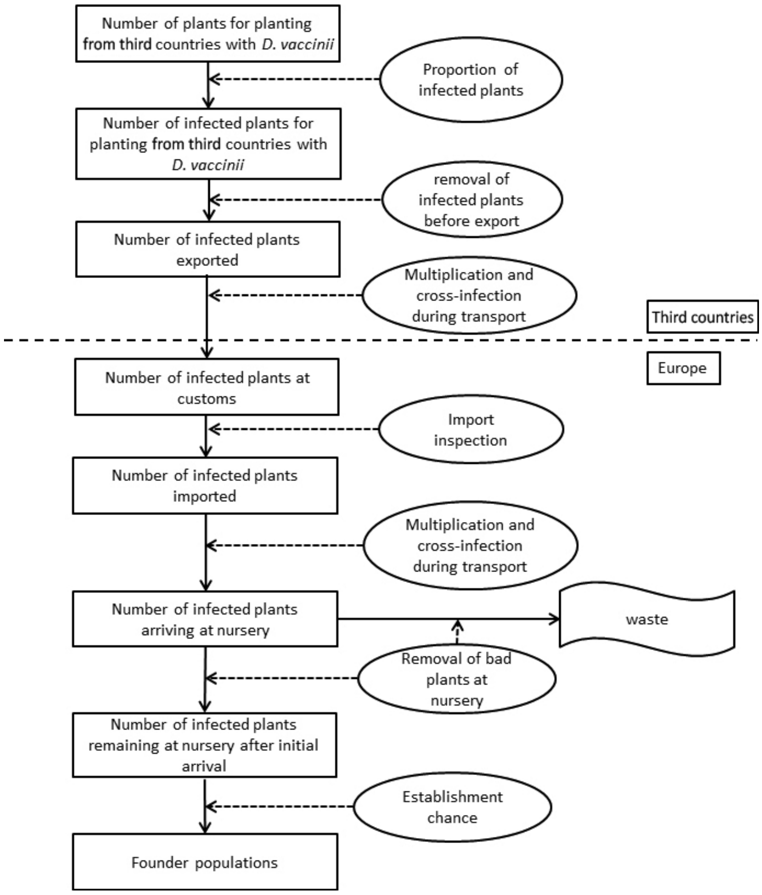


Figure 3: Flow chart of the entry model for *Diaporthe vaccinii* into the EU via the pathway of blueberry plant for planting

2.4.2. Model for Establishment

2.4.2.1. Conceptual model for Establishment

The establishment model calculates how many infected *Vaccinium* plants result from entry through the six pathways considered in the entry stepper year. The establishment model consists of two steps: (a) distribution of the import of infected fruit and plants for planting (P4P) over EU countries in four main regions (NW, NE, SW and SE – Figure 4), and (b) establishment in those regions based on suitability of the climate for *D. vaccinii* in production areas and both climate suitability and *Vaccinium* plant density in natural areas. These established infected plants are the starting point for spread within the EU.

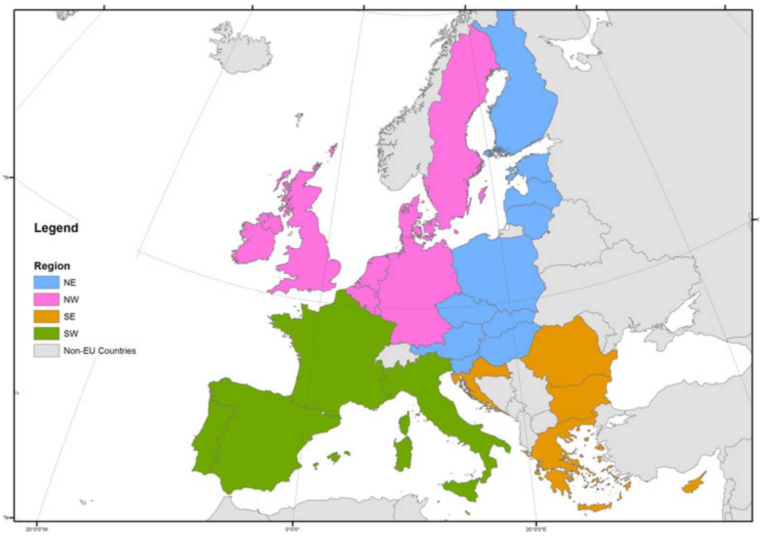


Figure 4: The four EU regions used to assess the establishment. France was included in the SW region because an area in SE France was highly suitable for *D. vaccinii*, similar to an area in north Italy (Narouei-Khandan et al., 2017)

2.4.2.1.1. Distribution of imported infected blueberry and cranberry fruits

Quantitative information on the importation of *Vaccinium* berries (blueberries and cranberries) is available by country from FAOSTAT (Tables C.3 and C.4). These data may reflect the density of human populations, their affluence, dietary preferences and the absence of sufficient local production, and are used for the estimation of the distribution of imported infected berries over the EU countries, assuming that the distribution of infected berries is the same as that of total berries (primarily healthy).

Deregulation (A1) or more stringent regulation (A2) will not affect the distribution of infected imported fruit over the EU territory compared to the current situation (A0).

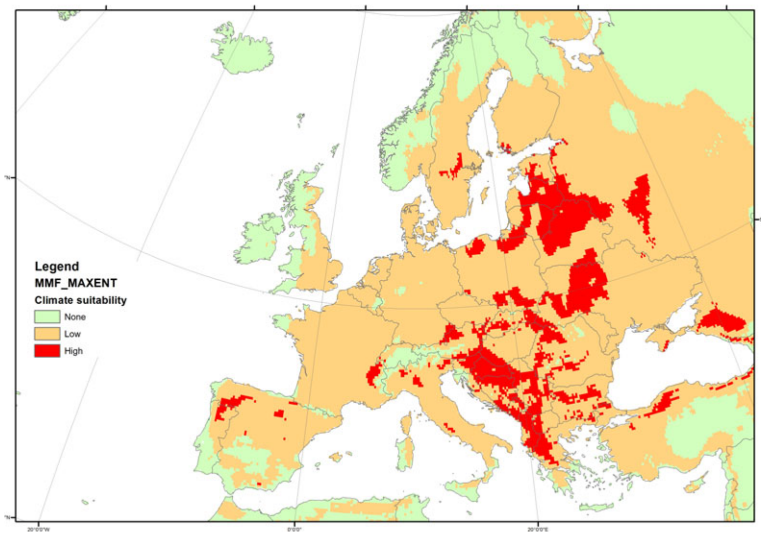
2.4.2.1.2. Probability of establishment of Diaporthe vaccinii *from blueberry and cranberry fruits*

Establishment is estimated as the number of transfers of *D. vaccinii* from infected fruit waste to *Vaccinium* plants in the particular country of entry. This transfer could realistically happen when waste is composted outside receiving packing houses, in municipal composting sites, or in home gardens provided that *Vaccinium* plants are in the near vicinity of the waste material (meters up to tens of meters). Transfer to *Vaccinium* plants could take place through pycnidiospores (conidia) on the waste material, as long as waste containing infected berries is exposed to the open air and the berries are not yet properly composted at high enough temperatures to kill *D. vaccinii*.

The waste from packing houses is thought to pose a risk if the correct procedures for disposal are not followed i.e. waste material dumped locally instead of going to an isolated landfill or the municipal composting site. Retail waste mostly goes to incineration or landfill, which poses minimal risk which is not further considered. Home waste could lead to plant infection in the garden if it is disposed onto the garden compost heap.

The probability of establishment of *D. vaccinii* from berry waste to *Vaccinium* plants in the vicinity is affected by the suitability of the local climate for the disease (Figure 5) as well as the density of *Vaccinium* plants in the area, including blueberry and cranberry production fields and *Vaccinium* plants in wild habitats (Figures 6 and 8).

A climate suitability map was prepared for this PRA based on the output from two correlative species distribution models (MaxEnt and Multi-model Framework (MMF)) with input of global occurrence data of *D. vaccinii* and long-term climate data (Narouei-Khandan et al., 2017). The map represents the average of the probabilities calculated by the two models.



Green areas: essentially no risk (score 0–0.33); orange areas: low risk (0.33–0.66); and red areas: high risk (score > 0.66).

Figure 5: Climate suitability for the potential establishment of *Diaporthe vaccinii* on *Vaccinium* species in Europe, based on the average risks calculated with the correlative models MaxEnt and Multi-model Framework (Narouei-Khandan et al., 2017)

A map for the relative densities of wild *Vaccinium* species in EU-28 was generated for this PRA based on spatial data for *V. myrtillus* and *V. vitis-idea* (Meusel et al., 1978, recompiled by Erik Welk) as described under Section 2.2. The area of natural *Vaccinium* spp. in the EU-28 is approximately 1,400, 000 km^2. This value indicates all areas where wild species of *Vaccinium* may occur, but the coverage with *Vaccinium* is variable.

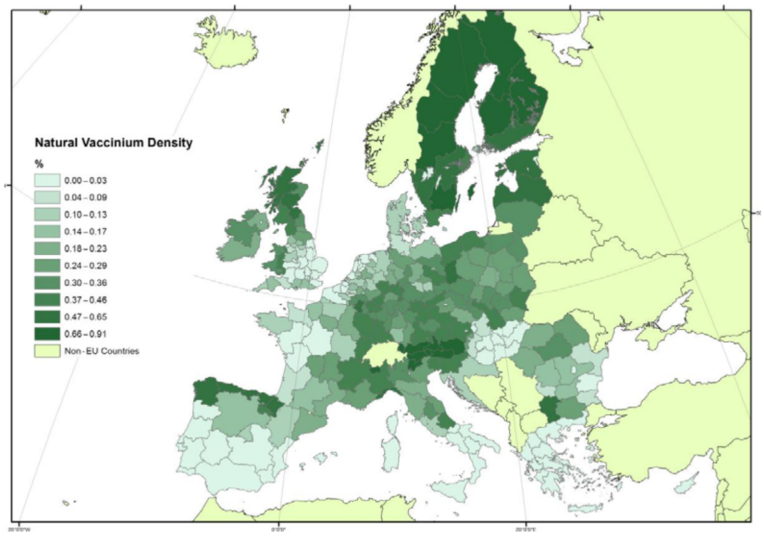


Figure 6: Relative densities of *Vaccinium* species in natural areas in the EU. The map was prepared from the following data sets: (1) Maps of realised distributions of *Vaccinium myrtillus* and *Vaccinium vitis-idea* (Meusel et al., 1978; recompiled by Erik Welk) at 10 × 10 km resolution; (2) Corine Land Cover data (EEA, 2014).

We do not expect any effect of deregulation (A1) or stricter regulation (A2) on the risk of *D. vaccinii* becoming established from berries compared to A0.

Thus, the conceptual model for establishment of *D. vaccinii* from berry waste is as follows:

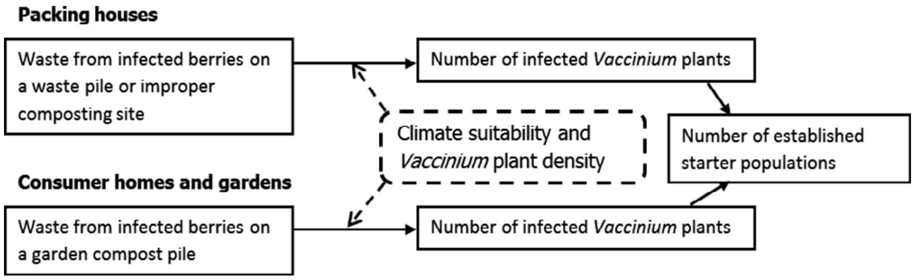


Figure 7: Conceptual model for the transfer of *Diaporthe vaccinii* from berry waste to *Vaccinium* plants. When berry waste is composted, transfer of the pathogen to *Vaccinium* plants is possible before and during the composting process (but not from properly composted materials)

2.4.2.1.3. Distribution of imported infected blueberry P4P and cranberry P4P

The importation of diseased plant material is not evenly or randomly distributed over all EU countries, but depends upon the intensity of *Vaccinium* berry production as this will influence the demand for new plants for planting. The distribution of blueberry production over the EU countries is reasonably well known for blueberries in 2014 (Figure 8). In addition, the destination countries of recent exports of blueberry P4P form an indication where imported plant material arrives in the EU, viz. primarily in Spain, Germany, the UK, the Netherlands, Poland and Italy (US nursery information for 2015–2017).

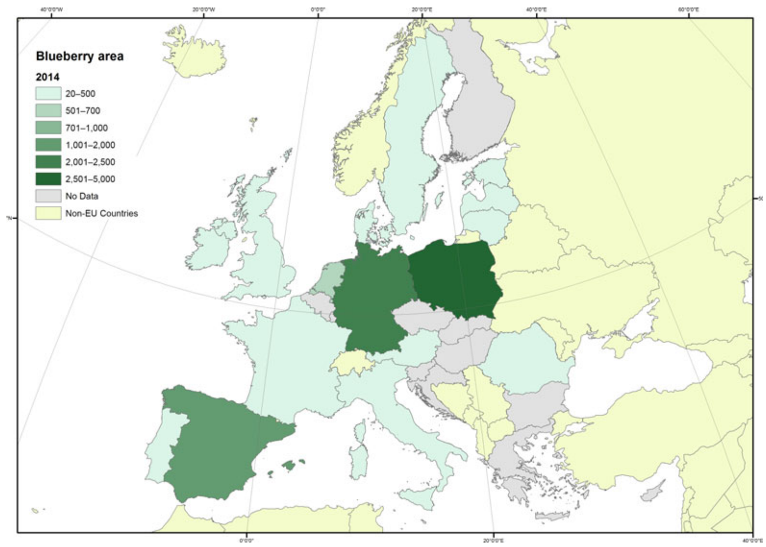


Figure 8: Blueberry production areas (ha) in EU countries in 2014 (Brazelton, 2016). The largest production area was in Poland, but blueberry production is expanding rapidly in Spain

Information on production area is not available for cranberries, except for a general overview of the importance of cranberry production on some websites (http://www.worldatlas.com/articles/10-top-countries-in-cranberry-production.html). Combined with export information from the USA, a coarse estimate of the distribution of cranberry plants over EU countries was made. Import data are available for all plants for planting (EUROSTAT), but not for *Vaccinium* plants as a separate category; therefore, EUROSTAT data could not be used.

Deregulation (A1) or more stringent regulation (A2) will not affect the distribution of infected imported P4P over the EU territory compared to the current situation (A0).

2.4.2.1.4. Probability of establishment of Diaporthe vaccinii *from blueberry and cranberry P4P*

As the infection is systemic, there is a one-on-one establishment of infected plants in a receiving nursery, where establishment is not limited by climatic conditions because overhead irrigation is commonly used. However, an introduced infected plant may be removed before the disease is spread.

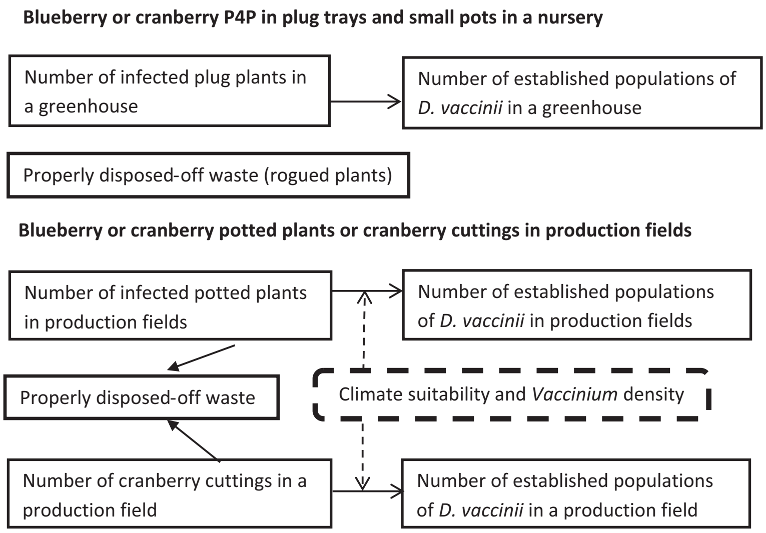
During the first 2 months after arrival in a nursery in the EU, plants that develop symptoms will be mostly removed. All plants that develop symptoms are considered established infections, and can be sources for spread. If infected plants are not rogued, establishment of the infection on this plant and one or more of its neighbours is highly likely.

Establishment of *D. vaccinii* through infected potted plants transferred to production fields will be affected primarily by climatic conditions (Figure 5) and the availability of cultivated and wild *Vaccinium* plants in the surroundings (Figures 6 and 8). The removal of symptomatic infected plants is considered less stringent than in receiving nurseries.

Plants in production fields that develop symptoms of *D. vaccinii* may still be removed, but inspection by will be less intensive than in nurseries. Under A1, post-entry quarantine will not be in place, and plant removal is likely reduced, while the situation under A2 is likely the same as under A0 (except that potted plants or field-grown cuttings would not be imported anymore).

Deregulation (A1) is expected to have a negative effect on post-entry removal of infected symptomatic plants but no effect on the establishment of *D. vaccinii* as affected by climate suitability. Stricter regulation (A2) would likely lower the number of infected plants coming into the EU (entry step), but would not have an effect on the removal rate of symptomatic plants nor on the risk of *D. vaccinii* becoming established from P4P compared to A0.

Thus, the conceptual model for establishment of *D. vaccinii* from plants for planting (P4P) in receiving nurseries (greenhouses and outdoor areas with overhead irrigation) and in production fields is as presented in Figure 9.



In a nursery, the number of established populations is considered to be primarily determined by the vigilance of nursery workers removing symptomatic plants (depending on the RROs in place), and not by environmental conditions, which are strongly influenced by overhead irrigation. Removal of P4P in production areas is more limited (again depending on the RROs in place), and establishment is primarily determined by climatic conditions in this case Waste is considered to be disposed of properly to avoid infection of *Vaccinium* plants, and is not considered further in the model.

Figure 9: Conceptual model for establishment of blueberry and cranberry plants for planting (P4P) in a nursery or production field

2.4.3. Model for Spread

2.4.3.1. Introduction to Spread

Whether the original infection came in on berries or on plants for planting, spread occurs from plant to plant. Transfer from waste of imported berries to *Vaccinium* plants is unlikely, but non-zero, and considering the large volume of import, it is difficult to rule out *a priori.* The transfer can take place in production fields, home gardens or natural areas. Transfer from imported P4P can take place in nurseries or – when P4P are introduced directly into production fields – in production fields. Five main pathways of spread are considered, which are: (1) from nurseries to production areas, (2) from production areas to natural areas, (3) from nurseries to garden centres, (4) from garden centres to home gardens, and (5) from home gardens to natural areas. In each of these cases, the possible means of spread are by the asexually produced conidia, the sexually produced ascospores, droppings of birds that have eaten infected berries and movement of plants including cuttings within production sites and to new production sites. Each of these processes is discussed below.

Conidia – Two types of conidia are produced but both are dispersed relatively short distances by rain splash. Conidia can also splash in water films onto vehicles, pruning or harvesting machinery, allowing transfer to the next field visited. Conidia can also wash into peat, which can be extracted from some natural sites for use in horticultural compost but this is currently not considered to pose a risk due to the peat routinely being sterilised by microwave or other heat sources before use in horticulture. Splash dispersed pathogens have been reported to travel moderate distances. In still air, rain-splashed spores have been reported to travel less than 1 m but distances of tens or even hundreds of metres are likely when a spray created by rain is combined with moderate wind speeds (Travadon et al., 2007; Perryman et al., 2014). However, much longer distances have also been reported. For instance, the citrus canker bacterium *Xanthomonas campestris* pv. *citri* was reported to travel up to 3.5 km, most probably in a tropical storm event where the pathogen was aerosolised by rain combined with strong wind (Gottwald et al., 2002).

In the case of *D. vaccinii*, consulted experts (A. Schilder and P. Harmon) report disease gradients to be very steep, suggesting dispersal is mostly by rain-splashed conidia affecting new plants within only 1–10 m from the original source. Therefore, although conidia are important to intensify or establish an infection at a site, the role of conidia contributes to spread over only short distances estimated at most to be 10–100 m extension per focus per year.

Ascospores – Ascospores of other ascomycete fungi are wind-dispersed after being released from mature fruiting bodies (ascomata) following wetting by rain or dew. However, the sexual stage of this fungus is reported to be very rare by many experts. Most report never to have seen evidence of the sexual stage (teleomorph). Some reports suggest that the teleomorph only occurs *in vitro*, while other suggest it occurs beneath bark with a relatively long protuberance extending to the surface of the bark to allow spores to be released, with frost required in the maturation process. Wind dispersed spores can travel hundreds of kilometres (Brown and Hovmøller, 2002) but those lacking pigmentation (such as *D. vaccinii* ascospores) are often sensitive to UV light. In early spring in northern latitudes, this may not reduce viability of the ascospores. *D. vaccinii* is thought to have spread from an outbreak in western Belarus, eastwards to near Moscow in a 20-year period (1980s and 1990s), a distance of approx. 900 km, i.e. 45 km per year on average, similar to the westerly spread of *Leptosphaeria maculans* on oilseed rape in Canada (Fitt et al., 2007). Spread in Belarus could have come about by plants for planting and possibly ascospore dispersal but there is little evidence for natural westerly spread despite wind patterns being random. Much of western Europe is not classed as particularly conducive for the pathogen's lifecycle (see Figure 5). Climate suitability for the potential establishment of *D. vaccinii*) but it may also suggest that plants for planting were the main means of spread. Due to the reported rarity of the sexual stage and lack of evidence of new satellite foci occurring at significant distances from established foci, we consider ascospores to play a negligible role that is incorporated into considered uncertainty of spread by conidia in this PRA.

Birds – Birds have been reported to vector fungal pathogens over relatively large distances (10–100s km) in their plumage (Coughlan et al., 2015), or in their faeces (Alfonzo et al., 2013). It is currently unknown as to whether *D. vaccinii* can survive being eaten by birds to be voided some distance from the original plant, however, it is considered that there would be a strong selection pressure for a berry-infecting pathogen to harness this potential means of spread. Preliminary evidence of *D. vaccinii* as an endophyte of some trees may support a possible role of dispersal in the droppings of birds but this is highly uncertain based on available evidence and will not be considered further in calculations.

Berries – Berry infection varies with species (estimates range from very low incidence of infection for lowbush blueberries, increasing to 20% incidence with highbush blueberries, and similarly, incidences of up to 20% are reported in affected cranberry production sites (A. Schilder, hearing expert). If infected berries are discarded into domestic gardens in close proximity to ornamental or home fruit-bearing *Vaccinium* bushes, it is possible for the fungus to transfer and cause infection via conidia. Further spread is unlikely due to isolation of the affected bush or bushes in a garden environment but is nevertheless included in calculations. Similarly, infected berries could act as a source of infection at packing houses, where large amounts of berries are discarded due to quality issues. Infected berries could end up in close proximity to natural or cultivated Vaccinium, if good practice is not followed, for instance if waste is dumped.

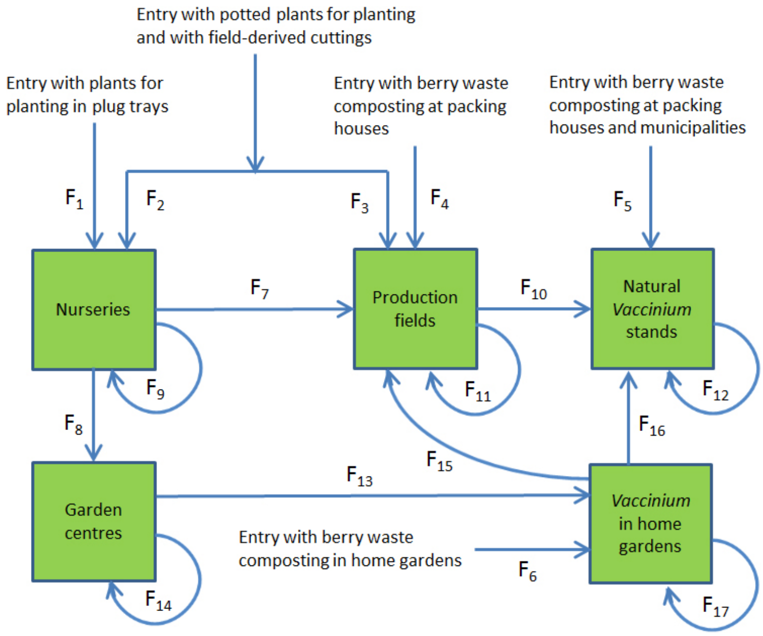
Plants for planting – Plants for planting (including cuttings) are considered to be an important source of spread locally within a production site and the movement of plant material is probably the most important means of spread to new locations within the EU. Producers routinely prune bushes every 2 years (cranberries) or 3 years (blueberries) by hand or by machine (depending on production scale) to encourage new branches that bear fruit. Each plant is estimated to produce approximately 20 cuttings (but it can be over 100 in the case of high-bush blueberries), of which in high-risk locations typically < 1% of stems may be infected for cranberry (range < 1% to 20%) or typically 12% of twigs may be infected for highbush blueberry (reports range from < 1% to 60% stems affected). Due to the large volumes involved, cut cranberry stems are usually raked up and planted into a new production location at the same farm or nearby farms. Stems harbouring latent infections or even small visible symptoms are unlikely to be noticed or removed and so can introduce the pathogen to the new production area. In some cases, this type of planting material can be sent to a completely new location.

Rate of spread – Observations in the USA, where *D. vaccinii* is endemic, indicate that rates of spread are greater in managed production sites than in natural sites despite the use of fungicides because of actors that favour dispersal and infection, such as overhead irrigation, fertiliser (which exacerbates disease severity), machinery and movement of plants contribute greatly to within-site dispersal or enhancement of disease. Moreover, in natural areas, *Vaccinium* plants are interspersed with other plants, and native plants seem to be more resistant to *D. vaccinii* than selected cultivars in the USA.

Mitigating RROs – Production fields of highbush blueberry in the USA are typically inspected every 2–3 years and affected stems may be removed by rogueing. Cranberry, lowbush blueberries and natural sites are usually not inspected. Fungicides applied to control other fungal diseases (typically 7–11 applications in USA, 3–4 in EU) are likely to reduce fruit infection and may reduce the disease impact but cannot eliminate an infection once established within a stem of a plant. Outbreaks have been eliminated by removal of affected plants and their surrounding plants.

2.4.3.2. Conceptual model for Spread

Spread is calculated separately for the four geographic regions in Europe that were distinguished for assessing establishment. Within each of these four regions, five compartments are distinguished: nurseries, production fields, natural *Vaccinium* stands, garden centres and home gardens (Figure 10). Within each compartment, the model calculates the number of infected *Vaccinium* plants. No distinction is made between species of Vaccinium. As a consequence, entry and establishment flows via blueberry and cranberry are summed.



The model comprises five ecological compartments, for each of four geographic regions in the EU: NW, NE, SW and SE. Within each region, the model comprises six flows of entry and establishment (F_1–F_6) and 11 flows of infection between compartments. Parameterisation of the flows is identical for the four regions, except for flows that involve dispersal of spores followed by infection. The parameterisation of these flows takes into account the prevalence of berries in each region, and the average suitability of the climate for *D. vaccinii*. The flows F_1–F_6 are flows of infected plants. These flows are already converted from the units used in the entry (infected berries and infected plants) to the units used in the spread model (infected plants). Establishment is accounted for.

Figure 10: Flow chart representing the conceptual model for spread

The model considers six inflows of infection from outside Europe. These flows are:

F_1: establishment of infected plants in nurseries following entry of infected plants for planting in plug trays (blueberry or cranberry);

F_2: establishment of infected plants in nurseries following entry of infected potted plants for planting (blueberry);

F_3: establishment of infected plants in production fields (blueberry plus cranberry) following entry of infected potted plants for planting (blueberry) and field-derived cuttings (cranberry);

F_4: establishment of infected plants in production fields via the entry pathway of infected berry waste at packing houses;

F_5: establishment of infected plants in natural *Vaccinium* stands via the entry pathway of berry waste at packing houses and municipalities;

F_6: entry and establishment as a result of disposal (home composting) of infected berries in home gardens.

The model further considers 11 flows of infection within and between compartments. The five flows within compartments are:

F_9: survival and propagation of the infection within nurseries;
F_{11}: survival and propagation of the infection within production fields;
F_{12}: survival and propagation of the infection within natural *Vaccinium* stands;
F_{14}: survival and propagation of the infection within garden centres;
F_{17}: survival and propagation of the infection within home gardens.

The six flows between compartments comprise three flows of plant material and three flows of infection due to dispersal by natural means (spores and vectors)

Movement of infection with infected plant material:

F_7: flow of infection from nurseries to production fields as a result of movement of infected plants;
F_8: flow of infection from nurseries to garden centres as a result of movement of infected plants;
F_{13}: flow of infection from garden centres to home gardens as a result of movement of infected plants.

Movement of infection by natural means (spores and vectors):

F_{10}: flow of infection from production fields to natural *Vaccinium* stands as a result of dispersal by natural means (spores and vectors);
F_{15}: flow of infection from home gardens to production fields as a result of dispersal by natural means (spores and vectors);
F_{16}: flow of infection from home gardens to natural *Vaccinium* stands as a result of dispersal by natural means (spores and vectors).

These 17 flows are illustrated in the flow diagram of Figure 10. Equations and parameters for flows 1–17 are given in Appendix A.3.1. Justification for parameters is given in Appendix A.3.2.

The model is run over a time period of 5 years, with constant yearly inflows F_1–F_6. The initial condition of this model is no infection within Europe (i.e. the presence of infection in Latvia is ignored). The rationale for leaving out the initial condition is a lack of knowledge on the extent of the current infection. The modelling aims to provide insight in the consequences over a time frame of 5 years of entry of new infection with international trade in berries and planting material.

2.4.4. Model for Impact

The impact of the presence of *D. vaccinii* in nurseries, berry production fields and the natural environment is assessed. The losses incurred to garden centres and consumers (home gardens) who lose plants to *D. vaccinii* in their own gardens will not be considered; home gardens will only be considered as potential sources of infection of *Vaccinium* plants in wild habitats.

The expected impact on berry yield is based on impact observed in areas in the USA and Canada where *D. vaccinii* is endemic. No information was found on the impact of *D. vaccinii* in any other countries where the pathogen was reported. A review of the literature on the impact of *D. vaccinii* in the USA and Canada is given in Section 3.5.1.

The Panel did not quantify the magnitude of impact, but addressed it in a narrative approach based on the results of the spread model (Section 3.4.2), where the number of infected *Vaccinium* plants infected with *D. vaccinii* in the four EU regions is estimated after a 5-year time frame in nurseries, berry production fields and the natural environment.

3. Assessment

3.1. Distribution of the pest

3.1.1. World distribution

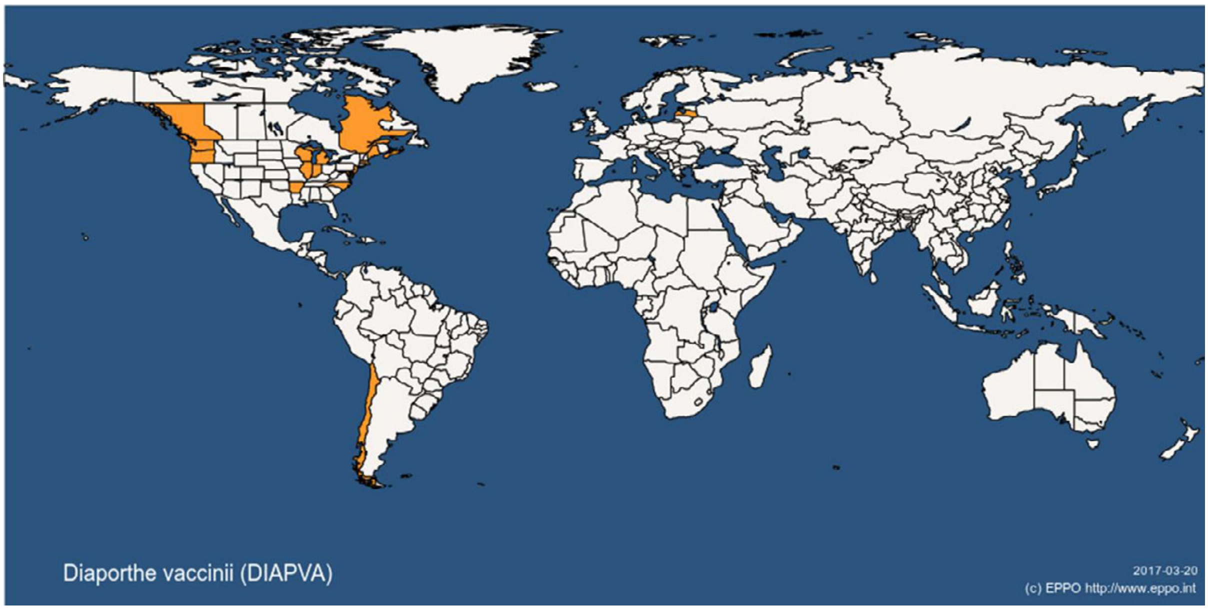


Figure 11: Distribution of *Diaporthe vaccinii* according to EPPO global database © www.eppo.int

D. vaccinii is most abundant in central and eastern states of the USA and is present at lower incidence in Canada, western USA, Chile, China, Latvia and possibly Belarus and Russia. The latter two locations have not formally been confirmed by molecular-based identification but literature suggests the presence of the pathogen (Dokukina, 2001; Galynskaya et al., 2011; Galynskaya and Liaguskiy, 2012), which coincides with high suitability of climate in these locations (Narouei-Khandan et al., 2017). The pathogen is not known to occur in the following important berry production locations: Peru, Argentina, Mexico, Morocco, South Africa, New Zealand and Australia (Figure 11).

3.1.2. EU distribution

In the EU, *D. vaccinii* is officially present only in Latvia. This status was confirmed by a survey done by EFSA among member states on the presence of *D. vaccinii* in 2016 (Table 6, details in Table C.19). Eight MS provided results so far on a total of 16 MSs that carried out the survey. The MS that provided feed-back indicated negative results, with the exception of Latvia, where the presence of the pathogen was already known.

Table 6: Summary of the results of the *Diaporthe vaccinii* survey at EU level

Country	No. of samples	Positive samples
Belgium	14	0
Netherlands	27	0
Latvia	53	3
Czech Republic	22	0
Germany	45	0
Poland	4	0
Sweden	19	0
Lithuania	24	0

Although the Panel recognised the efforts performed by the MS for surveying the pathogen, the Panel considers these results quite difficult to summarise in terms of presence and absence at the EU level. The survey designs are not comparable and the Panel recognises a need for harmonising the pest surveillance activity across the EU. Low numbers of samples taken in some of the member states (Table C.19) provide only weak evidence on absence of the pathogen.

3.1.3. Historical entry events into the EU

The first known outbreak of *D. vaccinii* occurred in the Netherlands in 1956, presumably from infected blueberry planting materials from the USA. From the Netherlands, infected plants were imported into Scotland, where another outbreak was observed. Approximately 30 subsequent outbreaks were detected (Figure D.8; original data from Narouei-Khandan et al., 2017). Details on past outbreaks are reported in the literature (Wilcox and Falconer, 1961; Baker, 1972; Teodorescu et al., 1985; Guerrero and Godoy, 1989; Gabler et al., 2004; Netherlands Plant Protection Service, 2009, 2013, 2015[5]; Kačergius and Jovaišienė, 2010; Lombard et al., 2014; EPPO, 2010, 2015; Vilka and Volkova, 2015; Michalecka et al., 2017).

3.2. Entry

3.2.1. Introduction to Entry

Until recently, the most important route of potential entry of *D. vaccinii* was considered to be via the movement of infected or contaminated host plants for planting, particularly asymptomatic infected plants (Wilcox and Falconer, 1961; Baker, 1972; Guerrero and Godoy, 1989). Infected *Vaccinium* spp. plants exported from North America to other countries were suspected to be an important pathway by which the pathogen was introduced into new areas (Wilcox and Falconer, 1961; Baker, 1972; Guerrero and Godoy, 1989; QingHua et al., 2015). This was especially true when rooted or unrooted cuttings were taken from field-grown or greenhouse-grown plants. However, in recent years, practically all blueberry planting materials are produced by micropropagation (tissue culture) (Debnath, 2006, 2007, 2009; Sedlak and Paprstein, 2009; Litwinczuk, 2013). The resulting plantlets are considered to be disease-free, and the risk situation may be quite different now compared to decades ago. On the other hand, the number of plants shipped worldwide has increased significantly (Brazelton, 2016), so that the risk of introduction of *D. vaccinii* on plants for planting could still be considerable (Diekmann et al., 1994a,b). Moreover, *Vaccinium* species have become popular potted plants for domestic use, either indoors or outdoors (Zee et al., 2010), which may involve additional risks.

Plants for planting are sorted and packaged at the production site or at the receiving location (Evans and Ballen, 2014; Ortúzar, 2014). They can also be shipped in bulk without sorting, and then be sorted and packaged at the receiving location, potentially enhancing the risk of pathogen spread in the receiving country. However, *Vaccinium* plants for planting are inspected twice: once by the exporting company before being shipped and then by the recipient company upon arrival in the EU (approximately 1% of plants are also inspected at the EU border). The majority of symptomatic infected plants are unlikely to escape detection. However, asymptomatic infection is quite common on blueberry and cranberry plants, as twig blight, since the incubation period can be relatively long (2–8 weeks). In North Carolina, 5% of non-inoculated, healthy looking blueberry plants became symptomatic one to two months after the start of a field experiment (Milholland, 1982), and *D. vaccinii* was isolated from 90% of apparently healthy cranberry vines (Friend and Boone, 1968). Thus, plants for planting from open nurseries in *D. vaccinii* affected areas can escape detection by visual inspection. Considering the current worldwide movements of *Vaccinium* plants and the possibility of latent or systemic infections by *D. vaccinii*, the most probable pathway of entry of this pathogen into the EU is infected host plants for planting. This is also a possible pathway for spread within the EU.

We distinguish three types of host plants for planting, differing in risk of carrying *D. vaccinii*: (a) tissue culture plants, (b) plug plants derived from tissue culture or cuttings grown in a greenhouse, (c) potted plants grown in a greenhouse or outside and unrooted cuttings produced outdoors.

Most berry plants for planting originate from *in vitro* propagation (tissue culture) these days (Debnath, 2006, 2007; Sedlak and Paprstein, 2009; Litwinczuk, 2013). New plants can be obtained from tissue culture through shoot proliferation from pre-existing buds or through adventitious shoot regeneration following shoot morphogenesis. The first method is most common for commercial *Vaccinium* plant production. *In vitro* propagation through axillary shoot proliferation involves the following steps: (i) initiation of aseptic culture, (ii) shoot multiplication, (iii) rooting of microshoots and

[5] Data were kindly provided by the Dutch National Plant Protection Organisation.

(iv) hardening and greenhouse and/or field transfer of tissue culture-raised plants. Steps (i) through (iii) take place under controlled conditions (named 'tissue culture plants' for this PRA), and these plants are considered to be disease-free, but step (iv) and additional propagation in a greenhouse or field can involve risks. These last plants are named 'plug plants' or 'potted plants', respectively, for this PRA.

A traditional method of propagation (still practiced) is through stem cuttings taken from fully grown mother plants in a greenhouse or field. Stem cuttings can be transported as unrooted cuttings or as potted plants, especially in the case of cranberry. The asymptomatic presence of *D. vaccinii* on unrooted or rooted cuttings can pose a serious risk, considering the past introductions of the pathogen into new areas that were attributed to plants for planting (Wilcox and Falconer, 1961; Baker, 1972; Teodorescu et al., 1985; Guerrero and Godoy, 1989; Netherlands Plant Protection Service, 2009; QingHua et al., 2015; Moore, 2016). In addition to these types of plants for planting, a wide variety of *Vaccinium* species are produced as flowering or fruiting plants in pots for domestic use. These potted plants may carry *D. vaccinii* in twigs or older branches, and the risk of the pathogen being present is considered to be higher than in young cuttings in plug trays. It is unlikely that the pathogen would be associated with potting mix, because this must be an unused artificial growing medium or a natural growing medium treated by fumigation or heat.

In addition to stem infections, *D. vaccinii* can cause blueberry fruit rot (Milholland and Daykin, 1983) and cranberry viscid rot (Kusek, 1995). Fruit infection can take place in the field at all development stages, and remain latent until maturity (Milholland and Daykin, 1983). Symptom development can continue during storage, but the extent of field rot is not a direct indicator of that of storage rot (Olatinwo et al., 2004). Thus, *Vaccinium* berries from third countries with D. vaccinii can carry the pathogen without showing symptoms. American type blueberries and cranberries are increasingly transported on a global scale (FAOSTAT, online; Evans and Ballen, 2014; USDA/ERS, 2013, 2016; Brazelton, 2016).

Blueberries are harvested by large machines or picked by hand (Longstroth and Hanson, 2012). Cranberries are harvested by combs, either dry or in standing water as the berries float (Pesticide Risk Reduction Program, 2007). They are sorted and packed in small containers in packing houses or put in boxes for bulk shipment. The packed berries are moved into controlled cool rooms, inspected for quality control, and then refrigerated to optimum storage temperatures, just below or above freezing. The berries may also be stored in controlled atmospheres (at elevated CO_2 or O_3 concentrations and reduced O_2 and ethylene concentrations, but at high relative humidity to prevent drying out). Under optimal conditions, fresh berries can be stored for up to 8 weeks. Berries can also be deep frozen and stored for longer periods. Berries too small for fresh consumption are frozen and processed into juice. We assume that frozen berries and juice will not lead to transfer of viable *D. vaccinii* spores, and these will not be considered in this PRA. Fresh berries can be transported overseas to the EU as prepackaged or as bulk shipments in large containers (http://www.freshfruitportal.com/news/2012/04/10/bulk-blueberry-shipping-a-future-alternative-for-chile/); bulk shipments are then sorted and packaged at the final destination within the EU. Berries can travel via air or sea freight under controlled environment conditions. We consider the risk of *D. vaccinii* importation to be minimal when fruit are sorted and packed in the country of origin, but this risk is not negligible when the berries are shipped in bulk and then processed in the country of destination. The risk will depend primarily on waste management and distance to berry production areas or natural areas containing *Vaccinium* species. However, no published information is available about this risk. Similarly, we have estimated waste of infected berries in retail but consider that these will be disposed of in a way that does not allow the pathogen to transfer infection (incineration or landfill) and we have also estimated waste in domestic household settings where a proportion of waste infected berries could transfer infection.

Despite these various potential entry ways, there was only one interception of *D. vaccinii* reported in EUROPHYT during the past 20 years, namely in 1996. The pathogen was associated with plants for planting of *Vaccinium* sp. and *Rubus* sp. imported from the US (interception nr. 2249). In the past 5 years, *Vaccinium* plants or fruits were intercepted, for other reasons, 46 times in total: 19 times from Argentina, seven times from the United States, six times from Morocco, four times from Peru, three times from Chile, twice each from Mexico and Ukraine and once each from Australia, Belarus and Germany. The reasons for these interceptions were the presence of pests other than *D. vaccinii*, absence of the required documents, or noncompliance with special requirements (EUROPHYT, online).

3.2.2. Assessment of Entry for the different scenarios

Six pathways were considered to estimate the number of infected berries or infected plants for planting entering the EU per year. It is important to note that infected berries are not equivalent to founder populations (i.e. established outbreaks) as various ecological processes affect the formation of a founder population from an infected berry (and the chance is quite small). In the case of infected berries, this is due to the colony of *D. vaccinii* in infected fruit being replaced by other microbes, eaten by animals, buried or discarded where it cannot contribute to further establishment and spread (e.g. landfill or incineration), while for infected plants, the number leading to an established outbreak is reduced due to being removed and discarded by nursery staff before contributing to establishment and transfer of infection (described fully in the next section).

The results of the entry assessment (described in detail in Appendix A.1) for the pathways berries and plants for planting are shown for the A0 scenario in Table 7, and in Figure 12a–c for all scenarios (A0, A1 and A2). Table 7 reports five quantile values (1%, 25%, 50%, 75% and 99%) of the predicted number of berries infected with *D. vaccinii* entering the EU per year, not including retail waste berries (which were not thought to allow transfer) ranged from about 6,000 (1% limit) to nearly 3 million (99% limit) with a median value around 200,000. Most infected berries were due to infected blueberry rather than cranberry fruits (about 85% of berry infections were on blueberries based on the median values). In contrast to the berry pathway, far fewer infected plants for planting were predicted to enter the EU per year: for plug plants, the number ranged from about 0.02 (1% limit) to about 10 (99% limit) with a median around 1 (most of which was due to blueberry plug plants rather than cranberry), while for potted plants and cuttings, the number of infected plants entering the EU per year was predicted to range from about 0.3 (1% limit) to about 220 (99% limit) with a median of about 19 (again mostly due to blueberry plants).

Table 7: Number of individual *D. vaccinii*-infected berries or plants for planting predicted to enter the EU under the A0 scenario. Figures include infected units originating from both high- and low-risk locations

Pathways	Percentiles				
	1%	25%	50%	75%	99%
Blueberry fruit – packing house	423	13,891	41,626	109,875	805,429
Blueberry fruit – consumers	5,544	62,491	140,573	297,502	1,502,544
Blueberry plugs	0.018	0.31	0.70	1.38	4.89
Blueberry potted plants	0.31	6.69	16.01	33.86	137.98
Cranberry fruit – packing house	396	11,965	33,382	80,308	439,856
Cranberry fruit – consumers	25	482	1,488	4,466	59,863
Cranberry plugs	0.001	0.055	0.23	0.71	5.09
Cranberry potted plants	0.001	0.51	2.70	9.65	82.88

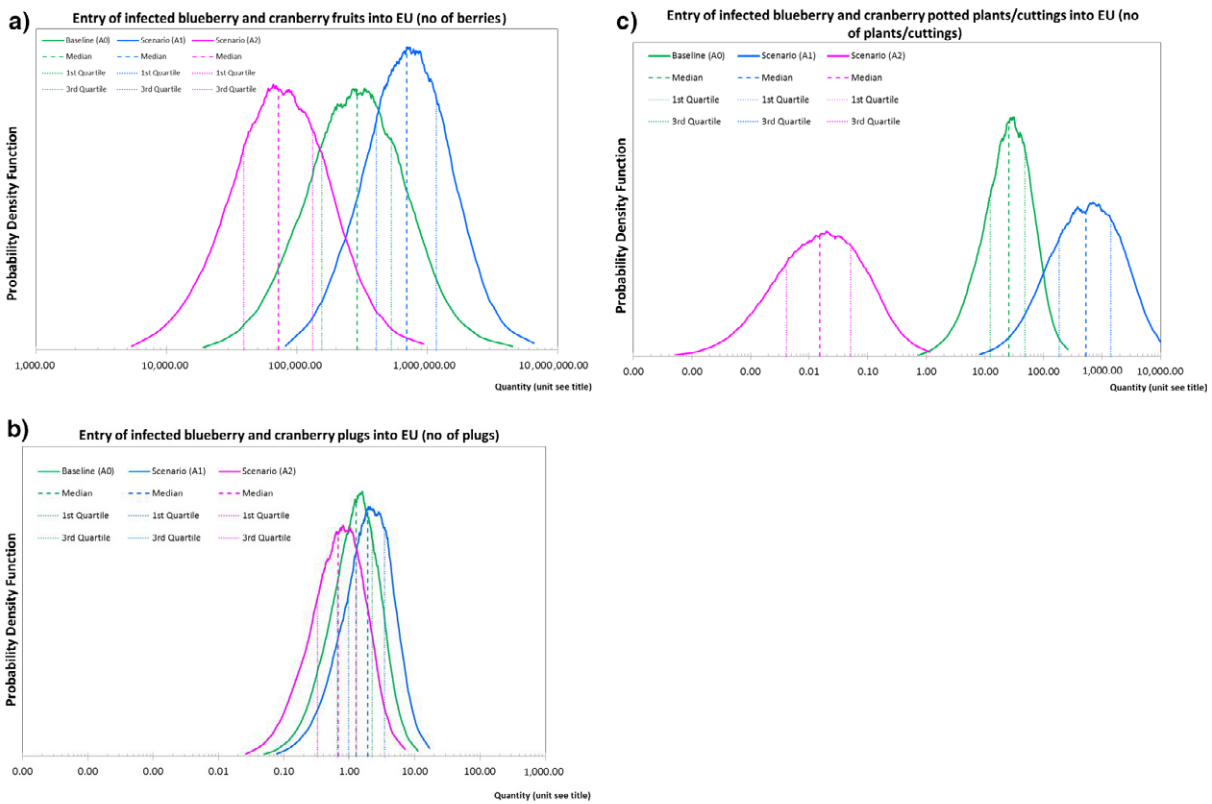


Figure 12: Probability distributions for the number of *Diaporthe vaccinii*-infected berries or plants for planting expected per year due to new entries into the EU for the scenarios (A0, A1 and A2), for each of three main pathways of entry (a) *D. vaccinii*-infected berries, (b) *D. vaccinii*-infected plug plants for planting and (c) *D. vaccinii*-infected potted plants or cuttings for planting. Note differences in scale of the horizontal axis. A combined figure showing the overall number of individual infections (potential founder populations) for all pathways is not shown because the numbers differ greatly between infected fruit and infected plants for planting and the chance of an infected berry leading to an established outbreak of the disease is much less than the chance from an infected plant (see next section). Nevertheless, the number of infected berries or infected plants entering the EU is a useful indicator of the efficacy of RROs by comparing the A0, A1 and A2 scenarios

The number of entries of infected berries into the EU per year under the A0 (current) scenario was predicted to range from about 7,000 to 3,000,000 (1–99% percentiles) with a median of about 200,000 (median values for waste at pack-houses, and domestic households were about 75,000 and 140,000, respectively).

The number of entries into the EU per year under the A0 (current) scenario from blueberry and cranberry plug plants for planting was predicted to range from about 0.02 to about 10 (1–99% percentiles) with a median of about 1 (median values for blueberry and cranberry plug plants were about 0.7 and 0.2, respectively).

The number of entries into the EU per year under the A0 (current) scenario from blueberry and cranberry potted plants for planting and cuttings was predicted to range from about 0.3 to about 230 (1–99% limits) with a median of about 19 (median values for blueberry and cranberry potted plants and cuttings were about 16 and about 2.70, respectively).

The A1 scenario is predicted to increase the number of infected berries entering the EU, with a median value predicted to be about 500,000 (ranging from about 25,000 (1% quantile) to about 6 million (99% quantile)), compared to a median of about 200,000 under the A0 scenario. For plug plants, the number of infected plants entering the EU under scenario A1 was predicted to be around 1.5, ranging from about 0.04 to about 14 (1–99% quantiles, respectively), compared to a median of about 0.9 under the A0 scenario. For potted plants and cuttings, the median number of potential founder populations entering the EU per year under the A1 scenario was predicted to be around 500 plants, ranging from about 5 to 9,000 (1–99% quantiles, respectively), compared to about 19 under A0.

The A2 scenario was predicted to reduce the number of infected berries entering the EU slightly compared to the A0, due to an enhanced level of disease control in affected production locations, leading to a slightly reduced incidence of infected berries being harvested. Similarly, for plug plants, the predicted median number was also slightly reduced at about 0.6, within a range from 0.01 as the 1% quantile, to about 5 as the 99% quantile and compared to a median of 0.9 under A0, while for potted plants and cuttings, the predicted median number of infections under the A2 scenario was close to zero due to restricted trade, (the predicted values ranged from 0 at the 1% quantile to about 0.6 as the 99% quantile) compared to a median of 19 under A0).

3.2.3. Uncertainties and sensitivities affecting the assessment of entry

Data used for the quantitative estimates of entry were based essentially on trade data (trade of blueberries and cranberries fruits and plants for planting) and on the parameters expressing the variations in abundance of the pest along the pathways from the countries of origin to the EU. Trade data were often available aggregated (fruits of all *Vaccinium* species), incomplete (ISEFOR database) and extrapolation or further processing were required. In other cases, especially for the parameters used in the model, expert judgement was used.

Uncertainties of data and parameters used for the entry submodel are discussed in detail in Appendix A.1.

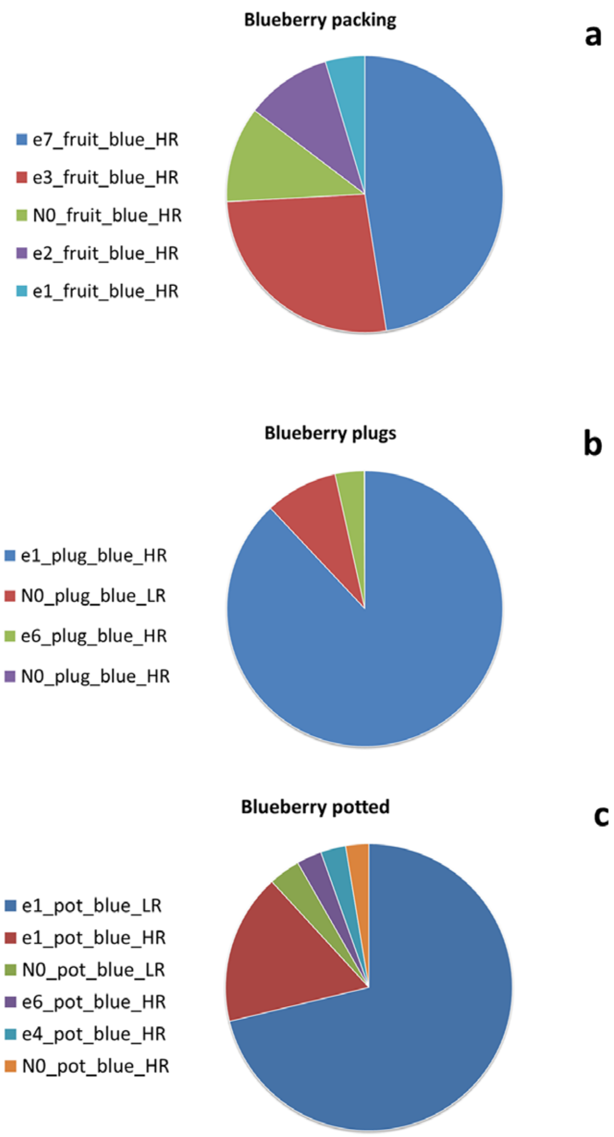


Figure 13: Examples for blueberry only (full set of figures for both blueberry and cranberry is in Appendix E) showing the relative contribution of factors included in the assessment to the quantified uncertainty for the entry of *Diaporthe vaccinii*) into the risk assessment area for the different scenarios considered (A0, A1 and A2) and for the different pathways (a) berries, (b) plug plants for planting, and (c) potted plants for planting

Figure 13 indicates the assessment of uncertainty of the results, showing that for the berry pathway, parameters E7 (proportion of infected berries removed at packing houses in the EU), followed by E3 (proportion of infected berries that are removed at packing houses before being exported to the EU) made the largest contributions to the uncertainty in the inflow of infected berries (Figure 13a). For the plug plants for planting pathway, the predominant parameter responsible for uncertainty in the entry was E1 (proportion of plants for planting infected with *D. vaccinii* when leaving the place of production from high-risk locations) (Figure 13b), while for the potted plants for planting pathway, the most important parameters for uncertainty were also E1 (proportion of plants for planting infected with *D. vaccinii* when leaving the place of production from high-risk locations), followed by the same parameter for low-risk countries (Figure 13c).

A detailed description of the uncertainty analysis is given in the Appendix. Due to trade flow, the blueberry pathways had a greater overall influence than those of cranberry. In the case of the berry pathways (for blueberry and cranberry), the estimates of infected fruits entering the EU are then subject to substantial reduction in the Section 3.3 (Establishment) to produce an estimate of established populations following estimation of processes that limit the ability of infected material (fruit or plants) to establish a population. Uncertainty around the estimated numbers of *D. vaccinii*-infected plant material entering the EU is highly connected to the scale of berries being discarded in each sector (pack-houses, retail or domestic households). Additional uncertainties affecting the entry assessment but not quantified within the assessment model are listed in Table 7, including undocumented or illegal import of fruit or plants for planting, and long-distance natural spread by ascospores or by birds that have eaten infected berries. Some of these additional factors cannot be controlled or are thought to be of relatively minor consequence.

Additional uncertainties affecting the entry assessment but not quantified within the assessment model are listed in Table 8.

Table 8: List of additional uncertainties affecting the entry assessment but not quantified within the assessment model

No.	Description of source of uncertainty	Description of effect on assessment of entry
1	Temporal trend in the blueberry and cranberry fruit trade	The most recently available data (until 2014) were considered, but the trade volumes are still increasing
2	Temporal trend in the blueberry and cranberry plants for planting trade	Cultivation of berries, especially highbush blueberry, is steadily increasing in EU and the majority of new varieties have been created by USA plants producers. Several of these producers (commercial companies, but also Universities) often allows associated plant nurseries in EU to produce and sell P4P, starting from imported mother plants. There is lack of this type of data and the overall combination of these processes render it difficult to estimate temporal trends of P4P trade
3	Undocumented import of berry fruit	Data not available
4	Illegal import of plants for planting	Data not available
5	Long-distance natural spread (by birds or ascospores)	Data not available

3.2.4. Conclusion on the assessment of Entry for the different scenarios

Results indicate that compared to the current situation (A0), a relaxation of regulations would lead to an increase in new entries of infected berries into the EU per year to about 500,000 (median value), which is more than double that predicted under A0. Similarly, the A1 scenario would increase the number of infected plants for planting (both plug plants and potted plants or cuttings) from a predicted median of about 20 under A0 to about 500. In contrast, the A2 scenario was predicted to decrease the median number of *D. vaccinii*-infected fruits slightly, while infected plants for planting (plugs and potted plants or cuttings combined) would also reduce according to predictions for A2, to 0.6 (entirely from plug plants as there would be no trade in potted plants or cuttings form affected production sites).

Although the number of *D. vaccinii*-infected berries predicted to arise in the EU each year is much higher than the number of *D. vaccinii*-infected plants for planting, the estimated numbers cannot be compared directly because a vastly reduced chance of transferring infection is likely to occur from infected fruits than from infected plants for planting (discussed in the Section 3.3, Establishment). Nevertheless, the measures proposed under scenario A2 would substantially reduce the number of *D. vaccinii*-infections entering the EU according to predictions.

The main uncertainties and sensitivities to this analysis were parameters E7 and E3 (proportion of infected berries removed at packing houses in the EU and in the exporting country, respectively), for the berry pathway, while for plants for planting, the predominant parameter that influenced the results most was; E1 (proportion of plants for planting infected with *D. vaccinii* when leaving the place of production from high-risk locations, followed by the same parameter for low-risk countries.

3.3. Establishment

3.3.1. Introduction to Establishment

Once *D. vaccinii* has entered the EU via plants for planting or berries, the pathogen may get established in a production area or natural environment. In plants for planting, the pathogen is in essence already established in that plant, although local spread and infection are needed for the pathogen to get established in a founder population. When the *D. vaccinii* enters the EU with a berry, sporulation, local transport and infection of a *Vaccinium* plant are needed before a founder population can get established; the probability of establishment via this route is thus much smaller than via plants for planting.

The pathogen enters *Vaccinium* host tissues mainly through pruning or freezing wounds and open flower buds, and to a lesser extent directly into the tips of young, succulent shoots and leaf margins (Milholland, 1982; Parker and Ramsdell, 1977). Field studies demonstrated that mature, healthy unwounded blueberry plants did not become infected by *D. vaccinii*, even after 1 month of exposure to natural field inoculum (Parker and Ramsdell, 1977; EFSA PLHP, 2014). The pathogen can enter into the host vascular tissues through leaf margins and open flower buds (Weingartner and Klos, 1975; Milholland, 1982; Williamson et al., 2013), and fungicide applications are most effective at the early flowering stages (Williamson et al., 2013).

During the growing season (generally, in the northern hemisphere, March–September), disease symptoms become evident in young plants within 2 weeks following infection (Milholland, 1982), and 2–3 weeks after infection of partially hardened twigs on older plants (Polashock and Kramer, 2006). Four weeks after inoculation with *D. vaccinii* twig blight lesions are on average 30–50 mm long on highbush and rabbiteye blueberries, and 22–24 mm on lowbush blueberries and their hybrids (Polashock and Kramer, 2006). Systemic infection results in wilting and dieback of twigs, and ultimately in stem canker (Milholland, 1982). Stem canker may lead to the death of entire bushes, for example in Southern Michigan (Wilcox, 1939; Weingartner and Klos, 1975). *D. vaccinii* may survive in symptomatic or asymptomatic branches or in broken twigs on the soil surface (Oudemans et al., 1998). The pathogen typically does not survive in leaves or soil (Oudemans et al., 1998).

Initial establishment (and subsequent spread as discussed in Section 3.3.1) depends on the climate in the region where the pathogen is introduced and the season at the time of introduction. Each systemically infected plant for planting can become a founder plant at the proper time for sporulation and spread (see Section 3.3.1). Infected berries or their waste would need more exacting conditions to create founder plant. The most favourable period for infection is April through September (during bloom), and for further disease development from May to October.

The optimum temperature for the growth of *D. vaccinii in culture* is 21–27°C (Ramsdell, 1995), but the pathogen has a very wide temperature range for growth (4–32°C) (Parker and Ramsdell, 1977; EPPO, 1990). Disease development in the field is optimal at an average annual temperature between 8 and 15°C, although the disease can occur at average annual temperatures between 0 and 25°C (Narouei-Khandan et al., 2017). Nevertheless, stem cankers were more common in areas with higher spring/summer temperatures (> 30°C) in Michigan, and heat stress appears to promote disease development (Weingartner and Klos, 1975).

3.3.2. Further specification of host range

All *Vaccinium* species tested thus far for infection and symptom development by *D. vaccinii* are susceptible to the pathogen. Very little is known about the relative susceptibility of different *Vaccinium* species in cultivated fields and wild habitats (Polashock and Kramer, 2006). Lowbush blueberry cultivars (*Vaccinium angustifolium*) and half-high bush cultivars (hybrids between highbush and lowbush blueberry plants) generally are more resistant to *Phomopsis* twig blight than the Southern highbush (*V. corymbosum*) and rabbiteye cultivars (*Vaccinium ashei* or *Vaccinium virgatum*). Sparkleberry, a native of south-central USA was somewhat resistant (Polashock and Kramer, 2006). Both lowbush blueberry and sparkleberry grow in wild habitats and are generally not cultivated (Annemiek Schilder, hearing expert, November 24, 2016). There was no clear resistance among cranberry cultivars. Yet, *D. vaccinii* infection seemed to be rare in wild cranberry stands (Annemiek Schilder, hearing expert, November 24, 2016). Indeed, *D. vaccinii* was not isolated from rotten cranberry fruits at four unmanaged or native stands in New Jersey, but was isolated from 16% to 23% of rotten fruits from two other unmanaged or native cranberry stands (Stiles and Oudemans, 1999).

Taking into account the literature on reported isolations of *D. vaccinii* as well as DNA sequences of *D. vaccinii* reported in GenBank (https://www.ncbi.nlm.nih.gov/nuccore?term=Diaporthe%20vaccinii&cmd=DetailsSearch), we conclude that *D. vaccinii* has been found as pathogen in many species of *Vaccinium* and as endophyte in a variety of different genera (Table 9).

Table 9: Host range of *Diaporthe vaccinii* as a pathogen and as an endophyte based on sequences deposited in GenBank (extracted in November, 2016)

Function	Plant species	Common name	Identification method	Location	Reference
Pathogen	*Vaccinium corymbosum*	Highbush blueberry	ITS	Michigan, North Carolina, USA	Farr et al. (2002a,b)
Pathogen	*Vaccinium corymbosum*	Highbush blueberry	Translation elongation factor 1; 5.8S, 18S, 28S, ITS1 and 2; calmodulin gene	USA, Netherlands	Lombard et al. (2014)
Pathogen	*Vaccinium macrocarpon*	American cranberry	Translation elongation factor 1; 5.8S, 18S, 28S, ITS1 and 2; calmodulin gene	USA, Lithuania, Latvia	Lombard et al. (2014)
Pathogen	*Vaccinium macrocarpon*	American cranberry	Partial sequence 5.8S, ITS1 and 2, 28S	Latvia	Vilka and Volkova (2015)
Pathogen	*Vaccinium macrocarpon*	American cranberry	ITS	Massachussets, New Jersey, Wisconsin, USA	Farr et al. (2002a,b)
Pathogen	*Oxycoccus macrocarpus* = *Vaccinium macrocarpon*	American cranberry	Complete sequence 5.8S, ITS1 and 2	Sand Hutton, York, North Yorkshire England	Hughes (2005) Direct submission to GenBank.
Pathogen	*Vaccinium oxycoccus*	European cranberry	Translation elongation factor 1; 5.8S, 18S, 28S, ITS1 and 2; calmodulin gene	Latvia	Lombard et al. (2014)
Pathogen	*Vaccinium palustris*	Bog cranberry	ITS1 and 2, 5.8S and 28S rRNA	Lithuania	Kačergius and Jovaišienė (2010)
Pathogen ? (brown spot)	*Potentilla fragarioides*	Chinese potentilla (medicinal plant)	Partial sequence 5.8S, 18S, 28S, ITS1 and 2	Shenyang Agricultural University, Liaoning, China	Zhou (2014) Direct submission to GenBank
Endophyte	*Physalis alkekengi*	Chinese Lantern plant	Partial sequence 5.8S, 18S, 28S, ITS1 and 2	Qingdao Agricultural University, Chengyang District, Shandong China	Yue and Liang (2013) Direct Submission to GenBank
Endophyte	*Populus simonii*	Simon's poplar	Partial sequence 5.8S, 18S, ITS1 and 2, 28S	Northwest A&F University, Yangling, Shaanxi, China	Zhang et al. (2014) Direct Submission to GenBank
Endophyte	Unknown	unknown	Partial sequence 5.8S, 18S, ITS1 and 2, 28S	Northwest A&F University, Yangling, Shaanxi, China	Zhang et al. (2014) Direct Submission to GenBank
Endophyte	Unknown (many species collected)	unknown	Complete sequence 5.8S, partial ITS1 and 2	Alicante, Spain	Macia-Vicente et al. (2008)
Endophyte	Unknown	Medicinal plant	Partial sequence 5.8S, 18S, 28S, ITS1 and 2	Guizhou University, Guiyang, Guizhou Province, China	Su et al. (2012) Direct Submission to GenBank

Function	Plant species	Common name	Identification method	Location	Reference
Endophyte	Unknown (many species collected)	Unknown	Partial sequence 5.8S, 28S, ITS1 and 2	Santo Domingo, Heredia, Costa Rica	Rojas-Jimenez et al. (2016)
Endophyte	Unknown	Unknown	5.8S,18S, 28S, ITS1 and 2	Beijing Forestry University, Qinghua, Beijing, China	Tian (2009) Direct Submission to GenBank

No information is available about the relative resistance or susceptibility of native European *Vaccinium* species, which have generally not been exposed to *D. vaccinii*, with the exception of native stands of *Vaccinium oxycoccus* in Lithuania (EPPO, 2004; Lombard et al., 2014), *Vaccinium palustris* in Lithuania (Kačergius et al., 2004; Kačergius and Jovaišienė, 2010), and possibly (no molecular identification) of *V. myrtillus* in Russia (Dokukina, 2001) and *V. angustifolium* in Belarus (Galynskaya et al., 2011; Galynskaya and Liaguskiy, 2012). Therefore, we consider the worst-case scenario of susceptible *Vaccinium* stands wherever *D. vaccinii* could establish according to its ecological niche (Narouei-Khandan et al., 2017).

3.3.3. Assessment of establishment for the different scenarios

The main EU countries where blueberries were produced in 2014 were Poland, Germany and Spain (Figure 8), while the countries where *Vaccinium* plants were imported from the USA (2015–2017) were Spain, Germany, Great Britain, the Netherlands, Poland and Italy (information from a large blueberry nursery in the USA). Blueberry production areas in Spain, Germany, Great Britain and the Netherlands have climates that are only moderately suitable for disease establishment, while production areas in Poland and northern Italy have a highly suitable climate (Narouei-Khandan et al., 2017). Imported infected blueberries and cranberries that are discarded outdoors may be sources of infection for *Vaccinium* plants but the probability of successful transfer and infection is affected by plant densities and climate (Appendix A.1.2). Imported infected P4P that have not been removed are planted in the middle of other *Vaccinium* plants, so that there is no shortage of infection courts. Plug plants and small potted plants arrive in nurseries, where establishment of *D. vaccinii* is hardly affected by the outside climate. Larger potted plants and imported cranberry cuttings may be planted directly in production fields, where establishment of the pathogen is affected by climate. Reduction factors due to suboptimal climates range from 0.08 in the NW to 0.30 in the SE of the EU.

The results of the establishment assessment for the different scenarios and for the four EU regions are shown in Table 10 and Figure 14. Table 9 reports five quantile values (1st, 25th, 50th, 75th and 99th) of the number of established populations of *D. vaccinii* in terms of infected founder plants per year in each of the four regions in the EU for scenarios A0, A1 and A2, whereas Figure 14 shows the estimated continuous probability distributions associated with the values of the number of established founder plants.

Table 10: Selected quantiles of the uncertainty distribution for the number of established founder plants infected by *Diaporthe vaccinii* expected per year in four regions in the EU over during one year for scenarios A0, A1, and A2

Quantile	Source	1% quantile	1st quartile (25%)	Median (50%)	3rd quartile (75%)	99% quantile
Number of established founder plants in scenario A_0 – NW region	Berries	0	0	1	5	215
	Plug plants	0	0.008	0.018	0.039	0.17
	Potted plants	0.008	0.164	0.419	0.935	47
	Total	**0.008**	**0.17**	**1.4**	**6.0**	**262**
Number of established founder plants in scenario A_0 – NE region	Berries	0	0	1	5	207
	Plug plants	0.01	0.086	0.17	0.316	1.258
	Potted plants	0.145	1.555	3.273	6.377	24.93
	Total	**0.15**	**1.6**	**4.4**	**11.7**	**233**

Quantile	Source	1% quantile	1st quartile (25%)	Median (50%)	3rd quartile (75%)	99% quantile
. . . Number of established pest in scenario A_0 – SW region	Berries	0	0	0	1	33
	Plug plants	0.011	0.091	0.178	0.321	1.062
	Potted plants	0.165	1.735	3.656	7.033	27.24
	Total	**0.18**	**1.8**	**3.8**	**8.4**	**61**
Number of established founder plants in scenario A_0 – SE region	Berries	0	0	0	0	0
	Plug plants	0	0	0	0	0.001
	Potted plants	0	0.002	0.004	0.008	0.031
	Total	**0**	**0.002**	**0.004**	**0.008**	**0.032**
Number of established pest in scenario A_1 – NW region	Berries	0	1	3	13	499
	Plug plants	0.001	0.016	0.038	0.082	0.36
	Potted plants	0.12	3.7	12.6	37.2	271
	Total	**0.12**	**4.7**	**15.6**	**50.2**	**770**
Number of established founder plants in scenario A_1 – NE region	Berries	0	0	2	11	433
	Plug plants	0.005	0.12	0.25	0.45	1.54
	Potted plants	1.628	23.183	62.798	163.974	1,043
	Total	**1.6**	**23.3**	**65**	**175**	**1,4778**
. . . Number of established founder plants in scenario A_1 – SW region	Berries	0	0	0	2	67
	Plug plants	0.016	0.15	0.30	0.56	1.99
	Potted plants	1.83	28.4	85.0	234	1,543
	Total	**1.85**	**28.5**	**85.2**	**237**	**1,611**
Number of established founder plants in scenario A_1 – SE region	Berries	0	0	0	0	0
	Plug plants	0	0	0	0	0.02
	Potted plants	0.002	0.032	0.092	0.25	1.64
	Total	**0.002**	**0.032**	**0.092**	**0.25**	**1.66**
Number of established founder plants in scenario A_2 – NW region	Berries	0	0	0	2	71
	Plug plants	0	0.007	0.016	0.034	0.15
	Potted plants	0	0	0	0.001	0.016
	Total	**0**	**0.007**	**0.016**	**2.03**	**71.2**
Number of established founder plants in scenario A_2 – NE region	Berries	0	0	0	1	26
	Plug plants	0.005	0.04	0.081	0.15	0.56
	Potted plants	0	0.001	0.002	0.006	0.061
	Total	**0.005**	**0.041**	**0.083**	**1.16**	**26.62**
Number of established founder plants in scenario A_2 – SW region	Berries	0	0	0	0	4
	Plug plants	0.005	0.051	0.109	0.21	0.81
	Potted plants	0	0.001	0.002	0.009	0.01
	Total	**0.005**	**0.052**	**0.111**	**0.22**	**4.82**
Number of established founder plants in scenario A_2 – SE region	Berries	0	0	0	0	0
	Plug plants	0	0	0	0	0.001
	Potted plants	0	0	0	0	0
	Total	0	0	0	0	**0.001**

Under the A0 scenario, potted plants were predicted to be the main source of established infected founder plants, followed by berries (Table 9). Plug plants were predicted to result in very few established founder plants. The risk of establishment was greatest in the NE region of the EU, followed by the SW. Under A1, by far the largest risk of establishment was predicted from potted plants, much less from berries, and hardly from plug plants. In this situation, the greatest risk was in the SW (where most P4P are imported), followed by the NE. Under scenario A2, the probability of establishment of founder plants with *D. vaccinii* were predicted to be very low, and highest from import of infected berries, which are not affected by extra regulation of import of P4P. In this case, the greatest risk was in the NW, where most blue- and cranberries are imported. Under all scenario's the risk of establishments of founder plants with *D. vaccinii* was lowest in the SE, where only few P4P are imported and no berries.

Probability density functions (Figure 14) clearly show that the proposed RRO's have little effect on the estimated establishment of founder plants from **berry waste** over a 1-year period. This is illustrated by the close proximity of the curves under the three scenarios, with median values close to one infected plant in the NW and NE of the EU under scenario A0 and between approximately 0.1 and 10 infected plants under scenarios A2 and A1, respectively. The uncertainty intervals became slightly wider under A1 and narrower under A2 compared to A0. In the SW, the risk of establishment of infected founder plants from berries was lower than in the NW and NE, with medians of about 0.1 under A0, and around 0.5 and 0.07 for scenarios A1 and A2, respectively. The lower medians in the SW can be ascribed to reduced import of berries and a less suitable climate for establishment. The uncertainty intervals were very similar for the three scenarios. No founder populations were predicted to become established in the SE, because berries were not expected to be imported in that region.

Probability density functions for the establishment of infected founder plants from **plug plants** (Figure 15) were very similar for the three scenarios in the NW of the EU, with medians of < 0.04 founder plants from plug plants under all scenarios over a 1-year period. The uncertainty levels were also similar in the NW. The estimated infected founder plants in the NE and SW from imported plug plants were higher than in the NW, with medians ranging from close to 0.1 plants (A2) to < 100 plants (A1) over a 1-year period. The difference with the NW was due to a more suitable climate in the NE and larger imports in the SW. The uncertainty ranges were similar for the three scenarios. The establishment of infected founder plants from imported plugs in the SE was estimated to be very low (< 0.0001 plants per year) for all three scenarios due to the expected low levels of imports from third countries. The uncertainty was similar for the three scenarios.

Probability density functions for established founder plants from **potted plants or cuttings** differed greatly for the different scenarios in all geographic regions of the EU (Figure 16). The median values increased from < 1 infected plant in the NW and < 4 infected plants in the NE and SW under scenario A0 to about 13 plants in the NW and 80 plants in the NE and SW under scenario A1. The median numbers were reduced to about 0.0001 in the NW and 0.001 in the NE and SW under scenario A2. In the SE region, the numbers of established infected plants from potted plants or cuttings was low (0.004–0.09) under scenarios A0 and A1, and 0 under A2. The uncertainties increased considerably under scenario A1 (at the higher end of the log-scale) in all regions.

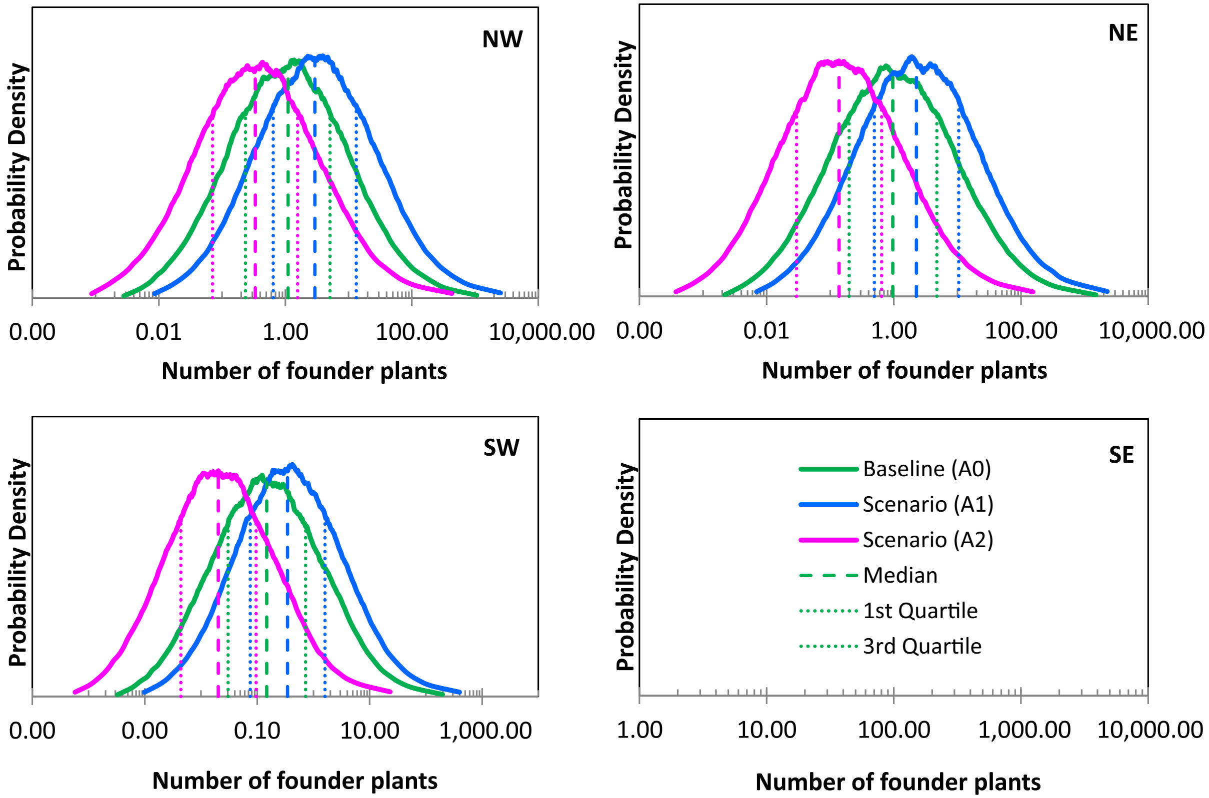


Figure 14: Probability density functions for the establishment from imported infected blueberry and cranberry fruits (number of infected plants or founder populations of *Diaporthe vaccinii*) expected per year in four geographic regions of the EU (NW, NE, SW and SE) under three scenarios (A0, A1 and A2). Note that the scales for the X-axes are different, and that no berries were imported into the SE

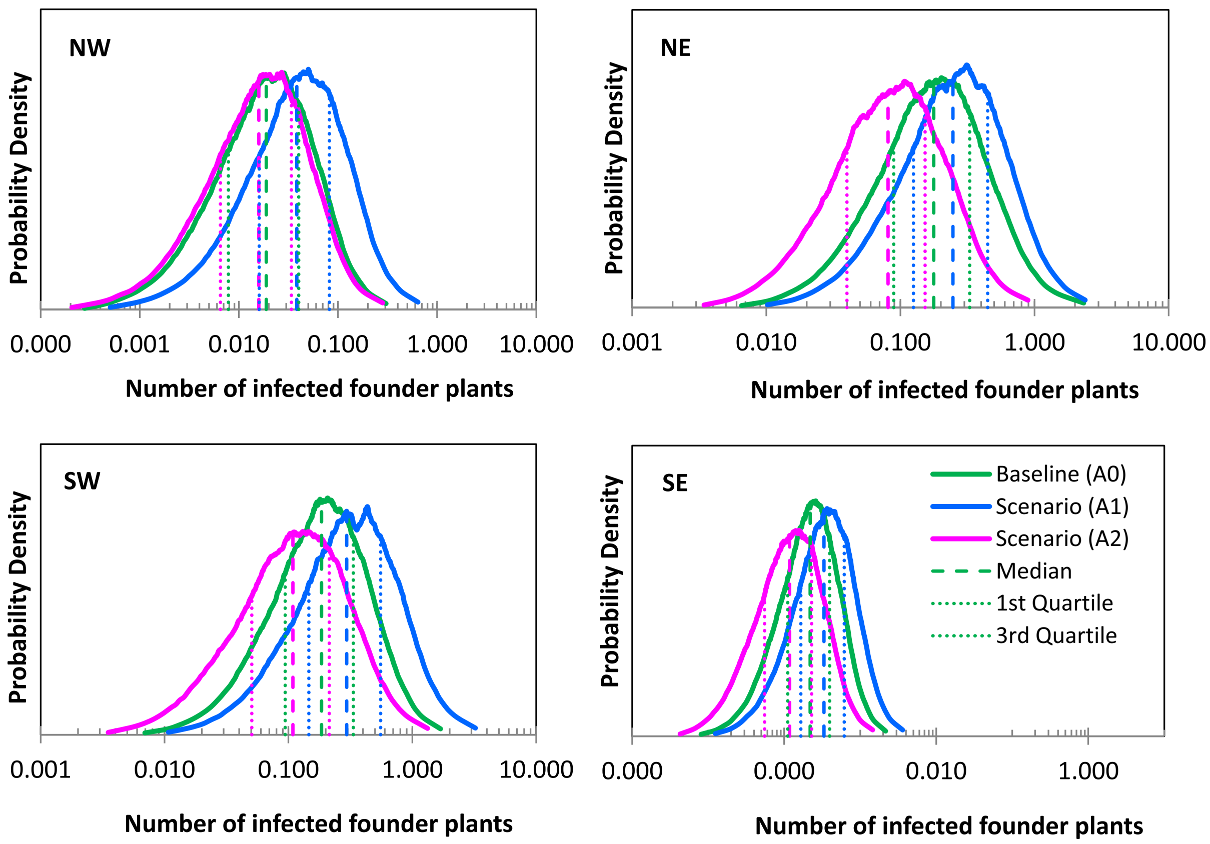


Figure 15: Probability density functions for the establishment from imported infected blueberry and cranberry plugs (number of infected plants or founder populations) in four geographic regions of the EU (NW, NE, SW and SE) per year under three scenarios (A0, A1 and A2). Note that the scales for the X-axes are different

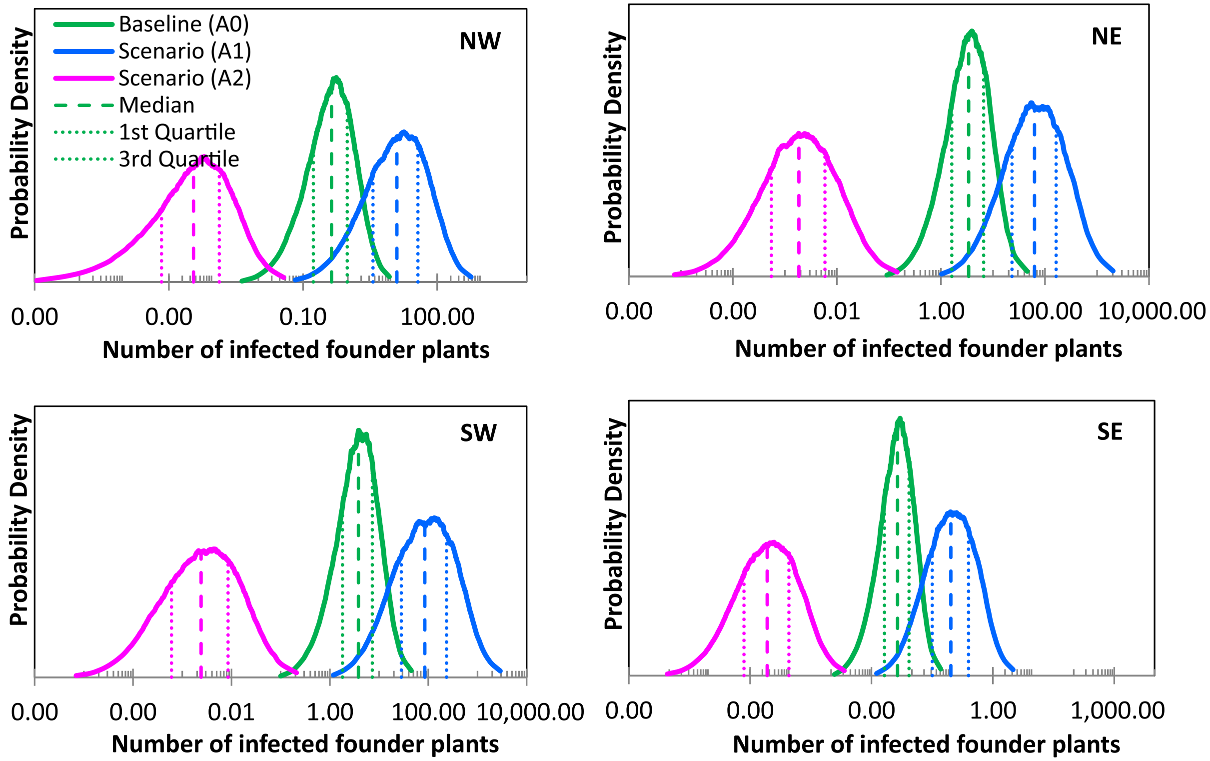


Figure 16: Probability density functions for the establishment from imported infected blueberry potted plants and cranberry potted plants or cuttings (number of infected plants or founder populations) in four geographic regions of the EU (NW, NE, SW and SE) per year under three scenarios (A0, A1 and A2). Note that the scales for the X-axes are different, and that the uncertainties at the lower end of the scale are much smaller than those at the higher end due to the log-scale

From the results presented in Table 9 and Figures 14, 15 and 16, it is clear that the numbers of established infected founder plants would be greatly increased under scenario A1, and reduced under scenario A2 compared to A0, primarily due to changes in the importation of infected potted plants and cuttings. The expected median total number of established infected plants in the whole of the EU is about 10 founder plants per year under the current situation (A0), 166 plants per year under A1 and 0.2 plants pea year under A2. More importantly, the potential maximum numbers (99 percentile) are estimated to be 556 under A0, 3,860 under A1 and 103 under A2 over a 1-year period. In addition, the uncertainty interval is greatly increased under scenario A1 compared A0 and A2. These results form an argument in favour of keeping the quarantine status of *D. vaccinii* and perhaps set extra restrictions to the import of potted plants and cuttings and even the importation of bulk fruit.

3.3.4. Uncertainties affecting the assessment of establishment

The contribution of the various factors to uncertainty in the establishment assessment for scenario A0 is shown in Figure 17. The contributions are expressed as standardised regression coefficients.

Under the current situation (scenario A0), the factor that contributed most to the uncertainty of establishment from blueberry and cranberry waste was rate b2 (proportion of fruits infected with *D. vaccinii* resulting in plant infection and establishment per year) in all regions of the EU. Because the contribution of b2 was (almost) 100%, no pie charts are shown for the establishment from waste. The factors contributing to the establishment of infected plants from plugs and potted plants or cuttings were similar for the four different geographic regions in the EU. However, differences in contributing factors could be observed between the plugs pathways and the potted plants/cuttings pathways. In the former pathway, the factors e1-HR (proportion of blueberry production fields infected with *D. vaccinii* in high incidence regions in third countries), N0-LR (number of blueberry plugs imported from low incidence regions in third countries) and e6-HR (multiplier accounting for a change in the number of infected plug plants from high incidence countries during intra-EU transport) had the greatest contribution to uncertainty in the establishment. In the pathways of blueberry potted plants, the factors e1-LR and e1-HR (proportion of blueberry production fields infected with *D. vaccinii* in low or high incidence regions in third countries), N0-LR and to a lesser extent N0-HR (number of blueberry potted plants imported from low- or high incidence regions in third countries), as well as e4-HR (multiplier for a change in the number of infected plants during transport from high incidence regions to the EU) and e6-HR (multiplier accounting for a change in the number of infected plants from high incidence third countries during intra-EU transport) contributed most to the uncertainty. Fewer factors were influential in the cranberry potted plants/cuttings pathways, viz. e1-HR (proportion of cranberry production fields infected with *D. vaccinii* in high incidence regions in third countries), N0-HR (number of cranberry plants or cuttings imported from high incidence regions in third countries) and e6-HR (multiplier accounting for a change in the number of infected plants from high incidence third countries during intra-EU transport).

Since establishment was considered to be little affected by changes in RROs, the relative contributions of the various factors to uncertainty were expected to be the same for the different scenarios (not assessed for scenarios A1 and A2).

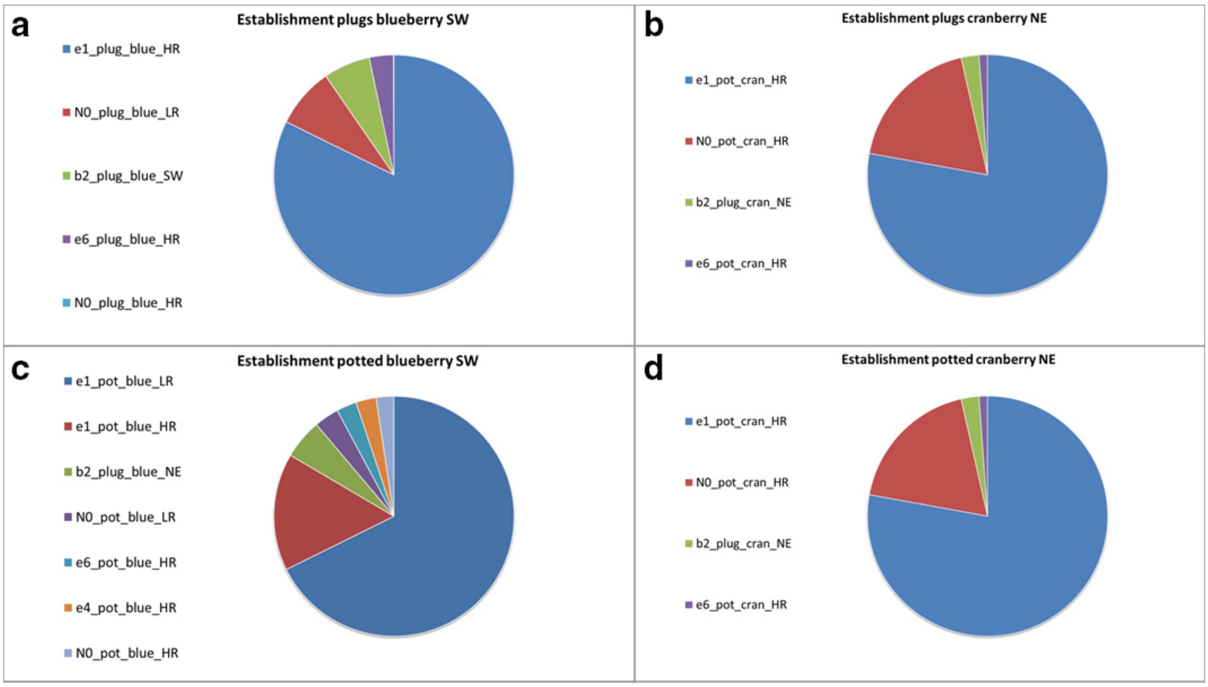


Figure 17: Contribution of factors included in the assessment to the quantified uncertainty for the establishment of *Diaporthe vaccinii* infected plants for scenario A0. The distribution of the contributing factors was the same for each of the geographic regions in the EU, but differences were obtained for plugs and potted plants, as well as for blueberry versus cranberry plants. Pie charts are displayed of plugs (a) and pots (c) of blueberry plants in the SW (where most import takes place) and of plugs (b) and pots/cuttings (d) of cranberry plants in the NE region (where most cranberries are grown)

Additional uncertainties affecting the establishment assessment but not quantified within the assessment model are listed in Table 11.

Table 11: List of additional uncertainties affecting the establishment assessment but not quantified within the assessment model

No.	Step: Division of infected imported berries and P4P over four climatic regions	Description of source of uncertainty for both sub-steps but considering all the factors separately	Description of effect on assessment of establishment
1	Division of all EU countries over four regions (NW, NE, SW and SE)	Allocation of the countries to four regions was partially based on relative numbers of imported P4P and berries, estimated from export data from the USA and FAOSTAT data, respectively. No information was available on imports of P4P in individual EU countries An important unknown is the introduction of berries and P4P from Belarus and Russia, and uncertainty about the occurrence of the pathogen in these countries (no molecular identification used)	Uncertainties about the distribution of imported plants and berries over EU countries and thus regions have a large influence on the risk calculations, because the four regions have distinct climate suitability for *D. vaccinii* development Because very few P4P and no berries are imported in the SE, and internal redistribution of P4P was not included in the model, the risk for establishment in the SE is grossly underestimated. Risks in the NE and SE would be greatly influenced by the potential presence of *D. vaccinii* in Belarus and Russia
No.	**Step: Number of established populations**	**Description of source of uncertainty for both sub-steps but considering all the factors separately**	**Description of effect on assessment of establishment**
2	Climate suitability for *D. vaccinii* establishment in the four regions	The grouping of countries was further based on climate suitability for *D. vaccinii* development, so that establishment could be assessed for each climatic region separately. Uncertainty about the relative climate suitability in smaller areas (NUT2 or NUTS3) was not considered	The climate suitability had been estimated previously from long-term climate data (Worldclim data) combined with global occurrence of the pathogen. Low-risk and high-risk regions were distinguished, but the outcome of the model is strongly affected by the relative suitability assumed in high-risk versus low-risk regions. However, differences in establishment in the four regions were determined more by relative berry and P4P imports than by differences in climate suitability
3	Host plant availability	For establishment from berry waste, the relative density of wild *Vaccinium* plants was estimated from geographic distributions of ecoregions and climate suitability for *Vaccinium* growth. Host plants were considered to be plentiful in production areas where imported P4P were located	The relative densities of host plants strongly influence the probability of transfer from berry waste to a hot plant, which is the single most influential factor affecting establishment of *D. vaccinii* from berry waste. Any over estimation of the proximity of host plants to berry waste greatly influence the establishment from berry waste

3.3.5. Conclusions on Establishment for the different scenarios including the area of potential establishment

a. The import of potted plants and field cuttings constitute the greatest risk of introduction and establishment of *D. vaccinii* in the EU. This is especially true for the SW region, where most P4P are imported, and for the NE region where the climate is highly suitable for disease development and plant material is imported with the highest probability of infection (cranberry cuttings imported as bales from fields in high incidence areas in the country of origin and planted directly into fields in NE EU). Under A0 (current situation), the range (1–99 percentile) in numbers of established infected plants is from < 0.01 to > 27 plants per year in the NW, NE and SW of the EU (SE excluded because of low imports). Under A1 (no quarantine), this range is from about 0.1 to > 1,500 plants per year. Under A2, this range is from 0 to < 0.1 plants per year. Thus, the risk of establishment of *D. vaccinii* from imported potted plants and cuttings would be greatly enhanced by removing this pathogen from the quarantine list, while additional regulations, allowing potted plants only from pest-free areas, would reduce the risk to practically zero. Additional risks, currently not in the model, are associated with intra-EU transport of imported infected plant materials, especially if the final destination would be in the SE region, which is currently not importing many P4P directly from third countries, but has a climate that is highly suitable for establishment of *D. vaccinii*.

b. The import of infected berries could theoretically lead to discarded waste material that could result in infection of nearby plants. However, the uncertainty about this happening is enormous. Under A0, our calculations result in a range (1–99 percentile) of 0–215 infected founder plants in the NW region, where most berries are imported. Under A1, this range increases to 0–499 infected founder plants in the same region, while under A2, this range is reduced to 0–71 infected founder plants. There is no indication in the literature that past outbreaks were ever associated with imported berries, and our parameter estimates may have been too high (biased, despite the wide range). On the other hand, the import of blueberries and cranberries has grown exponentially in recent years and may lead to infected founder plants in the future. In our model, we did not make a distinction between berries imported in bulk (without sorting out leaves, twigs and damaged berries at the source) and presorted and packaged berries. Our estimates may be more accurate for bulk shipments than for prepackaged shipments.

c. The import of plug plants that originate from tissue culture are predicted to lead to very few infected founder plants, despite the large numbers of plug plants imported annually (5–6 million). Under A0, the range (1–99 percentile) is expected to be 0–1.3 founder plants per year. Under A1, this range is 0.001–2.0 founder plants per year, and under A2, 0–0.8 founder plants per year. The uncertainty about plug plants is much less than about potted plants or berries.

Taking all sources of infected berries and P4P together, the median number of established founder plants would be expected being 17 times greater if the quarantine status of *D. vaccinii* were abolished (A1), and 46 times reduced if additional restrictions on import of P4P were instituted (A2). The greatest uncertainties in the model are about potted plants and cuttings, and these uncertainties are even larger under A1 than under A0 conditions.

An important additional uncertainty is the potential presence of the pathogen in Belarus and Russia. Planting materials are imported from Belarus (intercepted once), but the quantities are undocumented. Vegetative propagation of *Vaccinium* species from cuttings is easy and common practice, but movement of cuttings across borders is unknown. Moreover, in our model potential natural spread *D. vaccinii* from Belarus and Russia is not taken into account, because the pathogen has not been identified by molecular techniques, and the presence of ascospores (needed for long-distance dispersal) has not been documented formally.

3.4. Spread and further establishment

3.4.1. Introduction to Spread and further establishment

D. vaccinii overwinters in the previous year's infected blueberry twigs, in dead vines, and possibly in plant debris (twigs, leaves, fruit) lying on the soil surface (Shear et al., 1931; Wilcox, 1939). It can also survive as endophyte in living woody stems (Friend and Boone, 1968; Oudemans et al., 1998). In cranberry, the pathogen can also survive the winter in asymptomatic uprights (Kusek, 1995). *D. vaccinii* has been isolated from up to 90% of healthy looking cranberry vines from a bed with a history of high disease incidence in Wisconsin (Friend and Boone, 1968). It has also been isolated from fruiting bodies found on overwintered cranberry leaves in New Jersey (Wilcox, 1939).

In infested blueberry fields, the primary inoculum consists of conidia that are produced in pycnidia of *D. vaccinii.* Pycnidia are found on dead cankered stems and leaf lesions (Wilcox, 1939; Weingartner and Klos, 1975; Parker and Ramsdell, 1977; Milholland, 1982). The sexual stage (perithecia) has not been found on blueberry plants under field conditions (Weingartner and Klos, 1975; Parker and Ramsdell, 1977). However, perithecia have been observed on infected upright cranberry twigs (Wilcox, 1940) and on infected and decaying cranberry fruits (Boone and Caruso, 1995). Overwintering at cool temperatures seems to be necessary for ascocarp development on fruits (Shear et al., 1931; Wilcox, 1940). Production of ascospores of *D. vaccinii* has (rarely) been reported for cranberry fields in Canada (Pesticide Risk Reduction Program, 2007) and northern states of the USA (Shear et al., 1931; Wilcox, 1940; Boone and Caruso, 1995), as well as possibly in Belarus (Galynskaya et al., 2011; Galynskaya and Liaguskiy, 2012; Pleskatsevich and Berlinchik, 2012). Thus, ascospores may be a source of initial inoculum in Northern cranberry fields (Boone and Caruso, 1995).

Ascospores are released from perithecia formed in dead leaves and fruits under humid conditions in spring, and could be dispersed by wind over fairly long distances (tens to hundreds of km). Infected twigs and abscised leaves could also be blown over longer distances and then produce pycnidia and conidia. However, long distance spread by natural means has not been documented for *D. vaccinii*.

Conidia are splash dispersed over short distances generally less than a meter (Parker and Ramsdell, 1977; Milholland, 1982), and could be transported over longer distances in aerosols by wind or by surface flow of water (Parker and Ramsdell, 1977; Milholland, 1982; Schilder, 2006). In Michigan, USA, the major period of conidial dispersal occurred during rains from bloom through petal fall in late May and June, and during rains in June and August (Parker and Ramsdell, 1977). After this period inoculum was depleted, as no conidia were trapped after September although there was considerable rain. In North Carolina, rain-dispersed conidia of *D. vaccinii* have been trapped throughout the growing season, but mostly between blossom budbreak through to bloom (Milholland, 1982).

Once established, the pathogen has a high potential for local spread by natural means, but the rate of spread may be retarded by unfavourable environmental conditions (e.g. low temperatures, dry weather). There is no documented information on the spread of the pathogen by rain splash or by wind in the form of aerosol. However, analogous to the spread of similar pathogens, *D. vaccinii* inoculum (pycnidiospores or conidia and ascospores) can spread by weather related events such as rain, wind-driven rain, and wind. High humidity is not sufficient for germination of conidia (Parker and Ramsdell, 1977). Leaf wetness is needed for germination and infection, and rain (Travadon et al., 2007; Perryman et al., 2014) is needed for natural spread of the pathogen by splash dispersal (Parker and Ramsdell, 1977). The probability of occurrence of the disease is highest in areas with at least 100 mm precipitation in the driest quarter (Narouei-Khandan et al., 2017).

The pathogen could possibly spread within affected areas over short and long distances via running surface water and the water of rivers and streams containing infected plant debris, but this has not been documented. For example, *V. myrtillus* is common in the natural vegetation at high altitudes and in humid environments with a low soil pH at lower elevations throughout the EU and in Eastern Europe. *D. vaccinii* has been found in native *Vaccinium* species in low, wet areas in Eastern Europe and Russia (Dokukina, 2001; Vilka et al., 2009a,b; Kačergius and Jovaišienė, 2010; Galynskaya et al., 2011; Vilka and Volkova, 2015), and the pathogen could potentially be transported on broken twigs and as conidiospores in waterways. However, no quantitative information is available about this potential pathway and it is not considered in this PRA.

Although no evidence exists, insects or birds may act as carriers of the pathogen between *Vaccinium* spp. plants (Trappe and Claridge, 2005). Pycnidia and conidia, especially when produced on fruits, may be spread by birds and other animals that eat infected fruits over fairly long distances from the source plant. Pycnidia could pass the digestive tract intact and release conidiospores from the faeces. Alternatively, the production of ascocarps and release of ascospores could be stimulated by the passage through the digestive tract (Trappe and Claridge, 2005). However, this pathway has not been documented for *D. vaccinii*.

Although there is no information available in the literature on the spread of *D. vaccinii* on agricultural tools, it may be assumed that this pathogen, like other *Phomopsis* species, can spread locally (within a field) with pruning tools and agricultural machinery (EFSA PLH Panel, 2014). Blueberry bushes are pruned in winter, when infection would be very limited (Davies and Crocker, 1994; Caruso and Ramsdell, 1995). Cranberry plants are sometimes mowed to remove infected upright branches, but also to collect planting materials from clean fields. However, transmission by machinery and tools is considered only a minor pathway for introduction and further spread in the EU, and will not be considered further.

3.4.2. Assessment of spread and further establishment

Three scenarios were compared: current regulation (A0), deregulation (A1) and stricter regulation (A2). Spread was calculated over a 5-year time frame, 2018–2022, using entry flows that were kept constant each year at the estimated level for 2018, and using a model for entry, establishment and spread in each of four geographic regions within the EU. The model is described in Appendix A.3. This model is mostly identical for the geographic regions, but does take into account the effect of climate on natural spread of the disease in production areas and natural *Vaccinium* stands.

Under current regulation, spread in production areas is very limited, and with marked differences between geographic regions (Figure 18). The median level varies from less than one infected plant in the SE, to approximately 10 infected plants in the NW, 100 infected plants in the SW and 200 infected plants in the NE. These are estimated levels of spread that are amenable to control response by growers. Scenario A1 (deregulation) would raise these median levels of spread to approximately 10 infected plants in the SE, 250 in the NW, 2,000 in the SW and 3,000 in the NE. The median numbers of infected plants under this scenario appear higher than can be contained by growers, creating a situation that may result in impacts in due course. The scenario A2 with stricter regulation would reduce median spread to very low levels of less than 1 infected plant in the SE and NW, and between 1 and 10 infected plants in the SW and NE.

Spread in natural areas is an order of magnitude greater than in production areas (Figure 19). Under current regulation, the median spread (number of infected plants) in natural areas is far below 1 in the SE, around 100 in the SW, 250 in the NW and 2,000 in the NE. These are levels of infestation that are hardly noticeable. The median level of spread is slightly increased under the deregulation scenario (well below 1 infected plant in the SE, around 100 infected plants in the SW, around 600 infected plants in the NW and around 3,000 infected plants in the NE). Stricter regulation is expected to reduce the level of spread.

Thus, the model simulations indicate that spread will be more important in natural areas than in production fields (Figure 20).

Distributions of spread (Figures 18 and 19) are quite wide, spanning 2–3 orders of magnitude where it concerns the spread in production areas, and up to nine orders of magnitude for spread in natural areas. Therefore, the absolute levels of spread should be interpreted with considerable caution, especially in natural areas (Tables 12–15). Comparisons between scenarios are considered more robust than estimates of absolute levels of spread, due to uncertainty in the absolute value in parameters, but greater confidence of the assessors in comparative differences in model parameters between scenarios (see Appendix A).

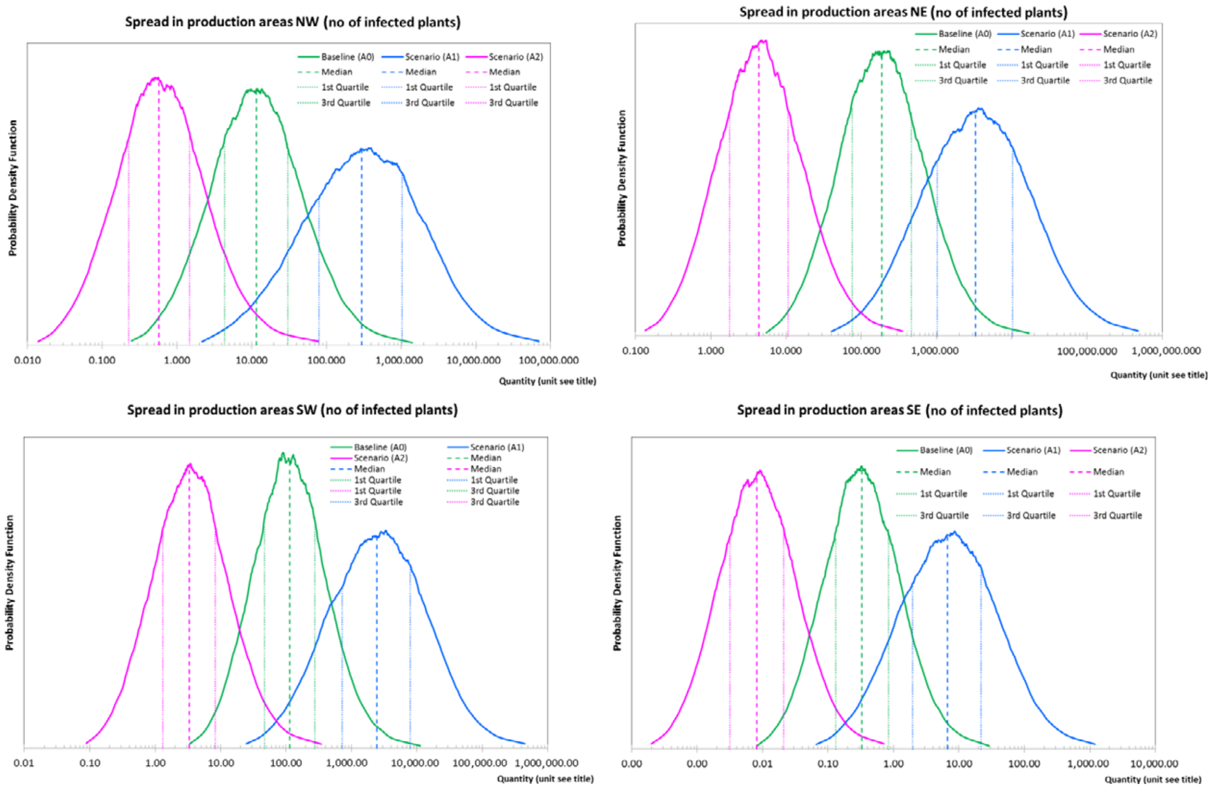


Figure 18: Simulated spread (number of infected plants) in *Vaccinium* production fields in four geographic regions in Europe under three scenarios for regulation

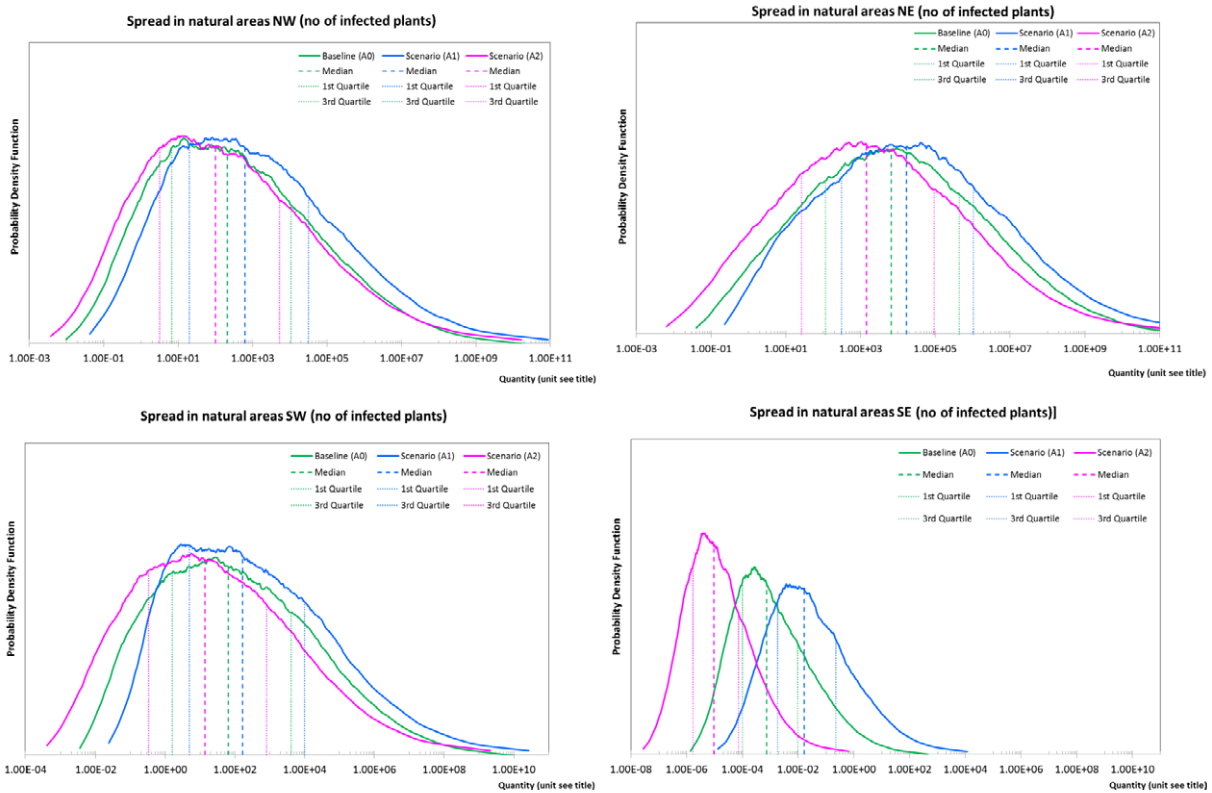


Figure 19: Simulated spread (number of infected plants) in natural areas in four geographic regions in Europe under three scenarios for regulation

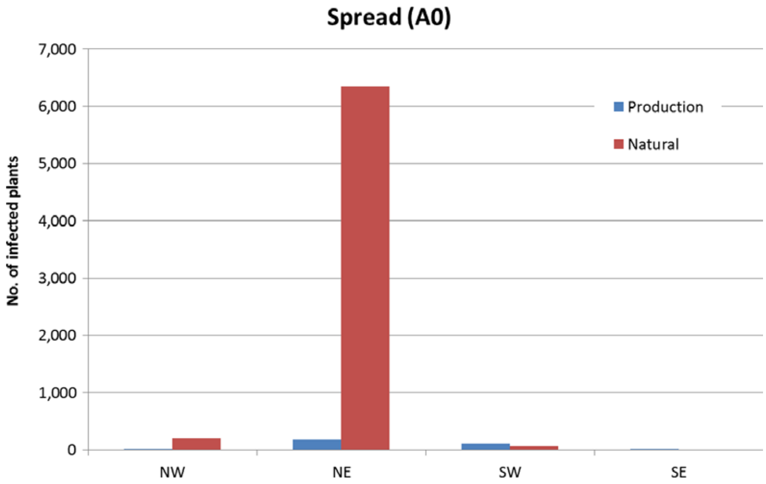


Figure 20: Simulated spread (number of infected plants) in *Vaccinium* production fields and in natural *Vaccinium* in EU under the baseline scenario of current regulation

Table 12: Selected quantiles of the uncertainty distribution for the number of *Diaporthe vaccinii* infected plants in production areas in the chosen time horizon for scenarios A0, A1 and A2

Quantile	1% quantile	1st Quartile (25%)	Median (50%)	3rd Quartile (75%)	99% quantile
Scenario A_0 – NW region	0.37	4.19	11.1	29.3	364
Scenario A_0 – NE region	7.7	72.9	180	444	4,557
Scenario A_0 – SW region	4.9	44.9	109	264	2,896
Scenario A_0 – SE region	0.012	0.13	0.32	0.81	8.6
Scenario A_1 – NW region	3.27	79.8	297	1,032	17,453
Scenario A_1 – NE region	59.8	1,021	3,298	10,243	151,166
Scenario A_1 – SW region	38.9	719	2,444	7,907	121,267
Scenario A_1 – SE region	0.10	1.95	6.67	21.7	339
Scenario A_2 – NW region	0.021	0.23	0.57	1.48	19.0
Scenario A_2 – NE region	0.20	1.77	4.35	10.6	106
Scenario A_2 – SW region	0.13	1.30	3.30	8.24	89.4
Scenario A_2 – NE region	0.000	0.003	0.008	0.021	0.22

Table 13: Selected quantiles of the uncertainty distribution for the number of *Diaporthe vaccinii* infected plants in natural areas in the chosen time horizon for scenarios A0, A1 and A2

Quantile	1% quantile	1st Quartile (25%)	Median (50%)	3rd Quartile (75%)	99% quantile
Scenario A_0 – NW region	0.02	6.44	201	10,315	283,385,626
Scenario A_0 – NE region	0.08	111	6,349	419,753	11,245,309,145
Scenario A_0 – SW region	0.006	1.52	61.4	3,901	113,021,203
Scenario A_0 – SE region	0.000	0.000	0.001	0.009	13.0
Scenario A_1 – NW region	0.076	19.90	622	31,661	875,566,390
Scenario A_1 – NE region	0.42	308	16,861	1,039,405	283,845,658,812
Scenario A_1 – SW region	0.041	4.88	164	9,799	279,023,882
Scenario A_1 – SE region	0.000	0.002	0.016	0.22	347
Scenario A_2 – NW region	0.004	2.39	79.3	4,176	130,704,915
Scenario A_2 – NE region	0.004	9.0	514	33,130	1,175,899,654
Scenario A_2 – SW region	0.000	0.11	4.61	283	9,354,012
Scenario A_2 – SE region	0.000	0.000	0.000	0.000	0.026

Table 14: Selected quantiles of the uncertainty distribution for the number of *Diaporthe vaccinii* infected plants in nurseries in the chosen time horizon for scenarios A0, A1 and A2

Quantile	1% quantile	1st Quartile (25%)	Median (50%)	3rd Quartile (75%)	99% quantile
Scenario A_0 – NW region	0.16	2.19	6.14	17.0	278
Scenario A_0 – NE region	2.29	19.6	47.7	121	1,787
Scenario A_0 – SW region	2.48	21.5	53.0	134	1,923
Scenario A_0 – SE region	0.003	0.025	0.061	0.15	2.22
Scenario A_1 – NW region	1.55	45.0	172	620	12,899
Scenario A_1 – NE region	17.0	274	885	2,835	52,473
Scenario A_1 – SW region	19.282	344	1,195	3,952	77,561
Scenario A_1 – SE region	0.022	0.38	1.29	4.24	80.68
Scenario A_2 – NW region	0.006	0.093	0.26	0.69	10.5
Scenario A_2 – NE region	0.059	0.52	1.29	3.23	43.9
Scenario A_2 – SW region	0.07	0.69	1.74	4.46	61.7
Scenario A_2 – SE region	0.000	0.001	0.002	0.005	0.067

3.4.3. Uncertainties affecting the assessment of spread

The contribution of uncertainty in model parameters to overall uncertainty in spread in the north-western region is shown in Figure 21a. Many factors contribute to the uncertainty in spread in production sites, but the most important is uncertainty in the number of potted blueberry plants for planting entering the EU territory (N0_pot_blue_HR). The second most important uncertainty contributing to the spread in production areas is uncertainty in the proportion of potted plants infected in the country of origin (e1_pot_blue_LR).

For spread in natural areas, uncertainty in the spread factor (S8_spread_natural_NW) is by far the most important contributing factor to overall uncertainty in the spread in the NW region.

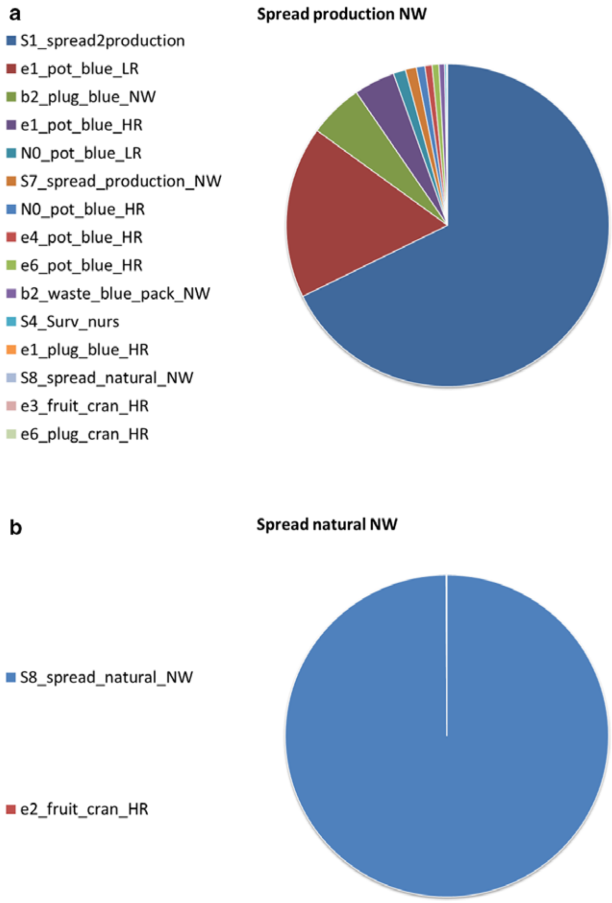


Figure 21: Contribution of factors included in the assessment to the quantified uncertainty for the spread of *Diaporthe vaccinii* infected plants for scenario A0. The distribution of the contributing factors was the same for each of the geographic regions in the EU, but differences were obtained for production areas and natural areas. Pie-charts are displayed of production area (a) and natural areas (b), both for NW region

Table 15: List of additional uncertainties affecting the spread assessment but not quantified within the assessment model

No.	Description of source of uncertainty	Description of effect on assessment of spread
1	Intra-EU trade of berries and plants for planting	The internal movement of infected berries and/or plants for planting can affect the spread

3.4.4. Conclusions on Spread for the different scenarios

Calculations with the model indicate that under current regulation, there is some spread expected in production sites and natural areas, but at levels that can be contained by growers by careful management, and that are hardly noticeable in natural areas. Deregulation is expected to increase these levels 10- to 100-fold, which would create a situation in which the disease would become difficult to contain in production sites, and in which its expected prevalence in natural areas is substantially higher than is presently the case. Stricter regulation would decrease disease prevalence in production sites and natural areas by a factor 10–100. These results indicate that regulation has a relevant level of impact on the prevalence of this pathogen in production sites and natural areas. The next section translates these findings to effects on impacts.

3.5. Impact

3.5.1. Introduction to Impact

EPPO (1990) summarised the losses from *D. vaccinii* in the USA (1933–1983) as follows: occasional severe losses (18–35%) of cranberries in production fields and in storage (65% due to infections by several fungi) in the north-eastern and central USA, and occasional epidemic outbreaks of Phomopsis dieback in blueberry fields in north-central USA and twig blight (causing a loss of 2–3 pints/bush or 25–37% yield loss at a maximum yield of 9,000 kg/ha) in the south-eastern USA. Moreover, the pathogen was associated with 15.2% defective blueberry fruit in New York supermarkets.

Blueberries

Weingartner and Klos (1975) isolated *D. vaccinii* from 38% of 242 asymptomatic blueberry stem segments, and from 25% of 2,838 symptomatic stem segments in Michigan and Indiana. From the same blueberry segments, they isolated *Godronia cassandrae* (*Fusicoccum putrefaciens*) from 20% of the asymptomatic and from 41% of the symptomatic stem segments.

Parker and Ramsdell (1977) observed an average of nine wilted 1-year-old blueberry stems per bush (about 9%) in untreated plots and 3.8 per bush (about 3.8%) in the best fungicide treated plots in Michigan. Isolations of *D. vaccinii* were made, as identified from morphological characteristics. The severe infection was attributed to freezing wounds and wounds from mechanical harvesting in 85% of the blueberry area. In consumer samples, 0.1% of blueberries were infected by *D. vaccinii* in North Carolina (Milholland and Daykin, 1983).

Based on the Plant Disease Management Reports (PDMRs) from 2000 to 2016, the overall yield of blueberries ranged from 841 to 8,968 kg/ha, with a median of 4,484 kg/ha. In nine spray trials in North Carolina (2000–2004), the median yield with the best fungicide was 8,100 kg/ha (5,040–8,955 kg/ha), and without fungicide was 5,310 kg/ha (2,250–8,748 kg/ha). The median percentage of blighted twigs was 5% (0.25–22%) in the best fungicide treated plots, and 28% (7–62%) in untreated control plots. There was a significant positive linear relationship between per cent twig blight and yield loss (Figure 22). The median percentage fruit rot at harvest was 9% (2.4–19%) in the fungicide treated plots and 12.4% (4.2–20%) in control plots (extracted from nine reports contributed by W. O. Cline, B. K. Bloodworth, and C. W. Meister). Fruit rot was considered to be caused by *D. vaccinii* when the berries split open under light pressure from rolling them between thumb and forefinger. There was no relationship between per cent twig blight and fruit rot nor between per cent fruit rot and yield.

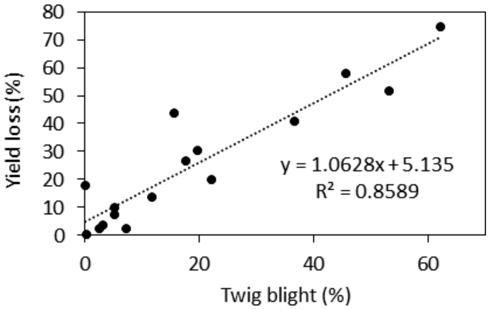


Figure 22: Relation between per cent of twigs blighted and yield loss per blueberry bush, derived from eight fungicide spray trials in North Carolina from 2000 to 2003 reported in Plant Disease Management Reports of the American Phytopathological Society by W. O. Cline, B. K. Bloodworth (NC State Univ.) and C. W. Meister (Univ. Florida). Data from the untreated control and best fungicide treatment were extracted from the reports and included in this graph

Blueberry cultivars differ in resistance to Phomopsis twig blight (Polashock and Kramer, 2006). Southern highbush blueberries (*V. corymbosum*) and rabbiteye blueberries (*V. ashei* or *V. virgatum*) are more susceptible than lowbush cultivars (*V. angustifolium*) and half-high cultivars (hybrids between highbush and lowbush blueberry plants), which develop smaller lesions on inoculated twigs. However, the relative resistance is also affected by the *D. vaccinii* isolate used.

Taking the available literature into account, blueberry twig blight caused by *D. vaccinii* can have a severe impact, especially on highbush cultivars in central and south-eastern parts of the USA after heat stress (Weingartner and Klos, 1975), and could be a problem in south-western and south-central parts of Europe (Narouei-Khandan et al., 2017), where the highly susceptible highbush blueberries with low chilling requirements are being planted on a large scale. Blueberry fruit-rot is generally not very severe and can be controlled with fungicides.

Cranberries

In PDMRs reporting on cranberry experiments, the median cranberry yield was 29,546 kg/ha (11,202–49,191 kg/ha) in the best fungicide treated plots, and 6,973 kg/ha (996–37,352 kg/ha) in untreated control plots in 27 spray trials in Wisconsin and Massachussets (2003–2012), i.e. indicating 76% yield loss from all fungal diseases. Upright dieback caused by *D. vaccinii* was not assessed. The median percentage fruit rot was 3.5% (1–20.9%) in fungicide treated plots, and 40.4% (4.7–89.3%) in untreated control plots (extracted from reports contributed by P. McManus, S. Hemauer, and V. Best in Wisconsin, and F.L. Caruso in Massachussets). Fruit rots included ripe rot by *Coleophoma empetri*, bitter rot by *Colletotrichum* spp., viscid rot by *D. vaccinii*, black rot by *Allantophomopsis* spp., end rot by *F. putrefaciens*, early rot by *Phyllosticta vaccinii* and blotch rot by *Physalospora vaccinii*. Again, there was no relationship between per cent fruit rot and yield. The other fungi were generally more common than *D. vaccinii*, which was isolated from 12% to 49% of the fruits at three of 11 locations in 1996 (Stiles and Oudemans, 1999). The range of fungi isolated was similar for various cultivars.

During surveys of cranberry fields in Michigan in 1999-2001, fruit rot incidence varied widely from 1% to 97% in individual fields. There were significant cultivar differences, but these varied by location and year. The predominant fungi isolated from the fruit varied from year to year. *D. vaccinii* was isolated less frequently than most other fungi, but became more dominant (up to 20%) in the last 2 years (Olatinwo et al., 2003). The pathogen occurred in both rotten and healthy-looking fruit. *D. vaccinii* became slightly more important during two months of storage, but was still only one of many fruit rotting fungi isolated (Olatinwo et al., 2004). The incidence of *D. vaccinii* storage rot on cranberries (stored at 5°C for 1 or 2 months) varied widely (from 0% to 15%) and was dependent on region and cultivar (Olatinwo et al., 2004). *D. vaccinii* was commonly found among several other fungi isolated from rotten cranberries.

Data from a recent report from Canada (Sabaratnam et al., 2016) indicated that 3.5% (median from 14 farms; range 0–24%) of cranberry fruits were lost due to fruit rot in the production phase, and an additional 24% (range 11–61%) after storage for 3 weeks, providing an indication of latent infection at harvest (Sabaratnam et al., 2016). Eight fungal pathogens were isolated at different stages of flowering and fruiting, *D. vaccinii* being the fourth most prevalent pathogen (based on isolation and DNA sequencing). In five farms, a median of 9% (range 4–23%) of the flowers were infected by *D. vaccinii*, 4% (2–14%) of green fruits and 13% (9–27%) of ripe fruits at harvest (Sabaratnam et al., 2016).

Similar to Canada and the USA, several pathogens were isolated from decaying cranberry fruit in Latvia, *Botrytis cinerea*, *F. putrefaciens*, and *D. vaccinii* being the most important ones (Vilka et al., 2009b).

Based on the available literature, cranberry fruits are highly susceptible to *D. vaccinii* (Sabaratnam et al., 2016), and this pathogen could have severe impact on cranberry production in north-central Europe, not only through viscid rot of fruits but also through upright dieback and the consequent yield loss (Michalecka et al., 2017).

Wild Vaccinium *berries*

Many *Vaccinium* species grow in wild habitats in Canada and the USA, and very little is known about the relative susceptibility of the various *Vaccinium* species in these habitats. Lowbush blueberries (*V. angustifolium*), native in the north-eastern USA and Canada, are relatively resistant to *D. vaccinii* (Polashock and Kramer, 2006). Similarly, sparkleberry (*V. arboretum*) a native of south-central USA is relatively resistant (Polashock and Kramer, 2006). Both lowbush blueberry and sparkleberry are generally not cultivated, and disease incidence is generally low on wild blueberry plants (Annemiek Schilder, hearing expert, November 24, 2016).

In New Jersey, *D. vaccinii* was isolated from 0% of rotten cranberry fruits from four unmanaged or native stands, but from 16% to 23% of rotten fruits from two other unmanaged or native cranberry stands (Stiles and Oudemans, 1999). Other fungal pathogens, like *C. empetri*, *Phyllosticta elongata*, *P. vaccinii* and *P. vaccinii* were isolated more frequently. In other areas, *Godronia cassandrae* (anamorph *F. putrefaciens*) were commonly associated with cranberry fruit rot (P. McManus, personal communication). No resistant cranberry cultivars were found (Stiles and Oudemans, 1999). Yet, *D. vaccinii* infection seems to be rare in wild cranberry stands (Annemiek Schilder, hearing expert, November 24, 2016).

F. putrefaciens is very common in wild and cultivated *Vaccinium* bushes in northern Europe (Kačergius et al., 2004; Vilka et al., 2009b; Strømeng and Stensvand, 2011), while *D. vaccinii* has been found only occasionally and temporarily (EFSA, 2014; Lombard et al., 2014; EPPO, 2015; NPPO, 2015; Vilka and Volkova, 2015; Michalecka et al., 2017).

No information is available about the relative resistance or susceptibility of native European *Vaccinium* species to *D. vaccinii*, which have generally not been exposed to *D. vaccinii* (for exceptions see Table 9). Therefore, we consider the worst-case scenario of susceptible *Vaccinium* stands wherever *D. vaccinii* could establish according to its ecological niche (Narouei-Khandan et al., 2017). However, considering the similarity in stem symptoms induced by *D. vaccinii* and *F. putrefaciens*, which is common in wild *Vaccinium* stands in northern Europe (Strømeng and Stensvand, 2011), and the ability of *Vaccinium* plants to regrow after twig blight and dieback from *F. putrefaciens*, it is unlikely that *D. vaccinii* infection would result in large-scale death of *Vaccinium* stands, although it could affect relative coverage and productivity.

3.5.2. Assessment of Impact

An overview of the estimation of the number of infected plants after a 5-year time frame in nurseries, berry production fields and the natural environment can be found in Figure 23.

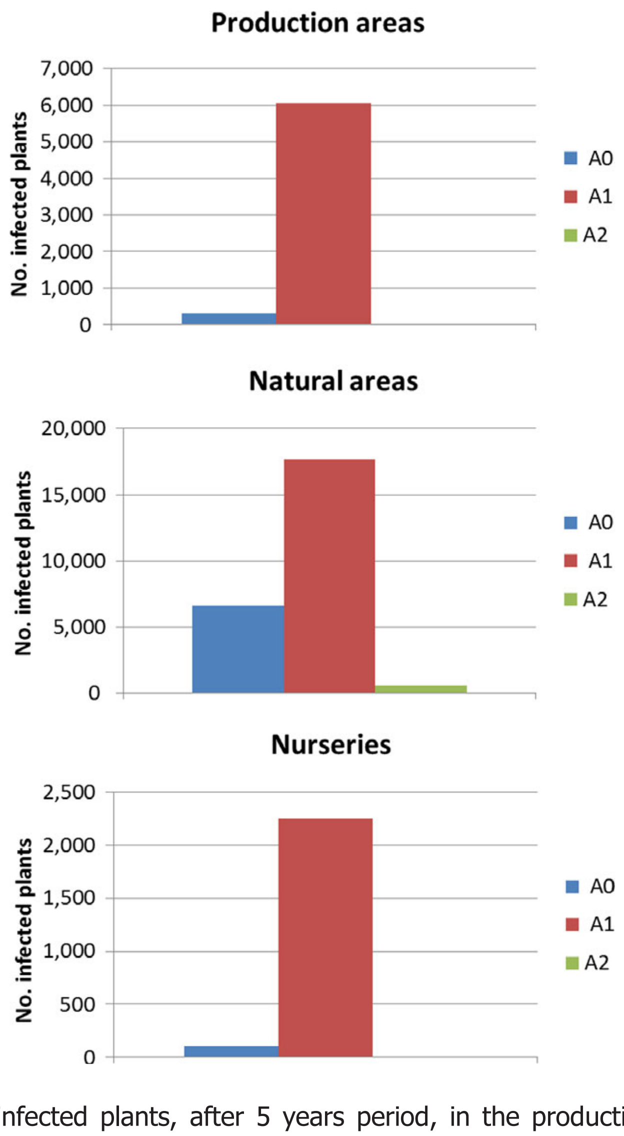


Figure 23: Number of infected plants, after 5 years period, in the production areas (blueberry and cranberry cultivations), natural areas and plant nurseries for scenarios A0, A1 and A2

3.5.2.1. Assessment of impact on *Vaccinium* production in nurseries

Given its current regulatory status, *D. vaccinii* has the potential to have impact on nurseries producing propagative or ornamental *Vaccinium* plants. With the current legislation in place (scenario A0), the detection of a *D. vaccinii* infection in a nursery will result in eradication measures and the loss of the complete production lot. Under scenario A0 the estimated number of infected plants present in EU nurseries after the 5-year assessment period is low for all regions in the EU. When the four regions are compared, the number of outbreaks in nurseries is expected to be higher in north-east and south-west EU (within the range of 20–130 infected plants in 5 years) compared to north-west and South East (within the range of 0–17 infected plants in 5 years). This difference between regions reflects the difference in estimated trade flow of plants to these areas in combination with favourable climatic conditions and presence of significant berry production (i.e. demand for *Vaccinium* plants).

3.5.2.2. Assessment of impact on berry production

There are several *Phomopsis* species present in *Vaccinium* production fields in Europe that have similar symptoms as *D. vaccinii*. If it is assumed that the majority of *D. vaccinii* plants in production fields are not recognised by the farmer, eradication measures may not be applied. An unnoticed infected plant in a production field could lead to an 'outbreak' in the production field in case overhead irrigation or mechanical harvesting is applied that promotes fast within-field spread of the pathogen. In general, farmers have a fungicide programme in place to control the fungal diseases present in the production place. It can be assumed that *D. vaccinii* will be partly controlled with these standard fungicide applications. Specific additional fungicide applications may be needed to control *D. vaccinii*. Farmers keep production fields relative clean from twig blight and may remove severely infected plants and replace them with new plants. For the replanted plants, it may take several years before the yield is at a normal production level. Thus, there may be a multiyear yield loss due to limited production of berries of new replanted plants after removal.

For the current situation (scenario A0), the highest maximum estimated number of infected plants after the 5-year assessment period in production areas is in the NE region with an estimate of between 70 and 440 infected plants (1st and 3rd quantile). In the NE region, both blueberry and cranberry production are important. Poland is an important blue berry producer in the NE region with 2,500–5,000 ha of blueberry production (Figure 8). Assuming that a blue berry production field of 1 ha has approximately 3,000 plants, the number of production plants in Poland is between 7.5 and 15 million plants. Assuming a worst-case scenario in which all entry, establishment and spread events in the NE region take place in blueberry production in Poland, the number of estimated infected plants after 5 years (70–440 plants) is still extremely low. The same reasoning can be applied for cranberry production with an estimated 100,000 plants/ha.]

The Panel considers that the expected impact of *D. vaccinii* in berry production is low. At a local scale, additional fungicide applications may have to be applied and there may be some loss in the production of berries due to replacement of infected blueberry bushes.

3.5.2.3. Assessment of impact in natural areas

Vaccinium species are widespread in natural areas in the EU (Figure 6). Although not listed as a characteristic species related to vulnerable habitat types in the EU (EU Habitats Directive 92/43/EEC), *Vaccinium* shrubs can be an important component of European ecosystems. Following the EFSA (2016) guidance on environmental risk assessment, the importance of *Vaccinium* is reflected in its role in providing provisional services (e.g. consumption of wild berries), regulating services (e.g. pollination, erosion), supporting services (e.g. nutrients and water cycling) and cultural services (e.g. recreation and tourism).

D. vaccinii has a narrow host range, but can likely infect all *Vaccinium* species in natural habitats in the EU. However, it should be stressed that there is very limited information on the host suitability of the native *Vaccinium* species present in the natural environment in Europe (see Section 3.3.2)

The overall impact in natural areas is expected to be similar to that of *F. putrefaciens*, which is already widespread in northern Europe. The impact may even be slightly less than that of *F. putrefaciens*, because in North America, *D. vaccinii* seems to be a fairly poor competitor of *F. putrefaciens* and other pathogenic fungi (McManus, personal communication; Weingartner and Klos, 1975).

The current quarantine status of *D. vaccinii* implies that new outbreaks in natural areas have to be eradicated. The Panel considered that eradication of *D. vaccinii* in the natural environment is difficult to achieve without drastic removal of all *Vaccinium* plants in the environment to ensure the removal of all potential inoculation sources in the outbreak area. In Latvia, where *D. vaccinii* is present in the natural environment no eradication efforts are taken. Therefore, the impact of eradication or containment measures for the natural environment was not assessed. It is assumed that infections in the natural environment may result in local founder populations that may result in visible local impact after some years.

With the current legislation in place (scenario A0), the estimated number of infected plants in the natural environment is high compared to nurseries and production fields. When the four regions are compared, the number of infected plants is expected to be highest in north-east EU (within the range of 100–400,000 infected plants in 5 years) compared to other regions (within the range of 0–10,000 infected plants in 5 years). The NE region has a relative high density of wild *Vaccinium* (see Figure 6) and *D. vaccinii* is already present in Latvia in the natural environment.

3.5.3. Uncertainties affecting the assessment of impact

Nurseries: undetected presence of *D. vaccinii* in nurseries may lead to the spread of the pathogen to garden centres, production fields and other nurseries Long-distance spread of infected plants for planting between regions is possible, but is not included in this PRA.

Berry production areas: Impact of *D. vaccinii* on berry production in organic blueberry and cranberry farms, where fungicidal control may be more difficult, the farmer has to rely more on removal and replacement of infected plants, which is difficult and can lead to multiyear yield losses and the potential for further spread.

Natural areas: The host suitability of wild European *Vaccinium* species and the level of induced mortality is unknown.

3.5.4. Conclusions on Impact for the different scenarios

Nurseries: Under scenario A1, where *D. vaccinii* is not listed as a quarantine organism anymore, the number of infected plants in nurseries is expected to increase with a factor of 20 compared to scenario A0. Reasons for this increase are the fact that the presence in of *D. vaccinii* in export and EU nurseries does not necessarily leads to rejection of consignments or eradication measures.

Under scenario A2 with more stringent requirements for plants for planting (i.e. plants directly originate tissue culture), the number of infected plants in nurseries is reduced to virtually zero.

Berry production areas: Blueberries and cranberries are high value crops, and even moderate percentages of loss can imply considerable financial loss (Oudemans et al., 1998). For scenario A0, the Panel estimates the general impact of *D. vaccinii* on blueberry and cranberry production as negligible. Local impact (outbreak in a production field) may occur.

Under scenario A1, where *D. vaccinii* is not listed as a quarantine organism anymore, the number of infected plants in production areas is expected to increase with a factor of 10–25 compared to scenario A0. Reasons for this increase are the fact that there is no guarantee anymore to new plants planted in production areas is free from *D. vaccinii* and there are no obligatory eradication measures in case of findings.

Under scenario A2 with more stringent requirements for plants for planting (i.e. plants directly originate tissue culture), the number of infected plants in production areas is reduced to virtually zero.

Natural areas: Only deregulation may lead to a significant presence of *D. vaccinii* in the natural environment and possible impact on ecosystem services.

Under scenario A1, where *D. vaccinii* is not listed as a quarantine organism anymore, the number of infected plants in natural areas is expected to increase with a factor 3 compared to scenario A0. Reasons for this increase are the fact that more founder populations will establish in natural areas. The increase in the abundance of *D. vaccinii* in the natural environment may negatively affect the ecosystem services *Vaccinium* provides. However, it is uncertain if the density of wild *Vaccinium* plants will decrease as a result of mortality of plants induced by the presence of *D. vaccinii* in the natural environment. Under scenario A2 with more stringent requirements for plants for planting (i.e. plants directly originate tissue culture), the number of infected plants in natural areas is reduced drastically.

Conclusions of the assessment

Overall conclusions

Diaporthe vaccinii Shear is the fungal agent responsible for twig blight, canker, viscid rot, fruit rot and storage rot of several *Vaccinium* species. The hosts are restricted to *Vaccinium* species. The main cultivated hosts are the highbush blueberries and cranberries. Highbush blueberry in particular is cultivated in several EU countries and wild *Vaccinium* species are common components of forests, and other arctic-alpine ecosystems (tundra, above timberline vegetation, etc.).

Based on the available information, Latvia is the only EU country where the presence of *D. vaccinii* is officially reported. However, on the base of evidence from scientific literature other outbreaks are reported for Poland in 2016.

The Panel identified six potential pathways of entry of *D. vaccinii*: trade of blueberry and cranberry fruit and trade of blueberry and cranberry plants for planting (plugs, cuttings and potted plants). The *D. vaccinii*-affected countries exporting plants for planting to the EU were differentiated into High Risk (part of the USA, Canada) and Low Risk (all the other affected countries).

For the establishment of *D. vaccinii*, the EU was dived into four main regions, characterised by different climate and different areas of cultivated blueberry and cranberry. For production fields, climate suitability determines the risk of establishment. For natural areas the risk of establishment is dependent on climate suitability and *Vaccinium* plant densities.

The spread was calculated for each of four geographic regions in the EU, and for five compartments: nurseries, production fields, natural *Vaccinium* stands, garden centres and home gardens.

The impact of the presence of *D. vaccinii* in nurseries, berry production fields and the natural environment is assessed. The losses incurred to garden centres and consumers (home gardens) were not considered; home gardens were only considered as potential sources of infection of *Vaccinium* plants in wild habitats.

Three scenarios were compared: A0, the current situation of *D. vaccinii* as a quarantine organism, A1, deregulation of specific requirements for *D. vaccinii* (removal from the quarantine list), and A2, extra quarantine regulations, including restriction of the source of planting materials to pest-free areas or pest-free production conditions. There were relevant differences in entry, establishment, spread and impact among these three scenarios, with the current situation being characterised by low levels of entry, establishment and spread, and negligible impact while deregulation would increase entry, establishment, spread and impact by approximately one order of magnitude, and areas in the EU. Estimates of spread of *D. vaccinii* in natural areas in the EU stricter regulation would likely reduce entry, establishment and spread to negligible levels.

The risks from introduced infected berries and plug plants were deemed to be negligible, but the risks from older potted plants for planting and field cuttings were estimated to be considerable. Export of bales of cranberry mowings directly from cranberry fields in areas where the pathogen occurs into fields in the EU were considered to be posing the highest risk.

The median estimates of the number of infected plants in the production areas were 301, 6,046 and 8 for scenario A0, A1 and A2, respectively. Assuming an average productivity of 16 tonnes/ha for highbush blueberry we can estimate 1.6, 32.2 and 0.04 tonnes of blueberry yield losses, respectively, for the three scenarios (A0, A1 and A2).

The number of infected plants in natural areas is considerably higher (6,611, 17,647 and 5,898 as median for A0, A1 and A2 scenarios) than in production areas and the uncertainty is extremely high with differences up to 10 orders of magnitude between the 1st and the 99th percentile.

Uncertainty affecting the assessment

Data on the trade in plants for planting in EUROSTAT and FAOSTAT are aggregated and could not be used directly for assessing trade flows relevant for this opinion. The Panel, therefore, relied on industry data. These are considered relatively reliable because certification papers are needed for the export of planting materials and horticultural products.

Quantitative data on disease incidence within the EU territory is virtually lacking. More information was available about the incidence and severity of the disease in countries of origin, but no information was available about the incidence on planting materials or fruit at the port of export, and hardly any information about this at the port of import. Interception data are inconclusive due to the possibility of asymptomatic infections.

Estimation of disease incidence in imported plant materials and berries based on past outbreaks in the EU leads to 'reverse engineering', adjusting the estimates of input parameters for the model to what is expected from past outbreaks. Such calibration of model inputs to information on past outbreaks is unavoidable in the case of lack of direct evidence. Ideally, risk assessment can be built with data at the level of the underlying processes, such that data on outbreaks can be used for testing the model rather than model calibration.

Information about the occurrence of *D. vaccinii* in the EU is still limited, especially in natural habitats, despite the surveys carried out in 2016. Survey protocols and reports should be standardised in the form of excel spread sheets, so that they can be integrated into one data base.

Information about the occurrence of *D. vaccinii* in countries bordering to EU countries is uncertain. Confirmation of the reported widespread occurrence of *D. vaccinii* in Belarus and Russia by molecular identification is urgently needed. Also, quantitative information about import of planting materials and berries from these countries is lacking.

Quantitative information about the import of planting materials and berries from Morocco is needed, as well as information about the presence of blueberry diseases there. Blueberry production is rising rapidly in Morocco, and so is trade between Morocco and Spain.

The occurrence and distribution of *D. vaccinii* in China needs to be confirmed. Molecular identification has been reported in GenBank, but not in refereed journals in English. Import of *Vaccinium* planting materials and berries from China does take place, but the quantities are unknown.

D. vaccinii is a pathogen of *Vaccinium* species, but occurs endophytically in other plant species. This has been shown for some medicinal plants in China as well as a variety of wild vegetation in Spain. It is unknown if endophytic *D. vaccinii* can be transferred to *Vaccinium* species and become pathogenic.

Information about the relative susceptibility of European *Vaccinium* species to *D. vaccinii* compared to American species is lacking, so that it is very difficult to predict the spread of *D. vaccinii* in natural areas in the EU. Estimates of spread of *D. vaccinii* in natural areas in the EU over a sequence of years were made using data on the spread of *Phomopsis* species in soybeans in the USA over a time frame of two months. The use of such surrogate data results in uncertainties that are very difficult to assess.

In this opinion, distinction was made between four geographic regions to calculate establishment and spread. This choice was made because the south-east of Europe is comparatively suitable for establishment but has comparatively low entry. As a result, the current analysis shows that the southeast has a low establishment, spread and impact as a result of the low entry. A disadvantage of this approach is that spread of the pathogen between these four regions (e.g. by movement of plants for planting) was not accounted for. A narrative approach would have reached much the same conclusion.

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Abbreviations

EPPO	European and Mediterranean Plant Protection Organization
FAO	Food and Agriculture Organization

ISPM	International Standard for Phytosanitary Measures
MMF	MaxEnt and Multi-model Framework
MS	Member State
P4P	plants for planting
PDMR	Plant Disease Management Report
PLH	EFSA Panel on Plant Health
PRA	Pest Risk Assessment
RRO	risk reduction option
SDM	Species Distribution Model
ToR	Terms of Reference

Appendix A – Formal model and parameters estimates

Notation

The following steps are defined

E = entry
B = establishment
S = spread
I = Impact

The steps are linearly ordered in a sequence E → B → S → I.

The letter A defines an assessment, the relevant scenario is defined by a subscript j (j = 0, 1, 2, ...). A_0 represents the current scenario.

Sub-components or sub-steps

Different sub-steps are defined by an integer following the letter of the step.

For example, E1 is the first sub-step of the entry step and B2 is the second sub-step of the establishment step.

Variables

X = a population abundance, a letter (E, B, S, I) and a number (1, 2, ...) in the subscript specify to which step and sub-step it refers to (e.g. X_{E1} represents the population abundance in the sub-step 1 of the Entry step)

N = a number, a letter (E, B, S, I) and a number (1, 2, ...) in the subscript specify to which step and sub-step it refers to (e.g. N_{E0} represents the number of transfer units in the sub-step 1 of the Entry step)

Y = an area, a letter (E, B, S, I) and a number (1, 2, ...) in the subscript specify to which step and sub-step it refers to

I = an impact, a number (1, 2, ...) in the subscript specifies to which sub-step of impact it refers to

T = represents a time horizon.

Parameters

e, ε = a generic parameter appearing in the model for entry (with a subscript from 1 to ... in order of appearance in the set of formulas defining the entry process)

b = a generic parameter appearing in the model for establishment (with a subscript from 1 to... in order of appearance in the set of formulas defining the establishment process)

s = a generic parameter appearing in the model for spread (with a subscript from 1 to... in order of appearance in the set of formulas defining the spread process)

i = a generic parameter appearing in the model for impact (with a subscript from 1 to... in order of appearance in the set of formulas defining the impact process)

A.1. Details on modelling and estimated parameter values for entry

A.1.1. Formal model for entry

Entry pathway 1: Blueberries for consumer use

Fruits are produced in countries of origin. We consider only the import of fresh fruits from countries with reported presence of *D. vaccinii*. The total number of fruit from those countries is named NE0, where N stands for number, the E in the subscript stands for 'Entry' and the 0 stands for the initial step of the entry (Table A.1)

Not all fields in a country or origin with the official presence of *D. vaccinii* need to be infected. Even in countries with a long history of infection with the pathogen (e.g. the USA), the proportion is not 1 because newly planted fields may be disease-free. In countries with recent introduction of the pathogen (e.g. Chile), the proportion of infected fields is likely to be low. The proportion of infected fields is e1 (Table A.2).

Not all berries harvested from production fields in which the pathogen is present are infected with *D. vaccinii*. The proportion of infected berries harvested from infected fields is e2 (Table A.2).

Berries are shipped as bulk or in small packages (blueberries in clam shells, cranberries in plastic bags). Berries that are packaged are cleaned before packaging in packing houses before export. Berries with visible symptoms will be removed. The proportion of berries removed by cleaning at packing houses is e3 (Table A.2). For berries that are shipped as bulk, there is no further cleaning in the country of origin.

During transport of berries from third countries to the EU, cross-contamination or cross-infection is in theory possible. It is also theoretically possible that the pathogen would not survive transport. Both processes are accounted for by considering a multiplier e_4 for the proportion of infected berries in the international trade (Table A.2).

At customs clearing, an inspection is carried out. The proportion of infected berries removed from the flow at import inspection is e5 (Table A.2).

During within-EU transport of berries, cross-contamination or cross-infection is in theory possible. It is also theoretically possible that the pathogen would not survive transport. Both processes are accounted for by considering a multiplier e6 for the change in the proportion of infected berries in the intra-EU trade (Table A.2).

Quality control is done at packing houses following import and before berries are shipped to retail. The proportion of infected berries removed during this quality control is e7 (Table A.2).

Quality control is done at retail. The proportion of infected berries removed during this quality control (usually whole packages) is e8 (Table A.2).

Consumers buying berries may sort out bad ones, or let berries go bad. The proportion of infected berries that is not consumed is e9 (Table A.2).

Table A.1: State variables of the entry model for blueberry fruit. All variables are expressed in numbers of individual blueberries, considering the whole yearly flow of blueberries from countries with official presence of *D. vaccinii* into the EU. Note: the model is the same for cranberries, but the parameter values are different

Symbol	Meaning
N_{E0}	Total number of blueberries imported from countries with official presence of *D. vaccinii* into the EU per year
N_{E1}	Total number of blueberries originating from fields with presence of *D. vaccinii in* countries with official presence of *D. vaccinii* imported into the EU per year
N_{E2}	Total number of blueberries infected with *D. vaccinii* that are prepared for export to the EU per year in countries with official presence of *D. vaccinii*
N_{E3}	Total number of blueberries infected with *D. vaccinii* that pass cleaning and culling before being put on transport to the EU per year
N_{E4}	Total number of blueberries infected with *D. vaccinii* that arrive at customs before import into the EU per year
N_{E5}	Total number of blueberries infected with *D. vaccinii* that pass import inspection at entry into the EU per year
N_{E6}	Total number of infected blueberries arriving at packing houses in the EU per year
N_{E7}	Total number of infected blueberries arriving at retail in the EU per year
N_{E8}	Total number of infected blueberries arriving at consumer per year
N_{E9}	Total number of infected blueberries ending up as waste at packing houses in the EU per year
N_{E10}	Total number of infected blueberries ending up as waste at retail in the EU per year
N_{E11}	Total number of infected blueberries ending up as waste at consumer in the EU per year

Table A.2: Parameters of the entry model for blueberry fruit. All parameters are multiplication numbers (mostly proportions, i.e. < 1). Note: the parameters are the same for cranberries but their values are different

Symbol	Meaning
e_1	Proportion of blueberry production fields infected with *D. vaccinii* in countries with official presence of the pathogen
e_2	Proportion of berries harvested in fields with presence of *D. vaccinii* that are infected with the fungus. This includes latent infections

Symbol	Meaning
e_3	Proportion of infected berries that are removed at packing houses before being further shipped for export
e_4	Proportion (or multiplier) accounting for a change in the number of infected berries during transport from Third countries to the EU, e.g. due to cross-infection or cross-contamination between berries
e_5	Proportion of infected berries that is intercepted at import inspection
e_6	Proportion (or multiplier) accounting for a change in the number of infected berries during intra-EU transport, e.g. due to cross-infection or cross-contamination between berries
e_7	Proportion of infected berries that is removed at packing houses in the EU
e_8	Proportion of infected berries that is removed at retail
e_9	Proportion of infected berries that is removed by consumers

Formulas

The total number of infected blueberries ending up as waste at packing houses in the EU is calculated as:

$$N_{E9} = N_{E0} \times e_1 \times e_2 \times (1 - e_3) \times e_4 \times (1 - e_5) \times e_6 \times e_7$$

The total number of infected blueberries ending up as waste at retail in the EU is calculated as:

$$N_{E10} = N_{E0} \times e_1 \times e_2 \times (1 - e_3) \times e_4 \times (1 - e_5) \times e_6 \times (1 - e_7) \times e_8$$

The total number of infected blueberries ending up as waste at consumer in the EU is calculated as:

$$N_{E11} = N_{E0} \times e_1 \times e_2 \times (1 - e_3) \times e_4 \times (1 - e_5) \times e_6 \times (1 - e_7) \times (1 - e_8) \times e_9$$

Entry pathway 2: Cranberries for consumer use

For cranberry fruit, we use the exact same pathway model as described above for blueberry fruit.
Transfer of inoculum from fruit waste to cultivated and naturally occurring *Vaccinium* plants.
Three kinds of waste were considered in the entry pathways of blueberry and cranberry fruit:

- Waste at packing house, partly composted
- Waste at retail not relevant: goes to landfill and incineration (low risk)
- Waste at consumer partly composted

Waste at processing was not considered, because all the fruit for processing is frozen. Across Europe, a large portion of waste is buried in landfill or incinerated. Especially, the waste at retail is expected to go to landfill or incinerator. This waste is assumed to pose no risk. Risk may exist if fruit waste is composted, in particular before the start of the composting process. In such cases, spores may be produced, especially from little branches (e.g. fruit stalks) contained in the waste. The most likely transfers occur at the packing house, which is often at the same location as berry production, and may use composting, and consumer waste, which may be composted in home gardens with *Vaccinium* plants being present.

Entry pathway 3: Blueberry plants for planting in plug trays (*Vaccinium corymbosum*)

Blueberry plants for planting are produced according to a strict scheme of quality control, with the original material originating from tissue culture. This original material is multiplied in protected glasshouses for most of the time.

The total yearly trade of blueberry plants for planting constitutes the variable PE0 (we use P to distinguish from berries, *N*).

Level of risk is considered to be homogeneous across countries with high and low prevalence of *D. vaccinii* because the plants originate from tissue culture and are multiplied under protected conditions.

The proportion of infected cuttings shipped from the place of production is ϵ_1. We use the Greek letter epsilon (ϵ) to distinguish entry parameters for the trade in plants for planting from entry parameters for the trade in berries (Table A.3).

Table A.3: Parameters of the entry model for blueberry plants for planting

Symbol	Meaning
ϵ_1	Proportion of blueberry plants for planting (plants in plug trays) infected with *D. vaccinii* when leaving the place of production
ϵ_2	Proportion of infected plants for planting that are removed before being further shipped for export. There are no packing houses. The material leaving the nursery goes straight to the port for export. This parameter was set to zero
ϵ_3	Proportion (or multiplier) accounting for a change in the number of infected plants for planting during transport from Third countries to the EU, e.g. due to cross-infection or cross-contamination between plants. Transport time is short, conditions are cool, symptoms can in theory develop (latent becomes visibly infected). No change (but keep the parameter)
ϵ_4	Proportion of infected plants for planting that is intercepted at import inspection (low effect, but relevant)
ϵ_5	Proportion (or multiplier) accounting for a change in the number of infected plants for planting during intra-EU transport, e.g. due to cross-infection or cross-contamination between individual plants. This parameter was set to one.
ϵ_6	Proportion of infected plants for planting that is removed during presence at the receiving nursery in the EU

Additional parameters account for removal of infected plants for planting before export (ϵ_2), a change in the proportion of infected plants for planting during transport from third countries to the EU, e.g. due to cross-contamination (ϵ_3), the proportion of infected plants for planting that is intercepted at import inspection (ϵ_4), a change in the proportion of infected plants for planting during transport within the EU, e.g. due to cross-contamination (ϵ_5), and the proportion of infected plants that is removed at arrival at nurseries in the EU (ϵ_6).

Formula

The total number of infected blueberry plants for planting (*V. corymbosum*) that are planted in nurseries in the EU is then equal to:

$$P_{E1} = P_{E0} \times \epsilon_1 \times (1 - \epsilon_2) \times \epsilon_3 \times (1 - \epsilon_4) \times \epsilon_5 \times (1 - \epsilon_6)$$

Entry pathway 4: Potted plants (*Vaccinium* spp.)

Three risk categories of countries of origin were distinguished

Low risk: Western USA (Oregon & Washington), Canada, Chile and China as low prevalence locations of origin

High risk: Central-east USA (Michigan as an example for blueberries; Wisconsin as an example for cranberries) as high prevalence places of origin

No risk: Places with no *D. vaccinii* (e.g. California, South Africa, Australia, Argentina)

Entry pathway 5: Cranberry plants for planting in plug trays (from cuttings)

Similar to blueberry plants for planting in plug trays

Entry pathway 6: Cranberry unrooted cuttings

Unrooted cuttings have been imported into the EU from the USA (USDA APHIS, 2017)

The proportion of infected cuttings and number of cuttings (stems) was estimated in a similar way to that described above for blueberry potted plants.

A.1.2. Assessment of Entry through fruits for the different scenarios

A.1.2.1. Introduction

Comtrade/EUROSTAT data

These data sets provide a unique code and a unique value for all the *Vaccinium* berries (081040 – Fruit of *Vaccinium* spp.), that include blueberry, cranberry and other minor *Vaccinum* berries. This data can be found in Table C.2 (Appendix C), and represent the quantities (tonnes) of berries imported into EU28 from Third countries.

The infection rate of blueberry and cranberry fruit can differ substantially, and this is the rationale behind the need to estimate in detail the import of blueberry and cranberry separately.

In order to calculate the ratio between blueberry and cranberry export, the FAOSTAT database was used. The FAOSTAT database reports export volumes of blueberry and cranberry from all countries, irrespective of destinations. From these data, the ratios of blueberry/cranberry, for a 10-year period (2004–2013) were calculated (Table A.4)

Table A.4: Total import of *Vaccinium* berries (tonnes) into EU and ratios blueberry/cranberry in the EU28 import, based on FAOSTAT data

Import of *Vaccinium* berries									
2004	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
11,075	10,942	13,264	12,584	12,922	14,143	18,014	22,485	25,529	28,023
Proportion of blueberries									
80.3	81.2	69.6	72.8	61.9	69.5	69.5	64.7	68.0	69.5
Proportion of cranberries									
19.7	18.8	30.4	27.2	38.1	30.6	30.5	35.3	32.0	30.6

These ratios were applied to Comtrade database in order to estimate the import volume into EU28 for blueberry and cranberry separately (Appendices C.3 and C.4).

A summary of import volumes of blueberry and cranberry from countries where *D. vaccinii* is present is presented in Table A.5.

Table A.5: Data on import into EU28 of cranberry and blueberry from countries where *Diaporthe vaccinii* is present. The mean annual estimated volume (tonnes) of cranberry and blueberry based on trade data of the period 2004–2013. The number of berries was calculated based on an average weight of 1.8 g/berry (Vargas and Bryla, 2015)

Country	**Cranberry**	**Blueberry**	**Cranberry**	**Blueberry**
	Annual average (kg)		**Number of berries**	
Belarus[(a)]	277,095	729,135	251,890,909	405,083,333
Canada	128,850	265,303	117,136,363	147,377,777
Chile	1,939,769	4,221,212	1,763,427,273	2,345,111,111
China[(a)]	6,415	14,562	5,831,924	8,100,000
Russian Federation[(a)]	259,748	861,914	236,134,639	478,844,444
USA	405,987	979,225	369,081,818	544,027,777

(a): Based on several publications (Dokukina, 2001; Galynskaya et al., 2011; Galynskaya and Liaguskiy, 2012; QingHua et al., 2015), *D. vaccinii* is presumably present in these countries.

A.1.2.2. Entry through blueberry fruit

A.1.2.2.1. Total trade flow from countries with *D. vaccinii*

NE0 – Estimated total number of blueberries (in millions) imported from countries with official presence of *D. vaccinii* into the EU per year

Table A.6: Estimated total number of blueberries imported from high- and low-risk countries

	1%	**25%**	**50%**	**75%**	**99%**
High-risk countries (USA)	272	408	544	816	1,088
Low-risk countries (all others)	1,692	2,538	3,384	5,076	6,769

Justification: The mean annual volume of blueberry was estimated from the total volume of all *Vaccinium* berries imported into EU28 and adjusted for the annual ratios blueberry/cranberry calculated using FAOSTAT export data. For low-risk countries, there could be variation in the actual ratio between blueberry/cranberry, but the average is assumed to be similar to the high-risk country (US). To calculate the number of berries, the estimated mean weight of one berry was used. The average ratio blueberry/cranberry was derived from US data. (Source: Comtrade.un.org).

File: Import of Vaccinium berry fruits (weight in kg) – Comtrade -01_feb_2017v2_Wageningen.xls

Uncertainty: As median value the estimated import value based on import data is used. We assume a normal distribution. Uncertainty is mainly due to variation in mean berry weight and annual variation in import quantities (1.1–1.8) (McManus et al., Univ. of Wisconsin, Plant Disease Management Reports 2003–2014; http://www.plantmanagementnetwork.org/pub/trial/PDMR/; Vargas and Bryla, 2015). There are differences among varieties and production systems.

A.1.2.2.2. Trade flow of berries infected by *D. vaccinii*

e1 – Prevalence level; Proportion of blueberry production fields infected with *D. vaccinii* in countries with official presence of the pathogen.

Table A.7: Proportion of fields having *D. vaccinii* in the countries of origin under A0

A0 – current situation	1%	25%	50%	75%	99%
High-risk countries (USA)	0.1	0.45	0.6	0.70	0.9
Low-risk countries (all others)	0.0001	0.001	0.01	0.015	0.03

Justification: High-risk countries (US): in East US (Michigan, Georgia, New Jersey) the prevalence level of *D. vaccinii* in blueberry can be very high (0.9). For West US (Washington, Oregon) the prevalence level is estimated to be 0.1. The estimated median prevalence is assumed to be 0.6. Low-risk countries: there is no detailed information on the prevalence level of *D. vaccinii* in the low-risk countries. The median estimate is based on the low prevalence level (0.1) in the west US. The climate in Chile is similar to the West US.

Uncertainty: Variation and incomplete information in prevalence levels within and between countries, incomplete information about which blueberry producing regions export to the EU. Correct identification of *Phomopsis* species.

Table A.8: Proportion of fields having *D. vaccinii* in the countries of origin under A1

A1 – deregulation	1%	25%	50%	75%	99%
High-risk countries (USA)	0.1	0.45	0.6	0.70	0.9
Low-risk countries (all others)	0.001	0.01	0.1	0.15	0.3

Justification: The proportion of fields with *D. vaccinii* will likely be the same in high-risk countries when quarantine regulations are lifted. In low-risk countries, removal of quarantine status will likely promote the spread of the disease so that the levels will become similar to those of the high-risk countries.

Uncertainty: Variation and incomplete information in prevalence levels within and between countries, incomplete information about which blueberry producing regions export to the EU. Correct identification of *Phomopsis* species.

Table A.9: Proportion of fields having *D. vaccinii* in the countries of origin under A2

A2 – stricter measures	1%	25%	50%	75%	99%
High-risk countries (USA)	0.1	0.45	0.6	0.70	0.9
Low-risk countries (all others)	0.0001	0.001	0.01	0.015	0.03

Justification: Extra RROs will not affect the prevalence of the disease in high- and low-risk countries.

Uncertainty: Variation and incomplete information in prevalence levels within and between countries, incomplete information about which blueberry producing regions export to the EU. Correct identification of *Phomopsis* species.

A.1.2.2.3. Proportion of infected fruits (visible and latent infections) at harvest in the countries of origin under A0

The incidence of *D. vaccinii* is lower in Chile than in the US because of the dry mediterranean climate (Schilder, pers. Comm.)

e2 – Incidence level; Proportion of blueberry fruit harvested in fields with presence of *D. vaccinii* that are infected with the fungus. This includes latent infections.

Table A.10: Proportion of fruits infected by *D. vaccinii* in infected fields under A0

A0	1%	25%	50%	75%	99%
High-risk countries (USA)	0.01	0.05	0.06	0.08	0.15
Low-risk countries (all others)	0.0001	0.0005	0.0006	0.0008	0.00015

Justification: High-risk countries: the Plant Disease Management Reports (PDMR) contain information on the incidence levels (visibly *D. vaccinii* infected blueberry) in east US. The range of incidence levels in east US is from 0.02 to 0.19. The median incidence level is estimated to be 0.09 in eastern US. The estimated incidence level in west US is 0.009. The median incidence level for the whole US is estimated to be 0.06, because most berries exported to the EU originate from east US. Low-risk countries: the incidence level of *D. vaccinii* in the most important exporter (Chile) of berries to EU is assumed to be 100-fold lower compared to high-risk countries.

Uncertainty: Variation and incomplete information on incidence levels within and between countries exporting to the EU. Correct identification of *Phomopsis* species. There is incomplete information on proportion of berries with latent infections at the time of harvest.

Table A.11: Proportion of fruits infected by *D. vaccinii* in infected fields under A1

A1	1%	25%	50%	75%	99%
High-risk countries (USA)	0.01	0.07	0.12	0.15	0.2
Low-risk countries (all others)	0.001	0.007	0.012	0.015	0.02

Justification: High-risk countries: we assume that fewer fungicide applications are made resulting in fruit quality equal to the one for the internal market in those countries. Low-risk countries: the standard of the internal market may be even lower than in high-risk countries.

Uncertainty: The effect of deregulation on control measures in third countries is uncertain. Variations among third countries are considerable. There is variation and incomplete information on incidence levels within and between countries exporting to the EU. Import of berries from low-risk countries like Chile and China may increase considerably, while spread of *D. vaccinii* within those countries in uncertain. Correct identification of *Phomopsis* species. There is incomplete information on proportion of berries with latent infections at the time of harvest.

Table A.12: Proportion of fruits infected by *D. vaccinii* in infected fields under A2

A2	1%	25%	50%	75%	99%
High-risk countries (USA)	0.001	0.005	0.006	0.008	0.015
Low-risk countries (all others)	0.0001	0.0005	0.0006	0.0008	0.00015

Justification: High-risk countries: if plants produced from cuttings are restricted to pest-free production areas, the proportion of infected berries will ultimately go down. Additionally, mandatory pruning of twig blight affected branches and fungicide applications during flowering would reduce the proportion of infected berries. Low-risk countries: extra RROs will not affect the proportion of berries significantly compared to the A0 (current) situation.

Uncertainty: The effect of extra control measures in third countries is uncertain due to uncertainty about the proportion of plants produced from field cuttings compared to those produced from tissue culture. Variation and incomplete information on incidence levels within and between countries, incomplete information about which blueberry producing regions export to the EU. Correct identification of *Phomopsis* species. There is incomplete information on proportion of berries with latent infections at the time of harvest.

A.1.2.2.4. Proportion of infected berries that are removed at packing houses before being further shipped for export

e3 – Proportion of infected berries that are removed at packing houses before being further shipped for export

Table A.13: Proportion of visibly infected berries that are removed at packing houses before being further shipped for export under A0

	1%	25%	50%	75%	99%
A0 – current situation	0.5	0.85	0.9	0.95	0.99

Justification: Table blueberries are generally handpicked (early season), whereas berries destined for processing are harvested mechanically in the late growing season. Handpicked berries are mostly healthy looking (but may have latent infection) while mechanically harvested berries may include higher number of infected berries. Mechanically harvested fruit is mostly frozen and used for processing; frozen fruit is not considered in this risk assessment because pathogen containing waste is negligible. The incubation period for visible symptoms on harvested ripe berries is 2–3 weeks (Schilder, pers. comm.). We assume that at the time of harvest 10% of the infected berries show symptoms of infection and 90% are latent infections. Here, we elicit the removal rate over the visibly infected fruit; the latent infected berries are assumed to remain undetected. We assume that culling of symptomatic berries is 100% effective. The median proportion of latent infected berries is assumed 0.9. In case the harvest is delayed a higher proportion of infected berries will show symptoms, but still 50% of the infected berries will be asymptomatic. Therefore, the 1% quantile is set at 0.5.

Uncertainty: The proportion of latently infected berries present. There are other diseases with similar symptoms as *D. vaccinii*. Effect of harvesting procedure: mechanical damage caused by mechanical harvesting.

Table A.14: Proportion of visibly infected berries that are removed at packing houses before being further shipped for export under A1

	1%	25%	50%	75%	99%
A1 – deregulation	0.5	0.85	0.9	0.92	0.95

Justification: Deregulation may lead to less stringent inspection at the packing house affecting the 75% and 99% efficiency levels.

Uncertainty: Removal of visibly infected berries for export may remain the same or be less effective.

Table A.15: Proportion of visibly infected berries that are removed at packing houses before being further shipped for export under A2

	1%	25%	50%	75%	99%
A2 – stricter regulation	0.5	0.85	0.9	0.95	0.99

Justification: The inspection efficiency will not be affected by extra control measures in the field.

Uncertainty: The same as under the A0 current situation.

A.1.2.2.5. Proportion of infected berries removed after export inspection

e3b – Proportion of infected berries removed after export inspection

Table A.16: Proportion of visibly infected berries removed after export inspection

	1%	25%	50%	75%	99%
A0 – current situation	1	1	1	1	1
A1 – deregulation	1	1	1	1	1
A2 – stricter measures	1	1	1	1	1

Justification: Assuming that an export inspection is based on visual inspection of consignments the proportion of infected berries remains the same as after packing house inspection.

Uncertainty: It is not sure if inspection prior to export is as effective as inspection at the packing house.

A.1.2.2.6. Number of infected berries during transport from Third countries to the EU

e4 – Multiplier accounting for a change in the number of infected berries during transport from Third countries to the EU, e.g. due to cross-infection or cross-contamination between berries

Table A.17: Multiplier accounting for a change in the number of infected berries during transport under A0, A1 and A2

	1%	25%	50%	75%	99%
A0 – current situation	1	1	1	1	1
A1 – deregulation	1	1	1	1	1
A2 – stricter measures	1	1	1	1	1

Justification: Berries are transported at low temperatures and/or under controlled atmosphere by air or ship (20% air transport, 1 day; 80% ship transport, 2–3 weeks, 1–2°C). We assume that there is no change in the number of infected berries during transport. There are no specific requirements concerning transport; thus, deregulation would not affect this multiplier. Stricter requirements, for example mandatory controlled atmosphere transportation would not be more effective than the current voluntary measures taken during transport.

Uncertainty: The uncertainty is considered very low.

A.1.2.2.7. Proportion of infected berries that is intercepted at import inspection

e5 – Proportion of infected berries that is intercepted at import inspection

Table A.18: Percentage of infected fruit being intercepted at EU customs

	1%	25%	50%	75%	99%
A0 – current situation	0	0	0	0	0
A1 – deregulation	0	0	0	0	0
A2 – stricter measures	0	0	0	0	0

Justification: There are no records of interception of *D. vaccinii* berries in the EU. As for the export inspection, the import inspection is assumed not to change the number of *D. vaccinii*-infected berries.

Uncertainty: Uncertainty is considered to be negligible.

A.1.2.2.8. Change in the number of infected berries during intra-EU transport

e6 – Multiplier accounting for a change in the number of infected berries during intra-EU transport, e.g. due to cross-infection or cross-contamination between berries

Table A.19: Multiplier accounting for a change in the number of infected berries during intra-EU transport under A0, A1 and A2

	1%	25%	50%	75%	99%
A0 – current situation	1	1	1	1	1
A1 – deregulation	1	1	1	1	1
A2 – stricter measures	1	1	1	1	1

Justification: Transport time within the EU is so short that there are no changes in the number of infected fruit.

Uncertainty: None

A.1.2.2.9. Proportion of infected berries that is removed at packing houses in the EU

e7 – Proportion of infected berries that is removed at packing houses in the EU

Table A.20: Percentage of infected fruit being culled at packing houses in the EU under A0, A1 and A2

	1%	25%	50%	75%	99%
A0 – current situation	0	0.01	0.03	0.05	0.1
A1 – deregulation	0	0.01	0.03	0.05	0.1
A2 – stricter measures	0	0.01	0.03	0.05	0.1

Justification: Bulk shipments likely contain a higher proportion of infected fruit than shipments in small packages (clam shells). Bulk shipments may also contain some leaves and other plant material. Most blueberries are imported in clam shells but may be resorted and repackaged after arrival in the EU (GianLuca Savini, hearing expert, personal communication). We assume that only a small proportion of latently infected berries develop symptoms because shipments are transported under refrigeration. Waste removal of imported berries is around 3–5% of all presorted berries. The median is taken as 0.3. This percentage may be higher in bulk shipments; therefore, the 99% is considered to be 0.1. Waste is assumed to be deposited at the local council composting facility, and could potentially become a source of infection if the composting is not carried out properly (Gianluca Savini, hearing expert, personal communication).

Deregulation does not affect the sorting efficiency because there is no regulation on sorting of culls in place for packing houses. Extra regulations on cull sorting would not affect the proportion of infected berries removed because the visibly infected berries are already removed under the current situation.

Uncertainty: The proportion of berries shipped in bulk (unsorted at the source) is uncertain but bulk shipment does take place, for example from Chile.

A.1.2.2.10. Proportion of infected berries that is removed at retail in the EU

e8 – Proportion of infected berries that is removed at retail in the EU

Table A.21: Percentage of infected fruit being culled at retail in the EU under A0, A1 and A2

	1%	25%	50%	75%	99%
A0 – current situation	0.01	0.05	0.1	0.12	0.2
A1 – deregulation	0.01	0.05	0.1	0.12	0.2
A2 – stricter measures	0.01	0.05	0.1	0.12	0.2

Justification: When retailers check for berry defects, they will not inspect individual berries. Instead, they will discard whole clam shells even if there is only one infected berry. Moreover, storage of the clam shells is longer than in packing houses. Therefore, we assume that the culling rate is higher than at stage 8 providing time for more latently infected berries to become symptomatic. The waste flow of discarded clam shells is assumed to go to the general waste which can be a landfill or incineration. Deregulation or stricter regulatory measures will not affect the proportion of berries culled.

Uncertainty: The inspection and sorting procedure for clam shells with blueberries is uncertain. Moreover, the quality of the berries is affected by the turnover rate in a store.

A.1.2.2.11. Proportion of infected berries that is removed by consumers in the EU

e9 – Proportion of infected berries that is removed by consumers (waste)

Table A.22: Proportion of infected berries that is removed by consumers (waste)

	1%	25%	50%	75%	99%
A0 – current situation	0	0.07	0.1	0.13	0.2
A1 – deregulation	0	0.07	0.1	0.13	0.2
A2 – stricter measures	0	0.07	0.1	0.13	0.2

Justification: Compared to the retail conditions the storage of berries may be longer resulting in increased rot. The waste flow of discarded blueberries is assumed to be maximum 20%. It is assumed that 50% of discarded food (berries) is treated as organic waste and 50% is discarded as general waste. Deregulation or stricter regulatory measures will not affect the proportion of berries culled.

Uncertainty: The storage conditions and rate of consumption vary considerably.

A.1.2.3. Entry through cranberry fruit

A.1.2.3.1. Total trade flow of cranberries from countries with *D. vaccinii*

NE0 – Total number of cranberries (in millions) imported from countries that have *D. vaccinii* into the EU per year.

Table A.23: Total number of cranberries (in millions) imported from countries that have *D. vaccinii* into the EU per year

A0, A1 and A2	1%	25%	50%	75%	99%
High-risk countries (USA, Canada)	450	470	486	490	500
Low-risk countries (Belarus, Chile, China, Russia)	1,800	2,000	2,257	3,000	4,514

Justification: The mean annual volume of cranberry was estimated from the total volume of all *Vaccinium* berries imported into EU28 (2006–2013), based on the annual ratios of blueberry/cranberry calculated using FAOSTAT export data. To calculate the number of berries, the estimated mean weight of one berry was used. The calculated numbers (in millions of berries) were used as median values.

Uncertainty: USA and Canada were considered high-risk export countries, and the other countries with export to EU28 as low-risk countries, but the exact export numbers for these two categories are uncertain, because the numbers are averages of berry imports from 2006 to 2013, while imports have likely grown in the meantime, especially from Chile. There are also differences in berry weight among varieties and production methods; the variation is uncertain.

A.1.2.3.2. Trade flow of cranberries infected by *D. vaccinii* into the EU per year

e1 – Proportion of cranberry production fields infected with *D. vaccinii* in countries with the presence of the pathogen.

Table A.24: Proportion of fields having *D. vaccinii* in the countries of origin under A0

A0 – current situation	1%	25%	50%	75%	99%
High-risk countries (USA, Canada)	0.8	0.87	0.9	0.93	1
Low-risk countries (all others)	0.0001	0.001	0.01	0.015	0.03

Justification: The median proportions in high-risk countries are based on incidence levels in the USA and Canada (Olatinwo et al., 2004; Sabaratnam et al., 2016). The proportions in low-risk countries are the same as those for blueberries.

Uncertainty: There are regional differences in incidence of viscid rot in the high-risk countries and even greater differences among the low-risk countries. In Belarus and Russia, the pathogen was identified from morphological characteristics only, while molecular identification tools were used in China and Chile. The disease incidence in Belarus and Russia is highly uncertain but most of the import is form Chile.

Table A.25: Proportion of fields having *D. vaccinii* in the countries of origin under A1

A1 – deregulation	1%	25%	50%	75%	99%
High-risk countries (USA, Canada)	0.8	0.87	0.9	0.93	1
Low-risk countries (all others)	0.0001	0.01	0.02	0.025	0.05

Justification: Deregulation will likely not affect the proportion of fields affected by *D. vaccinii* in high-risk areas. It may increase the number of small farmers that export cranberries to the EU, potentially resulting in a higher proportion of export fields affected.

Uncertainty: The same as for the current situation in high-risk areas, but increased uncertainty in low-risk areas if smaller farmers participate in the export of cranberries.

Table A.26: Proportion of fields having *D. vaccinii* in the countries of origin under A2

A2 – stricter measures	1%	25%	50%	75%	99%
High-risk countries (USA, Canada)	0.8	0.87	0.9	0.93	1
Low-risk countries (all others)	0.0001	0.001	0.01	0.015	0.03

Justification: Extra regulation will likely not affect the proportion of fields affected by *D. vaccinii* in both high-risk and low-risk areas.

Uncertainty: The uncertainty is the same as for the current situation in both high-risk and low-risk areas.

A.1.2.3.3. Proportion of cranberry fruit harvested in fields with presence of D. vaccinii that are infected with the fungus

e2 – Proportion of cranberry fruit harvested in fields with the presence of *D. vaccinii* that are infected with the fungus. This includes latent infections.

Table A.27: Proportion of infected fruit (symptomatic and latent) at harvest under A0

A0	1%	25%	50%	75%	99%
High-risk countries (USA, Canada)	0.06	0.14	0.18	0.24	0.41
Low-risk countries (all others)	0.0006	0.0014	0.0018	0.0024	0.0041

Justification: The median proportions in high-risk countries are based on incidence levels in the USA and Canada (Olatinwo et al., 2004; Sabaratnam et al., 2016; P. MacManus, personal communication; A. Schilder, hearing expert). The incidence of *D. vaccinii* is lower in Chile than in the eastern US and Canada because of the dry Mediterranean climate. We assumed that the incidence is 100 times lower in low-risk countries.

Uncertainty: There are regional differences in incidence of viscid rot in the high-risk countries and even greater differences among the low-risk countries. Latent infections are highly uncertain, but were demonstrated in Canada (Sabaratnam et al., 2016).

Table A.28: Proportion of infected fruit (symptomatic and latent) at harvest under A1

A1 – deregulation	1%	25%	50%	75%	99%
High-risk countries (USA, Canada)	0.11	0.20	0.24	0.34	0.61
Low-risk countries (all others)	0.006	0.014	0.018	0.024	0.041

Justification: High-risk countries: we assume that fewer fungicide applications are made resulting in fruit quality equal to the one for the internal market in those countries which is inferior quality compared to the current export quality. The proportions are based on Canadian data (Sabaratnam et al., 2016). Low-risk countries: the standard of the internal market may be even lower than in high-risk countries. We assume that the incidence levels are 10 times higher than in the A0 current situation.

Uncertainty: The effect of deregulation of control measures in third countries is uncertain. Variations among third countries are considerable. There is variation and incomplete information on incidence levels within and between countries exporting to the EU. Import of berries from low-risk countries like Chile and China may increase considerably, while spread of *D. vaccinii* within those countries is uncertain. Infection by the *D. vaccinii* results in distinct symptoms, viscid rot but the proportion of latent infection is even higher than in blueberries. There is incomplete information on the proportion of berries with latent infections at the time of harvest. The uncertainty range is considered to be similar to the current situation.

Table A.29: Proportion of infected fruit (symptomatic and latent) at harvest under A2

A2 – stricter regulation	1%	25%	50%	75%	99%
High-risk countries (USA, Canada)	0.06	0.14	0.18	0.24	0.41
Low-risk countries (all others)	0.0006	0.0014	0.0018	0.0024	0.0041

Justification: Mandatory fungicide applications and other extra regulations would not affect control in high-risk areas, where fungicides are already applied on 50–100% of the farms (P. MacManus, personal communication; Table A.30). We assume that the incidence levels are similar to those in the A0 situation.

Uncertainty: The effect of extra regulation of control measures (such as mandatory fungicide applications) in third countries is uncertain. The uncertainty range is considered to be similar to the current situation (A0).

Table A.30: Proportion of Cranberry fruit showing disease symptoms under different management regimes

Literature data	1%	25%	50%	75%	99%
Cranberry (sprayed, including symptomatic) (Plant disease management reports of the APS)	1	8	11	14	21
Cranberry (unsprayed) (Plant disease management reports of the APS)	4.7		50		89
Latent infection, Infection showing after 3 weeks of incubation at room temperature (Sabaratnam et al., 2016)	11	20	24	34	61
Estimated average cranberry infection (sprayed and latent)	6	14	18	24	41

A.1.2.3.4. Proportion of infected berries that are removed at packing houses before being shipped for export

e3 – Proportion of infected berries that are removed at packing houses before being shipped for export.

Table A.31: Proportion of infected berries that are removed at packing houses before being shipped for export under A0

	1%	25%	50%	75%	99%
A0 – current situation	0.95	0.97	0.98	0.99	1

Justification: We assume 90% visible infection and 10% latent infection. The removal rate is limited to visibly infected fruit; the latently infected berries all go through.

Uncertainty: The uncertainty is very low because exporters want to ship symptomless berries. Latent infection cannot be detected but detection and removal of symptomatic berries is almost perfect.

Table A.32: Proportion of infected berries that are removed at packing houses before being shipped for export under A1

	1%	25%	50%	75%	99%
A1 – deregulation	0.85	0.90	0.95	0.97	0.99

Justification: We still assume 90% visible infection and 10% latent infection. The removal rate is limited to visibly infected fruit, but is lower than in A0 situation.

Uncertainty: Deregulation may loosen the inspection standards and thus decrease the per cent removal. The uncertainty is slightly higher in this situation compared to A0.

Table A.33: Proportion of infected berries that are removed at packing houses before being shipped for export under A2

	1%	25%	50%	75%	99%
A2 – stricter measures	0.95	0.97	0.98	0.99	1

Justification: We still assume 90% visible infection and 10% latent infection. The removal rate is limited to visibly infected fruit, and is the same as in the A0 situation.

Uncertainty: The uncertainty is similar to the situation A0.

A.1.2.3.5. Change in the number of infected berries during transport from Third countries to the EU

e4 – Multiplier accounting for a change in the number of infected berries during transport from Third countries to the EU, e.g. due to cross-infection or cross-contamination between berries

Table A.34: Multiplier accounting for a change in the number of infected berries during transport under A0, A1 and A2

	1%	25%	50%	75%	99%
A0 – current situation	1	1	1	1	1
A1 – deregulation	1	1	1	1	1
A2 – stricter measures	1	1	1	1	1

Justification: Berries are transported at low temperatures by air or ship (20% air transport, 1 day; 80% ship transport, 2–3 weeks, 1–2°C). We assume that there is no change in the number of infected berries during transport. There are no specific requirements concerning transport; thus, deregulation would not affect this multiplier. Stricter requirements would not be more conducive than the current voluntary measures taken during transport.

Uncertainty: The uncertainty is considered negligible.

A.1.2.3.6. Proportion of infected berries that is intercepted at import inspection

e5 – Proportion of infected berries that is intercepted at import inspection.

Table A.35: Percentage of infected fruit being intercepted at EU customs

	1%	25%	50%	75%	99%
A0 – current situation	0	0	0	0	0
A1 – deregulation	0	0	0	0	0
A2 – stricter measures	0	0	0	0	0

Justification: There are no records of interception of *D. vaccinii* cranberries in the EU. The import inspection is assumed not to change the number of *D. vaccinii* infected berries.

Uncertainty: Uncertainty is considered to be negligible.

A.1.2.3.7. Change in the number of infected berries during intra-EU transport

e6 – Multiplier accounting for a change in the number of infected berries during intra-EU transport, e.g. due to cross-infection or cross-contamination between berries.

Table A.36: Multiplier accounting for a change in the number of infected berries during intra-EU transport under A0, A1 and A2

	1%	25%	50%	75%	99%
A0 – current situation	1	1	1	1	1
A1 – deregulation	1	1	1	1	1
A2 – stricter measures	1	1	1	1	1

Justification: Transport time within EU is so short that there are only very minor changes in the number of visibly infected fruit but this does not result in a multiplier effect. Changes in regulations have no effect on the multipliers.

Uncertainty: Uncertainty is considered to be negligible.

A.1.2.3.8. Proportion of infected berries that is removed at packing houses in the EU

e7 – Proportion of infected berries that is removed at packing houses in the EU.

Table A.37: Percentage of infected fruit being culled at packing house under A0, A1 and A2

	1%	25%	50%	75%	99%
A0 – current situation	0	0.01	0.03	0.05	0.1
A1 – deregulation	0	0.01	0.03	0.05	0.1
A2 – stricter measures	0	0.01	0.03	0.05	0.1

Justification: We assume that only a small proportion of latently infected berries develop symptoms because shipments are transported under refrigeration. Waste removal of imported berries is around 3–5% of all presorted berries. The median is taken as 0.3. This percentage may be higher in bulk shipments; therefore, the 99% is considered to be 0.1. The maximum number of bags removed is assumed to be 10%. These bags will likely go to municipal landfill or incineration facility. Changes in regulation are likely not affecting the removal rates.

Uncertainty: All fresh cranberries are shipped in plastic bags ready for retail. Some latent infections become symptomatic in transport but the exact proportion is uncertain. Berries affected by viscid rot are easily spotted in the bags, and whole bags with one or more rotten berries will be removed. The removal rate is highly uncertain but will likely not exceed 10%.

Percentage of infected fruit being culled at the retail

A.1.2.3.9. Proportion of infected berries that is removed at retail in the EU

e8 – Proportion of infected berries that is removed at retail.

Table A.38: Proportion of infected berries that is removed at retail **under A0, A1 and A2**

	1%	25%	50%	75%	99%
A0 – current situation	0.01	0.05	0.15	0.18	0.25
A1 – deregulation	0.01	0.05	0.15	0.18	0.25
A2 – stricter measures	0.01	0.05	0.15	0.18	0.25

Justification: At room temperature symptoms of viscid rot would develop over time and bags with symptomatic berries would be removed regularly. The percentages of removal are considered to be higher than those of blueberries. Changes in regulations will not affect the removal rates.

Uncertainty: The storage procedure may vary among stores. Cranberries are often displayed at open shelves without refrigeration, and the turnover time is uncertain thus the proportion of cranberries developing viscid rot is uncertain.

A.1.2.3.10. Proportion of infected berries that is removed by consumers in the EU

e9 – Proportion of infected berries that is removed by consumers (waste).

Table A.39: Proportion of infected berries that is removed by consumers (waste) under A0, A1 and A2

	1%	25%	50%	75%	99%
A0 – current situation	0.0001	0.0007	0.001	0.005	0.01
A1 – deregulation	0.0001	0.0007	0.001	0.005	0.01
A2 – stricter measures	0.0001	0.0007	0.001	0.005	0.01

Justification: In the refrigerator, symptoms of viscid rot would develop very slowly. The percentages of removal are considered to be very low. Changes in regulations will not affect the removal rates.

Uncertainty: Cranberries are stored in the refrigerator or cooked immediately. Very little viscid rot will develop at the consumer level. The uncertainty about the removal rate is considered to be low.

A.1.3. Assessment of entry through plants for planting for the different scenarios

A.1.3.1. Introduction

The EPPO Global database indicates that countries officially affected are the USA, Canada, Chile and Latvia. Molecular identification data is available from the USA, Canada, Chile, China, and Latvia. However, the EU countries rarely import plants from Chile (ISEFOR records show only one import of a consignment of 10 plants) or China (ISEFOR database contains one imported consignment of *Vaccinium* from China in 2002). Most imported plants from affected countries are from the USA. Belarus and Russia are also reported to be affected but no confirmation by molecular identification has been made (Dokukina, 2001; Galynskaya et al., 2011; Galynskaya and Liaguskiy, 2012). Export of *Vaccinium* P4P from Belarus and Russia is unknown, although information on general P4P exports to the EU is reported in the EUROSTAT data base. In some territories exporting P4P to the EU (e.g. Morocco, Mexico, Argentina, Peru and California), *D. vaccinii* is not reported to be present. Therefore, trade from these territories is not considered in the calculation of risk, although the pathogen may be detected in the future.

Different categories of risk were assigned to territories in the tables below (Tables A.39 and A.40) according to the prevalence and severity of the disease. Cat 3 countries have zero risk and data from these territories are not included in the tables for the risk calculations.

The genus *Vaccinium* is listed in EU decision 2015/789 as a plant known to be susceptible to the European and non-European isolates of *Xylella fastidiosa*. Import of *Vaccinium* plants originating from areas where *X. fastidiosa* is known to be present is restricted to officially recognised pest-free areas or pest-free production places. *X. fastidiosa* is present in the US and the USDA recognises official pest-free areas for *X. fastidiosa* in the states Oregon and Washington and official pest-free production places in Massachusetts, Michigan and Wisconsin. In Table 39, an overview is given of the possibility for trade in *Vaccinium* plants from US states where *D. vaccinii* is present.

Table A.40: Possibility to trade *Vaccinium* plants in relation to *Xylella* fastidiosa restrictions. The risk of *D. vaccinii* infection for each US state is also reported

EPPO Global database – presence *D. vaccinii*	Possibility for trade in *Vaccinium* plants	*D. vaccinii* risk category
Arkansas	No trade	
Illinois	No trade	
Indiana	No trade	
Georgia*	No trade	
Maine	No trade	
Maryland	No trade	
Massachusetts	Only trade from recognised pest-free production places (less strict requirements for tissue culture only)	1
Michigan	Only trade from recognised pest-free production places (less strict requirements for tissue culture only)	1
New Jersey	No trade	
North Carolina	No trade	
Oregon	Inside recognised pest-free area (PFA) all trade allowed; No trade outside PFA	2
Washington	Inside recognised pest-free area (PFA) all trade allowed; No trade outside PFA	2
Wisconsin	Only trade from recognised production places (less strict requirements for tissue culture only)	1

*: Georgia is not mentioned in EPPO Global database as a state where *D. vaccinii* is present.

The PRA considers uncertainty about the total trade volume, including differences in estimates depending on the source of information, trends and future projections, and also uncertainty on the identity of the pathogen.

The PRA distinguishes the following scenarios: A0 = current; A1 = deregulation (removal of specific quarantine regulations, while certification and inspection remain in place); A2 = additional RROs described in Section 2.3.1 (in summary, field-derived unrooted cuttings prohibited from *D. vaccinii*-affected countries. P4P supplied either as small plugs originally from tissue culture, or larger potted plants from pest-free areas).

Table A.41: Risk Summary for Blueberries

Material	Risk level
Tissue culture	Zero
Plugs from tissue culture	Very low
Small potted plants, cuttings and ornamentals	Low to high (depends on location)
Location	**Incidence category**
C&E USA	1) High
Can, W USA, Chile, China, Belarus[(a)], Russia[(a)]	2) Low-moderate or unknown
Peru, Arg, Mexico, Morocco, S. Africa, NZ, Australia,	3) Zero

(a): No formal molecular-based identification has been made in these locations but literature suggests presence of the pathogen (Dokukina, 2001; Galynskaya et al., 2011; Galynskaya and Liaguskiy, 2012) and high suitability of climate in these locations (Narouei-Khandan et al., 2017).

Table A.42: Risk Summary for Cranberries

Material	Risk level
Plugs from cuttings	Moderate
Potted plants from cuttings and ornamentals	Moderate to high (depends on location)
Bales of stem clippings or unrooted cuttings[(a)]	High
Location	**Incidence category**
C&E USA, Can	1) High
W USA, Chile, China, Belarus[(b)], Russia[(b)]	2) Low-moderate or uncertain
Peru, Argentina, Mexico, Morocco, S. Africa, NZ, Australia	3) Zero

(a): Most propagation is from cuttings clipped from production fields or mother plants.
(b): No formal molecular-based identification has been made in these locations.

A.1.3.2. Blueberries plants for planting

Evidence:

Sources of information on blueberry plants:

1) Need for blueberry plants in the EU:

The need for blueberry plants was calculated based on the planting area, number of plants used per Ha, turnover (amount of replanting annually for the given production area), and projections for new areas in the future (projected area for blueberries in 2017: 11,000 ha in EU; Brazelton, 2016). The average planting density is 3,000 plants/ha (Phil Harmon, hearing expert). Plants are replaced every 15–20 years (Gianluca Savini, hearing expert). The calculation of how many cuttings would be needed to fill the demand from replacement of old production sites and new planting provides a means to estimate the yearly demand for P4P in the field. P4P grown from plugs require 2 years of growth before being transplanted to the production field. Thus, projections of the need for plugs are those projected for the area two years later. This calculation results in about 5.4 million P4P needed in the EU for 2016 (Table C.16 – Appendix C). Extra plants may be produced or imported to guarantee that sufficient plants would be available for planting in the field one or two years later. Additional plants imported or produced in the EU are exported to countries surrounding the EU, like Morocco where blueberry production is increasing rapidly. Large nurseries in the EU can produce their own plugs from tissue culture. One source of information representing EU nurseries suggests that 90% of planting material is produced in the EU and the rest from outside sources, and that plug plants produced from tissue culture are only imported if EU nurseries are short of their own material (Gianluca Savini, hearing expert). However, the number of plants exported from the USA (about

6 million blueberry plants per year according to USA State Certification Agencies and the largest blueberry nursery in the USA) is almost as large as the estimated number of plants needed annually in the EU (7.7 million). Potential explanations are that (a) nurseries order more plants than needed, foreseeing potential losses before the plants are ready to be planted in production fields, (b) the sale of imported plants to other countries than the importing EU countries and (c) underestimation of the expansion of blueberry production in the EU used to calculate the needs for plants (Brazelton, 2016). Because large nurseries intend to move their plug plant production to subsidiaries in the EU (Brazelton, personal communication), the median number of P4P imported from third countries is taken as 5.5 million in 2017, slightly below the number exported to the EU by the USA in 2016.

2) Import data:

   a) The ISEFOR database of 12 importing EU countries provides no information on the type of *Vaccinium* plant material. Detailed information on species and type of planting material is available for the Netherlands (see b, below). Other countries report only '*Vaccinium* plants' (units: number of plants) and give only the number of consignments and total volume (weight).
   b) The Netherlands import data for 2015 from the Dutch NPPO: all the data on import of *Vaccinium* P4P into the Netherlands is recorded under a customs code, summarising the number of consignments, number of plants and the type of plant material. From this data, the weight per plant for the different plant types could be estimated. In addition, the total weight of blueberry plants imported into Spain was provided by the Spanish NPPO; these data were converted to numbers using the Dutch estimated weight data.
   c) The EUROSTAT provides the value (in Euros) of all plants (according to custom codes) imported from different countries worldwide. The proportions of *Vaccinium* plants imported into the EU were estimated based on several conversion factors. Five code categories were selected of P4P that were closest to the codes for the *Vaccinium* imports in the Netherlands (mentioned under b). Next, all countries were selected that provide blueberry plants to the EU (according to Dutch import data). These countries were grouped into three categories according to the prevalence of *D. vaccinii* (absent, low and high). The values in the different categories were converted to numbers of plants based on estimates of the price per plant for the different plant categories. The EUROSTAT and FAOSTAT data on acreages of berries were used to calculate the proportion blueberry area compared to all berry areas. The proportion of blueberry plants varied according to the type of planting materials (a high proportion for plugs, and lower proportions for potted plants and unrooted cuttings compared to other P4P like ornamentals). Finally, the numbers of P4P in the different categories were multiplied by the estimated proportions of blueberry plants. This resulted in estimates of 2.6 million P4P from the whole USA and Canada, and 276,000 P4P from countries with low prevalence of *D. vaccinii* (Belarus, Chile, China and Russia) in 2015.

3) Export data:

Export data from State Certification Agencies and from the largest *Vaccinium* nursery in the USA indicate that about 6 million blueberries P4P were exported to the EU from the USA in 2016, and that most of these exports were small plants (plugs) in trays derived from tissue cultures. Tissue culture material (aseptic) and larger potted plants were exported less frequently. Altogether, export data indicate that calculations of P4P based on projected needs and estimated imports underestimate the number of P4P imported into the EU. However, large nurseries project that the number of P4P (except for tissue culture) exported to the EU will drop in the near future because subsidiaries of USA companies have been established recently in the EU and surrounding countries like Morocco, where P4P are produced. However, import of P4P from Morocco is totally unknown.

A.1.3.2.1. Total trade flow of blueberries from countries with *D. vaccinii*

PE0 – Trade volumes of plants for planting.

Table A.43: Trade volumes of P4P plugs (blueberries) predicted for 2017 according to country incidence category exporting to the EU (based on data reported from 2013–2016) for the A0, A1 and A2 scenarios, respectively

Location incidence category	Percentiles				
	1%	**25%**	**50%**	**75%**	**99%**
A0					
1 (C&E USA)	50,000	150,000	200,000	300,000	500,000
2 (Can, W USA, China, Chile)	1,000,000	3,500,000	5,000,000	5,500,000	7,000,000
A1					
1 (C&E USA)	100,000	300,000	500,000	700,000	1,000,000
2 (Can, W USA, China, Chile)	1,000,000	3,500,000	5,000,000	5,500,000	7,000,000
A2					
1 (C&E USA)	50,000	150,000	350,000	500,000	700,000
2 (Can, W USA, China, Chile)	800,000	3,000,000	4,000,000	5,000,000	6,000,000

Justification

Calculations from EUROSTAT import data indicate that in 2015, approximately 2.6 million blueberry P4P were imported from the whole of the USA (EUROSTAT does not distinguish between western and eastern USA) and Canada, while 300,000 were imported from Belarus, Chile, China and Russia. However, export data from individual states in the USA (USDA-APHIS, 2017) indicate that much larger numbers of plants were sent to the EU in 2016 (at least 6 million P4P in total). Thus, the median values are based on a combination of information from exporters and the need for blueberry plants in the EU (considering that plugs would be imported 2 years in advance of field planting, and that more plugs are ordered than needed in the EU; see Table C.16).

For this PRA, the USA is split into two incidence categories (cat 1 and cat 2) according to the central and eastern USA (cat 1 with high prevalence of *D. vaccinii*) and the western USA (cat 2 with low prevalence of *D. vaccinii*). The median estimated number of plugs from cat 1 territories is 200,000, while that from cat 2 territories is 5,000,000 under the current scenario (slightly less than the number imported from the Western USA in 2016). Under scenario A1 (deregulation), the number of plugs imported from third countries would expected to remain the same, if the price does not change relative to that of locally produced plants. Under scenario A2 (stricter regulation), we predict a slight decrease in the number of imported plugs from third countries, in favour of a shift of purchasing plugs from EU nurseries.

Uncertainty

Estimates of uncertainties for the A0 scenario are based on variability in trade volumes over the past several years as well as variation dependent on the source of information used. A recent increase in blueberry production in the EU with associated demand for new plants may not be sustained. Additionally, a greater proportion of P4P may be produced within the EU.

Possible changes in the type of plants imported may occur. Under the A1 scenario, it is possible that sales of certified plugs will increase slightly compared to the A0 scenario if growers favour importing cheaper plug plants. Under the A2 scenario, it is likely that sales of imported plugs will decrease in favour of EU produced plants. It is not clear how much of a shift in sourcing of plants will occur as there are no data for scenarios A1 or A2.

A.1.3.2.2. Trade volumes of P4P potted plants including ornamentals (blueberries)

PE0 – Trade volumes of plants for planting.

Table A.44: Trade volumes of P4P potted plants including ornamentals (blueberries) predicted for 2017 according to country incidence category exporting to the EU (based on data reported from 2013–2016) for the A0, A1 and A2 scenarios, respectively

Location incidence category	Percentiles				
	1%	**25%**	**50%**	**75%**	**99%**
A0					
1 (C&E USA)	5,000	7,000	10,000	15,000	25,000
2 (Can, W USA, China, Chile)	50,000	175,000	250,000	275,000	350,000
A1					
1 (C&E USA)	5,000	30,000	50,000	65,000	100,000
2 (Can, W USA, China, Chile)	50,000	175,000	250,000	275,000	350,000
A2					
1 (C&E USA)	1,000	3,500	5,000	6,500	10,000
2 (Can, W USA, China, Chile)	200	20,000	50,000	100,000	200,000

Justification

Again, the USA is split into two prevalence categories according to the central and eastern USA (high prevalence) and the western USA (low prevalence). The ratios of potted plants to plug plants were calculated from export data provided by a large blueberry nursery in the USA (1:20 or 0.05 in 2016). Under the A1 scenario (deregulation), the number of potted plants from central and eastern USA will likely increase because this area of the USA is closer to the EU, but the uncertainty range will also increase. The number of potted plants from the western USA and Canada may decrease accordingly, but the numbers of potted plants may increase from low cost areas in cat 2 such as China and Belarus (which exports P4P to the EU according to EUROSTAT data). Thus, the number of plants imported from cat 2 locations is expected to remain the same. Under the A2 scenario, it is likely that sales of potted plants will reduce due to additional costs associated with restrictions or additional regulations imposed on their production. The proportional reductions (compared to A0) in the high-risk regions are likely to be greater than those from the low-risk regions, where pest-free areas can still be found.

Uncertainty

Estimates of uncertainty for the A0 scenario are based on variability in trade volumes over the past several years. A recent increase in blueberry production in the EU with associated demand for imported plants may not be sustained. Instead, potted plants may be produced more within the EU or neighbouring third countries. Moreover, the ratio of potted plants to plug plants may not be 1 in 20 (0.05) but larger (1 in just over 4 (0.24) according to the estimated imports from EUROSTAT data).

Possible changes to the type of plants imported (plugs or more expensive larger potted plants) may occur. Under the A1 scenario, it is possible that sales of plugs will increase slightly compared to the A0 scenario if growers favour importing new varieties from the USA. Thus, there is a lot of uncertainty about the calculations and shifts in production and plant imports.

A.1.3.2.3. Proportion of blueberry plants having *D. vaccinii* in the countries of origin at the place of production

ϵ**1** – Proportion of blueberry plants having *D. vaccinii* in the countries of origin at the place of production.

Evidence:

In berry production fields, the incidence of disease caused by *D. vaccinii* in cat 1 areas can be quite high (90–100% of the fields infected, and 9–40% in-field incidence), and the pathogen can be isolated from a large proportion of symptomless stem sections (Weingartner and Klos, 1975; Parker and Ramsdell, 1977). Even in the best fungicide-treated plots, the percentage of blighted twigs can be as high as 20% (Cline, 2000, 2007). Unlike the high prevalence and incidence in cat 1 areas, the incidence and severity are clearly less in cat 2 areas. For example, Oregon has a prevalence of 5–10% (A. Schilder, hearing expert).

While plug plants produced from tissue culture are grown in protected greenhouses and are hardly exposed to *D. vaccinii*, large potted plants are grown outdoors at the production site, even when they originate from tissue culture and may therefore be exposed to natural inoculum (A. Schilder and P. Harmon, hearing experts). Larger potted plants are sometimes imported by EU growers from third countries and may be infected, e.g. a US consignment of 2-year-old potted blueberry plants to Spain in 2016 was held up, because they had symptoms similar to twig blight but these were caused by a related species, *D. eres* (A. Schilder, hearing expert). There is also trade in various *Vaccinium* plants for the ornamental market, including bonsai plants. The quality of potted plants for household use can be lower than that of plants used for professional berry production (A. Schilder and P. Harmon, hearing experts).

A.1.3.2.4. Proportion of plants infected with *D. vaccinii* on P4P plugs (blueberries)

Table A.45: Proportion of plants infected with *D. vaccinii* on P4P plugs (blueberries) predicted for 2017 according to country incidence category exporting to the EU for the A0, A1 and A2 scenarios

Location incidence category	Percentiles				
	1%	25%	50%	75%	99%
A0					
1 (C&E USA)	0	0.0000001	0.0000002	0.0000004	0.000001
2 (Can, W USA, China, Chile)	0	0.0000001	0.0000002	0.0000004	0.000001
A1					
1 (C&E USA)	0	0.0000002	0.0000004	0.0000008	0.000002
2 (Can, W USA, China, Chile)	0	0.0000001	0.0000002	0.0000004	0.000001
A2					
1 (C&E USA)	0	0.0000001	0.0000002	0.0000004	0.000001
2 (Can, W USA, China, Chile)	0	0.0000001	0.0000002	0.0000004	0.000001

Justification

Infection rates were estimated from expert testimony and the literature on past outbreaks in the EU (9 outbreaks that were mostly eradicated plus one interception in 20 years). Due to nursery workers eliminating affected plants, we estimated 2 times more infections are likely to occur than the nine reported outbreaks (established infections) in the past 20 years in the EU, which means one infection per year or one in 6 million imported P4P may be infected, which supports evidence provided by hearing experts. Plugs from tissue culture, produced in glasshouses are now the main source of new plants and are considered to have the same low risk regardless of location (cat 1 or cat 2). China is considered a cat 2 country because *D. vaccinii* was isolated in China (Li et al., 2015; Su et al., 2012 (in GenBank); QingHua et al., 2015; Yue and Liang, 2013 (in GenBank); Zhang et al., 2014 (in GenBank)), although it does not occur in the EPPO database. Under the A0 scenario, plant producers keep plants protected and frequently treated with fungicides. Compared to the current A0 scenario, it is estimated that deregulation (A1) will cause infection rates in traded plug plants to increase slightly (by a factor of two at these low rates) based on an increased likelihood that some plugs may be left outdoors for hardening-off and the absence of rejection if *D. vaccinii* is found during inspections. The A2 scenario assumed no change in infection rates for plug plants as the infection rate is already low.

Uncertainty

The main uncertainty is due to the absence of information combined with a variation in production practices and exposure of plugs to inoculum at the controlled production sites. Additional uncertainties may be due to misidentification of infection, and inadvertent control of infection by producers to control other pathogens or to tidy up plants. It is unclear how scenarios A1 and A2 will impact on the proportion of plants affected. We have assumed no change other than a small increase under A1 in high-risk (cat 1) locations.

A.1.3.2.5. Proportion of plants infected with *D. vaccinii* on P4P potted plants (blueberries)

ϵ1 – Proportion of blueberry plants having *D. vaccinii* in the countries of origin at the place of production.

Table A.46: Proportion of plants infected with *D. vaccinii* on P4P potted plants (blueberries) predicted for 2017 according to country incidence category exporting to the EU for the A0, A1 and A2 scenarios

Location incidence category	Percentiles				
	1%	**25%**	**50%**	**75%**	**99%**
A0					
1 (C&E USA)	0	0.0001	0.001	0.002	0.003
2 (Can, W USA, China, Chile)	0	0.00001	0.0001	0.0002	0.0003
A1					
1 (C&E USA)	0.01	0.003	0.030	0.06	0.090
2 (Can, W USA, China, Chile)	0	0.00002	0.0002	0.0004	0.0006
A2					
1 (C&E USA)	0	0.000001	0.00001	0.00002	0.00003
2 (Can, W USA, China, Chile)	0	0.0000001	0.000001	0.000002	0.000003

Justification

Large potted plants typically spend 1–3 years outdoors on plastic sheets; they are treated with fungicides but still may become exposed to some natural inoculum. Smaller potted plants are typically kept under protection and so are exposed to natural inoculum to a limited extent. Infection rates on potted plants were estimated from expert testimony. Rates of infection for potted plants are highest for cat 1 regions and are estimated to be ten times lower for cat 2 regions based on expert testimony. Infection rates in commercial P4P production facilities are considered to be much lower than those of berry producers in production fields. A. Schilder (hearing expert) reported 2–3% infection on potted P4P grown outside, which is much lower than infection rates reported in commercial production fields in Michigan (90% of fields affected and up to 100% incidence of infection within fields).

Compared to the current A0 scenario, it is estimated that specific deregulation (A1) will cause infection rates in potted plants to increase. This is estimated not to be linear but to vary according to the inoculum pressure of the region (cat 1 or cat 2 locations). The proportional increase in infection rates under A1 are estimated as x30 for cat 1 regions and x2 for cat 2 regions, because shipments will not be rejected when *D. vaccinii* is present, and the incidence in cat 1 regions may be 15 times as high as that in cat 2 regions. This is still much less than the proportion of plants affected currently in production fields because plant traders will still have commercial pressure to supply healthy plants. The A2 scenario assumed a reduction by a factor of 100 in infection rates due to the absence of import of potted plants from *D. vaccinii* infested areas and more careful inspection during production.

Uncertainty

There are no changes in factors causing uncertainty between scenarios but uncertainty over natural exposure to inoculum, which varies from location to location, even within the current incidence categories, is much greater for potted plants than for plugs. Additional uncertainties may be due to limited data, underreporting or misidentification of infection, and inadvertent control of infection by operations to control other pathogens or to tidy up plants. Plant production and disease control methods vary from one producer to another, which contributes to uncertainty.

A.1.3.3. Cranberry plants for planting

A.1.3.3.1. Trade volumes of cranberry P4P plugs

PE0 – Trade volumes of plants for planting.

Evidence:

Cranberries are primarily multiplied from local materials in the EU (survey results). Very little information is available about the importation of cranberry P4P, but the area planted with cranberry in the EU is much smaller than that with blueberry (FAOSTAT, online), resulting in much lower trade flows than those of blueberry plants. The numbers of cranberry P4P were derived from:

1) The need for cranberry plants:

   The need for cranberry P4P is calculated based on planting area, number of plants per Ha, and turnover. The yearly demand for P4P is calculated from the number of cuttings needed to fill the demand from replacement of old production sites and new planting. There are 100,000 upright stems plants per Ha, typically, originating from approx. 40,000 cuttings per Ha (Patty McManus, personal communication). The turn-over time for cranberry is relatively long at 25–50 years (time from planting to re-establishing a production field). An average turnover time of 30 years was assumed. Assuming that European nurseries provide 90% of cranberry P4P (nursery survey results), the demand for imported cranberry P4P is calculated to be 53,333 per year. All traded plants are *V. macrocarpon*, i.e. the USA-native species. The production area for cranberries in the EU is 400 ha (FAOSTAT, 2013a,b). This does not include a large area of Latvia that produces a different species of cranberry, *V. oxycoccus*.

2) Export data:

   Export data is limited. Information was obtained from the State certification agency of Wisconsin (USDA-APHIS, 2017). A bale of cranberry cuttings was exported to Poland in 2015 and another bale was expected to be exported in 2017.

While some plant producers in the EU use tissue culture for cranberries (G. Savini, hearing expert; results from questionnaires), cranberry P4P are not routinely produced from tissue culture in the USA. The vast majority of imported P4P are from cuttings, even in the case of plug plants (Patty McManus, personal communication). Thus, import of cranberry plug plants is very limited compared to that of blueberry plants. The demand for cranberry plants is also much less than that for blueberry in the EU and so trade flows in P4P are also much less.

Table A.47: Trade volumes of P4P plugs (cranberries) predicted for 2017 according to country incidence category exporting to the EU

Location incidence category	Percentiles				
	1%	**25%**	**50%**	**75%**	**99%**
A0					
1 (C&E USA, Can)	5,000	15,000	20,000	30,000	50,000
2 (W USA, China, Chile, Belarus, Russia)	10,000	20,000	30,000	40,000	60,000
A1					
1 (C&E USA, Can)	1,000	3,000	8,000	10,000	15,000
2 (W USA, China, Chile, Belarus, Russia)	10,000	20,000	30,000	40,000	60,000
A2					
1 (C&E USA, Can)	5,000	15,000	15,000	25,000	40,000
2 (W USA, China, Chile, Belarus, Russia)	10,000	20,000	35,000	45,000	70,000

A.1.3.3.2. Trade volumes of P4P cranberry bales, unrooted cuttings and potted plants

<u>Justification</u>

The import of cranberry plants (*V. macrocarpon*, the USA-native species) was estimated from the need for plants based on planting area, number of plants per Ha, and turnover (see Table C.16). Expansion of the cranberry area in the EU is assumed to be very limited. European nurseries are assumed to provide 90% of cranberry P4P (nursery survey results), leading to an estimation for the demand for imported cranberry P4P to be about 53,000 per year, but due to uncertainties, the PRA assumes a median trade flow of 50,000 plugs per year under A0.

The estimated trade flow of tissue culture derived plugs under A1 is based on one-third of A0 in high-prevalence regions assuming that cheaper cuttings would be used instead of plug plants. We expect no change in the import of plug plants from the low-prevalence regions under A1. However, under the A2 scenario, no unrooted cuttings or large potted plants would be allowed from severely affected cat 1 regions and this change could lead to a slight increase in plug plants from less-affected regions like the W USA, accompanied by a similar decrease in plug plants from the high-prevalence areas.

Uncertainty

Uncertainty is mainly due to a lack of data on imported cranberry plants. Cranberry plants are often multiplied locally from the mowings of existing cranberry production fields, but import of high-yielding USA cultivars is possible. Trade flows in imported cranberry plants were estimated at approximately one-tenth that of blueberry plants but vary tremendously due to changes in demand. Uncertainty about import of P4P from low-prevalence areas is even greater, but cranberry production is increasing in Chile and China, which may lead to increased numbers of P4P exported to the EU. However, the uncertainty about this is large.

Table A.48: Trade volumes of P4P bales, unrooted cuttings and potted plants (cranberries) predicted for 2017 according to country incidence category exporting to the EU

Location incidence category	Percentiles				
	1%	25%	50%	75%	99%
A0					
1 (C&E USA, Can)	0	1,500	3,500	4,500	10,000
2 (W USA, China, Chile, Belarus, Russia)	0	500	1,000	2,500	5,000
A1					
1 (C&E USA, Can)	0	3,000	7,000	9,000	20,000
2 (W USA, China, Chile, Belarus, Russia)	0	500	1,000	2,500	5,000
A2					
1 (C&E USA, Can)	0	0	0	0	0
2 (W USA, China, Chile, Belarus, Russia)	0	1500	3,000	4,500	8,000

Justification

Although there is little information about the import of potted plants into the EU, information supplied by the State Authorities in Wisconsin (emails on February 3 and 6, 2017) indicated that one bale of cranberry mowings (about 25 kg) from a production field was exported to Poland in 2015. The material was accompanied by a certificate because the field had been inspected and found free from visible symptoms. It was estimated that one bale of 25 kg could supply 3,000 unrooted cranberry cuttings. In addition, 500 potted plants were estimated in the trade flow from cat 1 areas. Only 1,000 potted plants were estimated to be exported from cat 2 areas, which are located at a greater distance from the EU compared to cat 1 areas.

The estimated trade flow of unrooted cuttings and potted plants under A1 is estimated at double that from under A0, because unrooted cuttings are a cheaper source of plants and the risk of rejections due to *D. vaccinii* would be reduced, even though import and export inspections would remain in place. However, under the A2 scenario, no unrooted cuttings or large potted plants would be allowed from severely affected cat 1 regions, leading to a slight increase from less-affected regions.

Uncertainty

Trade flows in cranberry plants and cuttings are highly uncertain due to the absence of firm trade data. The main variation is due to variations in demand and price, including transportation costs. There may also be unregulated movement of P4P for example from non-EU Eastern European countries into the EU (personal communication Tomasz Kałuski, Instytut Ochrony Roslin, Poland).

A.1.3.3.3. Proportion of cranberry P4P infected with *D. vaccinii* predicted

ϵ1 – Proportion of cranberry plants having *D. vaccinii* in the countries of origin at the place of production.

Evidence:

There is little quantitative information in the literature on the incidence or severity of *D. vaccinii*-induced dieback on cranberry plants. A. Schilder (hearing expert) and P. McManus (consulted expert) reported the percentage of cranberry plants infected with *D. vaccinii* as 1–20% and the prevalence (% fields affected) as 80% in C&E USA (cat 1). Individual twigs were reported to become infected and die in a matter of weeks but the whole plant does not die, which is partially the reason why the disease can persist. P. McManus reports higher disease pressure in New Jersey, which is an important production area for new varieties that are traded overseas.

Incidence of infection is thought to be higher for cranberry than for blueberry as production fields are used for propagation. Nevertheless, no interceptions of cranberry P4P have occurred in the EU to date, possibly due to the relatively low numbers of imported cranberry plants. However, recent outbreaks in Poland were on cranberries (Michalecka et al., 2017).

As bales of cranberry cuttings were not imported into the EU until recently and the risk of introduction of *D. vaccinii* with cranberry fruit is likely minimal, the PRA used the number of *D. vaccinii* outbreaks on cranberries in the EU during the past ten years to estimate the percentages of infected cranberry plants introduced into the EU. The difference between plugs and potted plants is minimal in this respect, because both are produced from cuttings exposed to *D. vaccinii* in areas where *D. vaccinii* occurs. The first report of *D. vaccinii* on cranberry in the EU was in Lithuania in 2004 (EPPO data). A second outbreak on *V. macrocarpon* occurred in 2013 in Poland (Michalecka et al., 2017). The number of imported infected plants is estimated to be two times more than the number of outbreaks due to nursery workers eliminating affected plants by routine rogueing without formally identifying the pathogen.

Table A.49: Proportion of plants infected with *D. vaccinii* on P4P plugs (cranberries) predicted for 2017 according to country incidence category exporting to the EU

Location incidence category	Percentiles				
	1%	25%	50%	75%	99%
A0					
1 (C&E USA, Can)	0	0.000002	0.00002	0.00005	0.0001
2 (W USA, China, Chile, Belarus, Russia)	0	0.00000002	0.0000002	0.0000005	0.000001
A1					
1 (C&E USA, Can)	0	0.000004	0.00004	0.0001	0.0002
2 (W USA, China, Chile, Belarus, Russia)	0	0.00000004	0.0000004	0.000001	0.000002
A2					
1 (C&E USA, Can)	0	0.0000002	0.000002	0.000005	0.00001
2 (W USA, China, Chile, Belarus, Russia)	0	0.00000002	0.0000002	0.0000005	0.000001

Justification

Plugs of cranberry plants are generally not produced from tissue culture, although they are grown under controlled conditions. Assuming that 20,000 plug plants (plus 500 potted plants) were imported every year from high-risk countries, and 200,000 in 10 years, two outbreaks but four imports would result from a 0.00002 proportion of plants infected. Thus, in cat 1 areas, plug plants can have a significant infection risk, but the estimate is between that of blueberry plugs (from tissue culture) and blueberry potted plants. Infection rates in cat 2 areas are considered 100-fold lower than those in cat 1 areas based on expert opinion.

Under the A1 scenario, infection rates for plug plants are estimated to be twofold higher than those under the A0 scenario in both the high-prevalence and low-prevalence regions, because no rejections due to the *D. vaccinii* presence would be expected, although export inspection and certification and import inspection would remain in place. Under A2, no changes in infection rates are expected for plug plants from cat 2 areas as infection risk is low. However, under A2, the infection rates are thought to be 10-fold reduced by the extra regulations in cat 1 areas, because stricter regulations will be in place for greenhouse production. No change is predicted for cat 2 regions.

Uncertainty

Uncertainty in the proportion of plants affected is due to natural variability in exposure of plants to the pathogen, when plants are not produced from tissue culture. Moreover, the proportion of plants affected may increase in cat 2 regions or countries currently without the pathogen present (cat 3) that may change to cat 2.

A.1.3.3.4. Proportion of cranberry P4P bales, unrooted cuttings and potted plants predicted to be infected with *D. vaccinii*

ϵ1 – Proportion of cranberry plants having *D. vaccinii* in the countries of origin at the place of production.

Table A.50: Proportion of plants infected with *D. vaccinii* on P4P bales, unrooted cuttings and potted plants (cranberries) predicted for 2017 according to country incidence category exporting to the EU

Location incidence category	Percentiles				
	1%	**25%**	**50%**	**75%**	**99%**
A0					
1 (C&E USA, Can)	0	0.0002	0.002	0.005	0.01
2 (W USA, China, Chile, Belarus, Russia)	0	0.00000002	0.0000002	0.0000005	0.000001
A1					
1 (C&E USA, Can)	0	0.0004	0.004	0.01	0.02
2 (W USA, China, Chile, Belarus, Russia)	0	0.00000004	0.0000004	0.000001	0.000002
A2					
1 (C&E USA, Can)	0	0	0	0	0
2 (W USA, China, Chile, Belarus, Russia)	0	0.00000002	0.0000002	0.0000005	0.000001

The infection rates on potted plants and bales are considered to be higher than that on plugs, even though all categories are originating from stem cuttings. Bales are imported straight from an inspected production field, but it is difficult to inspect all plants in a field. Infection rates for potted plants and bales are highest for cat 1 regions and estimated to be 100-fold higher than plugs. Bales are not imported from cat 2 locations, and the infection rates are considered the same as those of plugs. Under the A1 scenario, infection rates for potted plants and bales of plants (unrooted cuttings) are estimated to be twofold higher than those under the A0 scenario in both the cat 1 and cat 2 regions, because no rejections due to the *D. vaccinii* presence would be expected, although export inspection and certification and import inspection would remain in place. Under A2, no cranberry cuttings or potted plants will be allowed from cat 1 regions (disease risk 0), while no change in infection rate is predicted for cat 2 regions, as rejection of loads with *D. vaccinii* symptoms will remain in place.

Uncertainty

Variation in the proportion of plants affected is included in the range presented in the table and is due to natural variability in exposure of plants to the pathogen, particularly for unrooted cuttings (bales) and large potted plants which have been outdoors.

Additional uncertainty remains due to the proportion of plants affected potentially increasing in cat 2 regions or countries currently without the pathogen present. There is also large uncertainty about potential imports from Belarus; free movement of people from this country into Poland (100 km from the border) is allowed (Tomasz Kałuski, Instytut Ochrony Roslin, Poland, personal communication). The disease has been reported as being widespread, but the pathogen has not been identified with molecular tools in Belarus.

A.1.3.3.5. Proportion of infected plants for planting that are removed before being further shipped for export. There are no packing houses. The material leaving the nursery goes straight to the port for export. (both blueberry and cranberry)

ϵ2 – This parameter was set to zero.

A.1.3.3.6. Proportion of infected plants for planting that are removed at export inspection at the EU point of entry (both blueberry and cranberry)

ϵ3 – Proportion of infected plants for planting that are removed at export inspection at the EU point of entry (both blueberry and cranberry).

A phytosanitary certificate is added to each shipment of plants. This is issued by the State plant pest regulatory agency, who visit the production site and check before export, whether the consignment is compliant with the requirements. Therefore, there is currently no additional inspection at the exporting country border and this process.

In all cases, 100% of the symptomatic plants are assumed to be removed before shipment. Weingartner and Klos (1975) isolated *D. vaccinii* from 38% of 242 symptomless stem sections, and 25% of 38 symptomatic stem sections in Michigan and Indiana. For this PRA, it is assumed that about half of the infections are asymptomatic at the plant production stage. Therefore, only half of the infected plants are assumed to be removed before they are shipped.

A.1.3.3.7. Proportion of infected plants for planting that are removed at import inspection at the EU point of entry

Evidence:

Currently only < 1% of plugs in trays are inspected at the EU border (although it is assumed that the exporting company removed any symptomatic plants before shipment and the recipient company will also make an inspection). For larger potted plants, a more detailed inspection at the EU border is thought to occur. No increase in abundance is likely during transport of plants carrying symptomless infections. However, the appearance of symptoms from existing infections can occur, which may affect subsequent detection if plants are inspected. No change in the appearance of infection is likely with air freighted plants due to travel time being very short but appearance of new symptoms on latently infected plants could occur with surface shipped plants (in particular potted plants), allowing the possibility of border inspection noticing some infections.

The incubation period (time from infection to symptom development) on blueberry ranges from 3 weeks to 3 months (A. Schilder, hearing expert). There was only one notification in EUROPHYT in the last 30 years, which was in 1996, when Milano airport identified *D. vaccinii* on *Vaccinium* P4P from the USA. No increase in abundance is likely during transport of plants with symptomless infections. However, the appearance of existing infections that were incubating can occur, which may affect subsequent detection if plants are inspected.

Table A.51: Proportion of infected plants at the EU border that could be detected visually and removed (blueberry plugs)

Location incidence category	Percentiles				
	1%	**25%**	**50%**	**75%**	**99%**
A0					
1 (C&E USA)	0	0.00001	0.0001	0.0003	0.001
2 (Can, W USA, China, Chile)	0	0.00001	0.0001	0.0003	0.001
A1					
1 (C&E USA)	0	0.00001	0.0001	0.0003	0.001
2 (Can, W USA, China, Chile)	0	0.00001	0.0001	0.0003	0.001
A2					
1 (C&E USA)	0	0.00001	0.0001	0.0003	0.001
2 (Can, W USA, China, Chile)	0	0.00001	0.0001	0.0003	0.001

Justification

The table above shows proportions of **infected plants** that could be detected and removed, not a proportion of all plants. The numbers in the tables are used to calculate the number of infected plants removed from the entry pathway at the border inspection. Proportions are very low for plugs because the plants are young and so there are usually no developed symptoms. Any visual symptoms will be small and easily missed; the main symptom being wilted shoots. Our estimate of likely detection is based on expert opinion with a median at one detection per thousand infected plants and an upper (99%) range a factor of ten less than that and a lower (1%) range at zero (i.e. unable to detect any infected plants because they are all latent infections). In addition, currently only < 1% of plugs in trays are inspected at the EU border. We assume that > 99% of infected P4P are symptomless infections when packed for export because those with symptoms will be discarded by the producer before export. Hence, the table above shows only the proportion of infected plants that might be detected and removed. No changes to these values are expected under scenarios A1 nor A2 and there is no difference in the chance of an infected plant being noticed between those originating from cat 1 and cat 2 locations. Differences in the proportion of infected plants between locations are already considered in the previous steps.

Uncertainty

Uncertainty is based on the assumption that > 99% of infected P4P are symptomless when packed for export. If the figure is actually less than this, we should expect more infected plants to be noticed and removed at the original exporting company, which will lower the proportion of infected plants being shipped but will not significantly alter the chances of symptomless infected plants being noticed at inspection. If the figure is actually more than this, then we will have very slightly underestimated the number of infected plants passing unnoticed. The figures also assume that less than 1% of plants are actually inspected, which may change according to the policy of a member state border force.

A.1.3.3.8. Proportion of infected plants at the EU border that could be detected visually and removed (blueberry potted plants)

ϵ**4** – Proportion of infected plants at the EU border that could be detected visually and removed.

Table A.52: Proportion of infected plants at the EU border that could be detected visually and removed (blueberry potted plants)

Location incidence category	Percentiles				
	1%	**25%**	**50%**	**75%**	**99%**
A0					
1 (C&E USA)	0.05	0.15	0.25	0.35	0.5
2 (Can, W USA, China, Chile)	0.05	0.15	0.25	0.35	0.5
A1					
1 (C&E USA)	0.05	0.15	0.25	0.35	0.5
2 (Can, W USA, China, Chile)	0.05	0.15	0.25	0.35	0.5
A2					
1 (C&E USA)	1	1	1	1	1
2 (Can, W USA, China, Chile)	0.05	0.15	0.25	0.35	0.5

NB Where the pathway is not applicable due to restrictions in trading, a score of 1 has been entered, which means that all plants will be removed (since this type of material is not allowed) and so the number of plants imported under this category will be zero.

Justification

For larger potted plants, a more detailed inspection is thought to occur than for plug tray plants but still only a few per cent of plants are inspected. Again, it is assumed that > 99% of infected P4P are symptomless when packed for export because those with symptoms will be discarded by the producer. Hence, the table above shows only the proportion of infected plants that might be detected and removed. Based on expert opinion and a greater severity of symptoms appearing on larger potted plants than plug-tray plants, our estimated median proportion of infected plants detected and removed at the EU border is 0.25 and an upper (99%) range is 0.5 (i.e. 50% of affected plants will be noticed and removed), while the lower (1%) range is 0.05 (i.e. 5% of affected plants will be noticed. No changes to these values are expected under scenarios A1 nor A2 for cat 2 locations but the trade will be restricted under scenario A2 for cat 1 locations so a value of 1 is used in the table above, indicating that all plants will be removed.

Uncertainty

The appearance of symptoms from existing infections depends on the transport period and conditions during transport. These are variable and may affect subsequent detection if plants are inspected. As for plugs, uncertainty is based on the assumption that >99% of infected P4P are symptomless when packed for export. Variation in this percentage can give a slight under- or overestimate as described for plugs.

A.1.3.3.9. Proportion of infected plants at the EU border that could be detected visually and removed (cranberry plug plants)

ϵ4 – Proportion of infected plants at the EU border that could be detected visually and removed.

Table A.53: Proportion of infected plants at the EU border that could be detected visually and removed (cranberry plug plants)

Location incidence category	Percentiles				
	1%	25%	50%	75%	99%
A0					
1 (C&E USA, Can)	0	0.00001	0.0001	0.0003	0.001
2 (W USA, China, Chile, Belarus, Russia)	0	0.00001	0.0001	0.0003	0.001
A1					
1 (C&E USA, Can)	0	0.00001	0.0001	0.0003	0.001
2 (W USA, China, Chile, Belarus, Russia)	0	0.00001	0.0001	0.0003	0.001
A2					
1 (C&E USA, Can)	0	0.00001	0.0001	0.0003	0.001
2 (W USA, China, Chile, Belarus, Russia)	0	0.00001	0.0001	0.0003	0.001

Justification

The incubation period for cranberry is similar to that on blueberry, viz. up to 3 months (P McManus, consulted expert). Thus, the appearance of existing infections that were incubating can occur, which may affect subsequent detection if plants are inspected. Currently, only < 1% of plugs in trays are inspected. We assume that > 99% of infected plug P4P symptomless, for the same reason as given for blueberries. There have been no interceptions at the EU border on cranberry P4P. Based on expert opinion, our estimated median proportion of infected plug-tray plants detected and removed at the EU border is one per thousand infected plants and an upper (99%) range is one in 100, while the lower (1%) range is 0 (i.e. there is a 1% chance that no infected plants will be noticed due to all infections being latent). No changes to these values are expected under scenarios A1 nor A2 and there are no differences due to the origin of the plants (cat 1 or cat 2 locations, as differences in the proportion of plants affected is already considered in a previous step).

Uncertainty

Uncertainty is based on the assumption that > 99% of infected P4P are symptomless when packed for export, and that no changes in infection occur during transportation. As explained above, the transport duration and conditions may be variable, resulting in variable symptom development. Variations in the percentage symptomless infections can lead to slight under- or overestimations, as described above.

A.1.3.3.10. Proportion of infected plants at the EU border that could be detected visually and removed (cranberry unrooted cuttings and potted plants)

ϵ4 – Proportion of infected plants at the EU border that could be detected visually and removed.

Table A.54: Proportion of infected plants at the EU border that could be detected visually and removed (cranberry unrooted cuttings and potted plants)

Location incidence category	Percentiles				
	1%	25%	50%	75%	99%
A0					
1 (C&E USA, Can)	0.005	0.015	0.025	0.035	0.05
2 (W USA, China, Chile, Belarus, Russia)	0.005	0.015	0.025	0.035	0.05
A1					
1 (C&E USA, Can)	0.005	0.015	0.025	0.035	0.05
2 (W USA, China, Chile, Belarus, Russia)	0.005	0.015	0.025	0.035	0.05

Location incidence category	Percentiles				
	1%	**25%**	**50%**	**75%**	**99%**
A2					
1 (C&E USA, Can)	1	1	1	1	1
2 (W USA, China, Chile, Belarus, Russia)	0.005	0.015	0.025	0.035	0.05

NB Where the pathway is not applicable due to restrictions in trading, a score of 1 has been entered, which means that all plants will be removed (since this type of material is not allowed) and so the number of plants imported under this category will be zero.

Justification

For larger potted plants, a more detailed inspection is thought to occur than for plug tray plants but still only a few per cent of plants are inspected. In contrast, it is impossible to check most unrooted cuttings that are transported as a bale because they will be within the bale. No change in the appearance of infection is likely with air freighted plants due to travel time being very short but appearance of new symptoms on latently infected plants could occur with surface shipped plants, allowing the possibility of border inspection noticing some infections. However, symptoms may appear on previously asymptomatic but infected plants, which may affect subsequent detection if plants are inspected. We assume that > 99% of infected P4P are symptomless incubating infections when packed for export because those with symptoms will be discarded by the producer.

There have been no interceptions at the EU border on cranberry P4P. However, the recent practice of importing bales of cut stems directly taken from the production field as material for P4P is considered to be a high-risk activity and it is not possible for inspectors to see any of the internal plant material.

Based on expert opinion and a greater severity of symptoms appearing on larger potted plants than plug-tray plants, but a reduced ability to inspect baled cuttings, our estimated median proportion of infected plants detected and removed at the EU border is 0.025 (i.e. 2.5% of infections will be noticed) and an upper (99%) range is 0.05 (i.e. 5% of affected plants will be noticed and removed), while the lower (1%) range is 0.005 (i.e. 0.5% of affected plants will be noticed). No changes to these values are expected by location or under scenarios A1 nor A2 apart from that trade in this material from cat 1 locations will be prohibited in scenario A2. Inspectors should concentrate on potted plants rather than plugs because larger potted plants are more likely to have visible symptoms.

Uncertainty

Uncertainty is based on the assumption that > 99% of infected P4P are symptomless when packed for export, and that no changes in infection occur during transportation. However, the transport duration and conditions may be variable, resulting in variable symptom development and variable percentages of symptomless infected plants, leading to slight under- or overestimation of the numbers of plants removed at the border.

A.1.3.3.11. Proportion (or multiplier) accounting for a change in the number of infected plants for planting during intra-EU transport, e.g. due to cross-infection or cross-contamination between individual plants (cranberry unrooted cuttings and potted plants)

ϵ5 – This parameter was set to one (1)**:** no effect.

A.1.3.3.12. Proportion of infected plants for planting that are removed at the recipient nursery site in the EU (both blueberry and cranberry)

ϵ6 – Proportion of infected plants for planting that are removed at the recipient nursery site in the EU.

Evidence:

Figures in the tables below are based on the proportion of infected potted blueberry plants estimated (by expert opinion in the absence of data) to be detected at the EU border inspection (previous section), adjusted for a 6-month period at the recipient plant nursery, where further development of latent infections will cause symptoms to appear on some affected plants. Estimates are based on potted plants because it is expected that plants imported as plug plants will be potted up and will be spaced out slightly to allow for growth. There may be some pruning to encourage side shoots to develop. The incubation period is up to 3 months (A. Schilder, hearing expert), so most incubating infections should appear. It is possible that sporulation of the asexual stage could cross infect neighbouring plants if they are exposed to rain or overhead irrigation and if the plants are flowering or have pruning wounds. Hence, although most original infections on imported plants would become symptomatic and could be noticed and removed (if good practice is followed), some new infections, constituting establishment of an infection focus and described more fully in the next section (Spread) would mean that some symptomless infections remain, hence the pathogen becomes established at a new site.

Table A.55: Proportions of infected plants at the recipient site that could be detected visually and removed within 2 months of entry (blueberry plug plants)

Location incidence category	Percentiles				
	1%	25%	50%	75%	99%
A0					
1 (C&E USA, Can)	0.05	0.15	0.25	0.35	0.5
2 (W USA, China, Chile, Belarus, Russia)	0.05	0.15	0.25	0.35	0.5
A1					
1 (C&E USA, Can)	0.05	0.15	0.25	0.35	0.5
2 (W USA, China, Chile, Belarus, Russia)	0.05	0.15	0.25	0.35	0.5
A2					
1 (C&E USA, Can)	0.05	0.15	0.25	0.35	0.5
2 (W USA, China, Chile, Belarus, Russia)	0.05	0.15	0.25	0.35	0.5

Justification

The table above reflects a change in the proportion of infected plants caused predominantly by removal of symptomatic infections contrasted with a small potential component of cross-infection to new hosts. The estimated median proportion of infected plants detected and removed at the recipient nursery is 0.25 (i.e. 25% of infected plants will be removed, which is most visibly affected plants but no new latent infections) and an upper (99%) range is 0.5 (i.e. 50% of affected plants will be noticed and removed), while the lower (1%) range is 0.05 (i.e. 5% of affected plants will be noticed. No changes to these values are expected under scenarios A1 nor A2, or for plants originating from different countries.

Uncertainty

Uncertainty is based on the assumption that most infected P4P will develop symptoms within 2 months and be removed. Some nurseries may not follow good practice and may not eliminate the infections in a timely way, which could make our estimate of removed plant proportions too high. Similarly, the estimated component of cross-infection to new hosts may be greater than predicted, which will also increase the abundance of the pathogen. In contrast, good practice and lack of conditions conducive for cross infection (no watering from above or plants reared indoors) could mean that no cross-infection occurs in the initial 6-month period deemed to constitute the establishment period.

A.1.3.3.13. Proportion of infected plants at the recipient site that could be detected visually and removed within 2 months of entry (blueberry potted plants)

ϵ6 – Proportion of infected plants for planting that are removed at the recipient nursery site in the EU.

Table A.56: Proportion of infected plants at the recipient site that could be detected visually and removed within 2 months of entry (blueberry potted plants)

Location incidence category	Percentiles				
	1%	**25%**	**50%**	**75%**	**99%**
A0					
1 (C&E USA, Can)	0.05	0.15	0.25	0.35	0.5
2 (W USA, China, Chile, Belarus, Russia)	0.05	0.15	0.25	0.35	0.5
A1					
1 (C&E USA, Can)	0.05	0.15	0.25	0.35	0.5
2 (W USA, China, Chile, Belarus, Russia)	0.05	0.15	0.25	0.35	0.5
A2					
1 (C&E USA, Can)	0.05	0.15	0.25	0.35	0.5
2 (W USA, China, Chile, Belarus, Russia)	0.05	0.15	0.25	0.35	0.5

NB Where the pathway is not applicable due to restrictions in trading, a score of 1 has been entered, which means that all plants will be removed (since this type of material is not allowed) and so the number of plants imported under this category will be zero.

Justification

The table above reflects a change in the proportion of infected plants caused predominantly by removal of symptomatic infections contrasted with a small potential component of cross-infection to new hosts. The estimated proportions of infected plants detected and removed at the recipient nursery are the same as for plug plants (that were transplanted into pots upon arrival). No changes to these values are expected under scenarios A1 nor A2 for plants originating from cat 2 locations but no material of this type will be permitted from cat 1 locations under scenario A2, so a coefficient of 1, is used here to show that this pathway reduces to zero risk.

Uncertainty

Uncertainty is based on the assumption that most infected P4P will develop symptoms within 2 months and be removed. Like the estimated proportions, the uncertainties are the same for potted plants and plug plants, and are strongly affected by agricultural practices of the receiving nurseries. Limited spread of the pathogen is possible during the first 2 months, depending on the climate and irrigation system used.

A.1.3.3.14. Proportion of infected plants at the recipient site that could be detected visually and removed within 2 months of entry (cranberry plug plants)

ϵ6 – Proportion of infected plants for planting that are removed at the recipient nursery site in the EU.

Table A.57: Proportion of infected plants at the recipient site that could be detected visually and removed within 2 months of entry (cranberry plug plants)

Proportion of plants with infection visible	Percentiles				
	1%	**25%**	**50%**	**75%**	**99%**
A0					
Cat 1	0.05	0.15	0.25	0.35	0.5
Cat 2	0.05	0.15	0.25	0.35	0.5
A1					
Cat 1	0.05	0.15	0.25	0.35	0.5
Cat 2	0.05	0.15	0.25	0.35	0.5
A2					
Cat 1	0.05	0.15	0.25	0.35	0.5
Cat 2	0.05	0.15	0.25	0.35	0.5

Justification

The table above reflects a change in the proportion of infected plants caused predominantly by removal of symptomatic infections contrasted with a small potential component of cross-infection to new hosts. The estimated proportions are the same as those estimated for blueberries, because symptoms are equally obvious for both *Vaccinium* species. No changes to these values are expected under scenarios A1 nor A2, or for plants originating from different countries.

Uncertainty

Uncertainty is based on the assumption that most infected P4P will develop symptoms within 2 months and be removed. Like the estimated proportions, the uncertainties are the same for potted plants and plug plants, and are strongly affected by agricultural practices of the receiving nurseries.

A.1.3.3.15. Proportion of infected plants at the recipient site that could be detected visually and removed within 2 months of entry (cranberry unrooted cuttings and potted plants)

ϵ6 – Proportion of infected plants for planting that are removed at the recipient nursery site in the EU.

Table A.58: Proportion of infected plants at the recipient site that could be detected visually and removed within 2 months of entry (cranberry unrooted cuttings and potted plants)

Proportion of plants with infection visible	Percentiles				
	1%	**25%**	**50%**	**75%**	**99%**
A0					
Cat 1	0.05	0.15	0.25	0.35	0.5
Cat 2	0.05	0.15	0.25	0.35	0.5
A1					
Cat 1	0.05	0.15	0.25	0.35	0.5
Cat 2	0.05	0.15	0.25	0.35	0.5
A2					
Cat 1	1	1	1	1	1
Cat 2	0.05	0.15	0.25	0.35	0.5

NB Where the pathway is not applicable due to restrictions in trading, a score of 1 has been entered, which means that all plants will be removed (since this type of material is not allowed) and so the number of plants imported under this category will be zero.

Justification

The table above reflects a change in the proportion of infected plants caused predominantly by removal of symptomatic infections contrasted with a small potential component of cross-infection to new hosts. The estimated proportions of infected potted cranberry plants detected and removed at the recipient nursery are the same as those of infected potted blueberry plants. No changes to these values are expected under scenarios A1 nor A2 for plants originating from cat 2 locations. Similarly as for blueberries, no material of this type will be permitted from cat 1 locations under scenario A2, so a coefficient of 1, is used here to show that this pathway reduces to zero risk.

Uncertainty

Uncertainty is based on the assumption that most infected P4P will develop symptoms within 2 months and be removed. Like the estimated proportions, the uncertainties are the same for potted plants and plug plants, and are strongly affected by agricultural practices of the receiving nurseries. Limited spread of the pathogen is possible during the first 2 months, depending on the climate and irrigation system used.

A.2. Establishment

A.2.1. Formal model for Establishment

As mentioned under conceptual model for establishment, we divide assessment of establishment into two steps: (a) distribution of imports of infected berries and P4P in individual EU countries, and (b) the probability of establishment of *D. vaccinii* in those countries. The distribution and establishment is described first for blueberry and cranberry fruit, then for distribution and establishment of plug plants in nurseries and for distribution and establishment of potted plants and cuttings in production fields.

A.2.1.1. Distribution of imported infected blueberry and cranberry fruits

Infected blueberries and cranberries are allocated to four regions in the EU according to fixed proportions as described below.

Importation of *Vaccinium* berries is available by country (FAOSTAT). Thus, knowledge about the distribution of imported blueberries and cranberries over the EU countries is fairly firm (Table A.59). We assume that the distribution of infected blueberries and cranberries over the EU countries is similar to that of total blueberries and cranberries. The EU MS were grouped into four large regions (NW, NE, SW and SE) with similar levels of import of blueberries or cranberries and climate suitability for *D. vaccinii*. Because it is too complex to estimate the risk of import and establishment for each individual country and the numbers of infected berries would be too low for individual countries, the estimated allocations of imported blueberries or cranberries per country were added for each of the four regions, which occupy similar total areas (Table A.59). Thus, the largest import of infected blueberries (parameter *b*1) is in the NW (52%), followed by the NE (26%) and SW (22%). Similarly, the largest import of infected cranberries is in the NW (93%), and hardly any import in the NE (4%) and SW (3%). There is no import of blueberries or cranberries in the SE (0%). These are considered fixed proportions that cannot be varied independently, because they need to add up to 100%.

Table A.59: Allocation (proportion) of imported infected blueberry and cranberry P4P based on estimated imports and presence of *D. vaccinii* in neighbouring countries, and allocation of imported infected blueberry and cranberry fruits (parameter *b*1)

		Import of P4P in 2016		*D. vaccinii* present	Allocation of	Allocation of	Allocation of	Allocation of
Region in EU	**Country**	**Blueberry[a]**	**Cranberry[b]**	**or nearby[c]**	**Imported blueberry P4P[d]**	**Imported cranberry P4P[d]**	**Imported blueberry fruit[e]**	**Imported cranberry fruit[e]**
NW	Belgium	None	None	No	0.0001	0.0001	0.02	0.07
NW	Denmark	None	None	No	0.0001	0.0001	0.02	0.00
NW	Germany	Low	None	No	0.05	0.0001	0.23	0.08
NW	Ireland	None	None	No	0.0001	0.0001	0.00	0.01
NW	Luxemburg	None	None	No	0.0001	0.0001	0.00	0.00
NW	Netherlands	Low	None	No	0.05	0.0001	0.08	0.28
NW	Sweden	None	None	No	0.0001	0.0001	0.02	0.01
NW	United Kingdom	Medium	None	No	0.1	0.0001	0.15	0.48
NW EU					**0.2005**	**0.0008**	**0.52**	**0.93**
NE	Austria	None	None	No	0.0001	0.0001	0.12	0.00
NE	Czech republic	None	None	No	0.0001	0.0001	0.01	0.00
NE	Estonia	None	Low	Yes	0.01	0.1	0.00	0.00
NE	Finland	None	None	Yes	0.01	0.0001	0.03	0.01
NE	Hungary	None	None	No	0.0001	0.0001	0.00	0.00
NE	Latvia	None	Low	Yes	0.05	0.1	0.01	0.00
NE	Lithuania	None	Low	Yes	0.01	0.1	0.04	0.02
NE	Poland	Low	Medium	Yes	0.15	0.2	0.05	0.01
NE	Slovakia	None	None	No	0.0001	0.0001	0.00	0.00
NE	Slovenia	None	None	No	0.0001	0.0001	0.00	0.00

Region in EU	Country	Import of P4P in 2016 Blueberry[a]	Cranberry[b]	*D. vaccinii* present or nearby[c]	Allocation of Imported blueberry P4P[d]	Allocation of Imported cranberry P4P[d]	Allocation of Imported blueberry fruit[e]	Allocation of Imported cranberry fruit[e]
NE EU					**0.2303**	**0.5004**	**0.26**	**0.04**
SW	France	Very low	None	No	0.01	0.0001	0.08	0.01
SW	Italy	Low	None	No	0.05	0.0001	0.06	0.01
SW	Portugal	None	None	No	0.0001	0.0001	0.00	0.00
SW	Spain	Very high	Medium	No	0.5	0.5	0.08	0.01
SW EU					**0.5601**	**0.5003**	**0.22**	**0.03**
SE	Bulgaria	None	None	no	0.0001	0.0001	0.00	0.00
SE	Croatia	None	None	no	0.0001	0.0001	0.00	0.00
SE	Cyprus	None	None	no	0.0001	0.0001	0.00	0.00
SE	Greece	None	None	no	0.0001	0.0001	0.00	0.00
SE	Malta	None	None	no	0.0001	0.0001	0.00	0.00
SE	Romania	None	None	No	0.0001	0.0001	0.00	0.00
SE EU					**0.0006**	**0.0006**	**0.00**	**0.00**
Total					**1.0**	**1.0**	**1.0**	**1.0**

(a): Based on information from Fall Creek nursery for 2015–2017.
(b): Based on increase in production of cranberries in recent years (EUROSTAT data combined with information at http://www.worldatlas.com/articles/10-top-countries-in-cranberry-production.html and export information from the USA (USDA-APHIS, 2017)).
(c): Based on the presence of *D. vaccinii* in Latvia and its presumable presence in Belarus and Russia.
(d): Relative estimates from qualitative information in the columns to the left (expert information).
(e): FAOSTAT data.

A.2.2. Formal model for establishment of *D. vaccinii* from imported infected fruits

A.2.2.1. State variables and parameters for establishment from fruits

Table A.60: State variables of the establishment model for blueberry and cranberry fruit waste from packing houses or consumers (waste from retail is incinerated or put into landfills and plays no role in *D. vaccinii* transmission). All variables are expressed in numbers of individual berries and plants, considering the whole yearly flow of blueberry and cranberry fruit from countries with official presence of *D. vaccinii* into the EU

Symbol	Meaning
N_{b0}	Total number of berries infected by *D. vaccinii* ending up as waste in the EU per year
N_{b1a}	Total number of berries infected by *D. vaccinii* ending up as waste in the NW region of the EU per year
N_{b1b}	Total number of berries infected by *D. vaccinii* ending up as waste in the NE region of the EU per year
N_{b1c}	Total number of berries infected by *D. vaccinii* ending up as waste in the SW region of the EU per year
N_{b1d}	Total number of berries infected by *D. vaccinii* ending up as waste in the SE region of the EU per year
N_{b2a}	Total number of plants infected with *D. vaccinii* from infected berry waste in the NW region of the EU per year
N_{b2b}	Total number of plants infected with *D. vaccinii* from infected berry waste in the NE region of the EU per year
N_{b2c}	Total number of plants infected with *D. vaccinii* from infected berry waste in the SW region of the EU per year
N_{b2d}	Total number of plants infected with *D. vaccinii* from infected berry waste in the SE region of the EU per year

Table A.61: Parameters of the establishment model for blueberry and cranberry fruit waste from packing houses or consumers. All parameters are multiplication numbers (mostly proportions, i.e. < 1)

Symbol	Meaning
b_{1a}	Proportion of fruits infected with *D. vaccinii* allocated to countries in the NW region of the EU per year
b_{1b}	Proportion of fruits infected with *D. vaccinii* allocated to countries in the NE region of the EU per year
b_{1c}	Proportion of fruits infected with *D. vaccinii* allocated to countries in the SW region of the EU per year
b_{1d}	Proportion of fruits infected with *D. vaccinii* allocated to countries in the SE region of the EU per year
b_{2a}	Proportion of fruits infected with *D. vaccinii* resulting in plant infection and establishment in the NW region in the EU per year
b_{2b}	Proportion of fruits infected with *D. vaccinii* resulting in plant infection and establishment in the NE region in the EU per year
b_{2c}	Proportion of fruits infected with *D. vaccinii* resulting in plant infection and establishment in the SW region in the EU per year
b_{2d}	Proportion of fruits infected with *D. vaccinii* resulting in plant infection and establishment in the SE region in the EU per year

A.2.2.2. Model equations for establishment from fruits

The Panel calculated the number of founder populations of *D. vaccinii* resulting from transfers from berry fruit using the following formula:

$$N_{b1} = b1 \times (N_{E9} + N_{E11})$$

$$N_{b2} = b2 \times N_{b1}$$

Variable N_{B1} is the number of blueberry and cranberry fruits that go to waste in packing houses and consumer yards and is distributed over four regions in the EU according to fixed proportions ($b1$), with different values for each of the four regions (Table A.59). Variables N_{E9} and $\sim N_{E11}$ denote the number of infected berries per year ending up as waste at packing houses and consumer homes per year (from the Entry model).

Variable N_{B2} is the estimated number of established founder plants resulting from berry waste flows across the EU each year. Parameter $b2$ indicates the probability of transfer of inoculum and establishment of *D. vaccinii* on a host plant per berry when fruit is discarded (commonly composted) outside packinghouses or in a home garden. The calculation is made separately for blueberry waste and cranberry waste, as well as for each of the four regions in the EU. The resulting numbers of infected plants are summed to obtain the total number of established founder plants resulting from blueberry and cranberry fruit waste in each of the four regions:

$$N_b^{total} = N_b^{blueberry\ pathway} + N_b^{cranberry\ pathway}$$

A.2.2.3. Parameter estimation for establishment of *D. vaccinii* from blueberry and cranberry fruit waste

The establishment of infection foci is calculated in terms of numbers of infected plants from the waste of individual berries occurring per year.

The probability of establishment of *D. vaccinii* from berry waste in a production field or natural areas is affected by the suitability of the local climate for disease development as well as the density of *Vaccinium* plants in the particular country of importation. The climate suitability was calculated from the percentage of each country located in low and high suitability conditions (Figure 5 in Section 2.3.2.1). The weighted average was calculated by adding the percentage under low suitability multiplied by 0.1 and the percentage under high suitability multiplied by 0.9. *Vaccinium* densities were estimated from Figure 6, websites (http://www.worldatlas.com/articles/10-top-countries-in-cranberry-production.html), and Figure 8 (Section 2.3.2.1). Establishment risk in production areas was estimated from climate suitability (assuming unlimited plant densities), and that in natural areas from climate suitability and plant densities. The EU countries were grouped into four regions (NW, NE, SW and SE), occupying similar total areas (Figure 4, Section 2.3.2.1). The average risks of establishment were calculated for each region (Table A.62), and these risks were considered the median values for modelling purposes.

Table A.62: Estimation of the risk of establishment of *D. vaccinii* from blueberry and cranberry waste. For production fields, climate suitability determines the risk of establishment. For natural areas the risk of establishment is dependent on climate suitability and *Vaccinium* plant densities

Sector in EU	Country	Climate suitability				*Vaccinium* density		Relative establishment risk in natural areas
		Low (1)	High (2)	Average	Weighted average[(a)]	Wild berry relative area	Weighted average[(a)]	Climate × density[(b)]
NW	Belgium	90.4	0.0	0.09		0.21		
NW	Denmark	100.0	0.0	0.10		0.10		
NW	Germany	97.1	0.8	0.10		0.28		
NW	Ireland	1.6	0.0	0.00		0.26		
NW	Luxemburg	66.7	0.0	0.07		0.35		
NW	Netherlands	100.0	0.0	0.10		0.07		
NW	Sweden	63.6	1.8	0.08		0.80		
NW	United Kingdom	45.8	0.0	0.05		0.29		
NW average					**0.0773**		**0.46**	**0.04**
NE	Austria	56.4	26.8	0.30		0.61		
NE	Czech republic	98.0	1.7	0.11		0.33		
NE	Estonia	79.4	20.6	0.26		0.58		
NE	Finland	56.5	0.8	0.06		0.79		
NE	Hungary	76.2	23.8	0.29		0.00		
NE	Latvia	27.5	72.5	0.68		0.53		
NE	Lithuania	50.9	49.1	0.49		0.33		
NE	Poland	81.2	18.8	0.25		0.31		
NE average					**0.2299**		**0.48**	**0.11**
SW	France	93.6	2.0	0.11		0.15		
SW	Italy	76.0	4.6	0.12		0.22		
SW	Portugal	44.3	9.9	0.13		0.00		
SW	Spain	73.7	3.4	0.10		0.12		
SW average					**0.1116**		**0.14**	**0.02**
SE	Bulgaria	75.9	24.1	0.29		0.20		
SE	Croatia	30.6	59.0	0.56		0.11		
SE	Cyprus	56.0	0.0	0.06		0.00		
SE	Greece	57.3	22.1	0.26		0.00		
SE	Malta	0.0	0.0	0.00		0.00		
SE	Romania	78.0	18.9	0.25		0.20		
SE	Slovakia	62.8	34.9	0.38		0.22		
SE	Slovenia	35.2	55.7	0.54		0.43		

Sector in EU	Country	Climate suitability				*Vaccinium* density		Relative establishment risk in natural areas
		Low (1)	High (2)	Average	Weighted average[(a)]	Wild berry relative area	Weighted average[(a)]	Climate × density[(b)]
SE average					**0.3032**		**0.16**	**0.05**

(a): Regional averages were weighted according to the areas (km^2) of the countries in each region.
(b): Relative risks in natural areas were calculated by multiplying the regional weighted averages of climate suitability and *Vaccinium* plant density.

The probability of establishment of *D. vaccinii* from the waste of blueberry and cranberry fruit is expected to be very small. Two factors contribute to the low likelihood of establishment from infected berries as compared to infected plants for planting: (1) a berry is an uncertain and comparatively small source of inoculum; the fungus will need to sporulate on the berry, and other pathogens or saprophytic fungi in a berry may interfere with such sporulation, especially if berries are deposited as waste (plants with stem lesions are more reliable and larger sources of spores); (2) berry waste on compost heaps will not often be deposited in close proximity to berry plants, while plants for planting will always be planted near other berry plants. A conceptual model for the risk of transfer and establishment of *D. vaccinii* from berry waste to a *Vaccinium* plant is given below (Figure A.1).

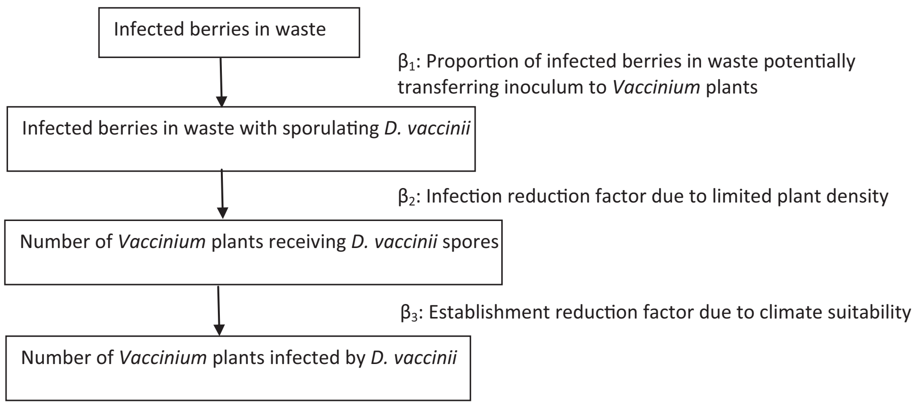


Figure A.1: Conceptual model of the transfer of *D. vaccinii* from infected berries in waste to *Vaccinium* plants becoming infected. Three rates are distinguished: β_1 for infected berries becoming sporulating berries, β_2 for spores from sporulating infected berries to reach *Vaccinium* plants and β_3 for *Vaccinium* plants with *D. vaccinii* spores becoming infected. These rates are not used individually in the model, but are combined into one probability of establishment factor (Table A.63)

The parameter β_1 is composed of two components: for the median, the probability is 1/100 that *D. vaccinii* in an infected berry will survive and 1/100 that it will sporulate at the time when *Vaccinium* plants are susceptible in close proximity are susceptible. This results in a probability of 1/10,000 that viable inoculum is produced at the right time. The uncertainty is quite large with a lower limit of 1/100,000 and an upper limit of 1/100 (Table A.63). Parameters β_2 and β_3 are reduction factors for density of *Vaccinium* plants in the immediate surroundings of sporulating berry waste and climate suitability, calculated as 'relative risk of establishment' by multiplying β_2 and β_3 (Table A.63). The resulting probability distributions for establishment of *D. vaccinii* from fruit waste are presented in Table A.63 for the four geographic regions in the EU.

Table A.63: Distribution of probabilities of establishment of *D. vaccinii* from blueberry and cranberry fruit waste (parameter $\boldsymbol{b_2}$) in four geographic regions in the EU based on climate suitability and *Vaccinium* density in individual EU countries

			Percentiles (β_1 is in bold)				
Risk of establishment from	**Region in EU**	**Relative risk ($\beta_2 \times \beta_3$)**	**1%**	**25%**	**50%**	**75%**	**99%**
			0.00001	**0.00004**	**0.0001**	**0.001**	**0.01**
Blueberry waste	NW	0.04	0.0000004	0.0000016	0.000004	0.00004	0.0004
	NE	0.11	0.0000011	0.0000044	0.000011	0.00011	0.0011
	SW	0.02	0.0000002	0.0000008	0.000002	0.00002	0.0002
	SE	0.05	0.0000005	0.000002	0.000005	0.00005	0.0005
			0.00001	**0.00004**	**0.0001**	**0.001**	**0.01**
Cranberry waste	NW	0.04	0.0000004	0.0000016	0.000004	0.00004	0.0004
	NE	0.11	0.0000011	0.0000044	0.000011	0.00011	0.0011
	SW	0.02	0.0000002	0.0000008	0.000002	0.00002	0.0002
	SE	0.05	0.0000005	0.000002	0.000005	0.00005	0.0005

In the above, no account was taken of clustering of berries during the transfer and establishment process, i.e. the pathway unit equals the transfer unit, or each infected berry can result in an infected *Vaccinium* plant and initiate an established focus of infection. The rationale for this assumption is that the number of infected berries entering Europe is quite large, but the probability of any one berry causing a successful transfer and infection is very small with a median value of 1/10,000 in the NE and 2/100,000 in the SW region of the EU. As a result, 'successful' berries are likely to be 'alone'.

The probability of establishment from fruit waste is not dependent on the regulation scenario.

A.2.3. Distribution of imported infected blueberry and cranberry P4P

The numbers of infected plants as estimated in the Entry steps of the models are allocated to countries according to fixed proportions (Table A.59) based on total (healthy) plant imports from the largest blueberry nursery in the USA (Fall Creek Nursery in Oregon), and from estimated expansion of cranberry production in the various EU countries (EUROSTAT data combined with information at http://www.worldatlas.com/articles/10-top-countries-in-cranberry-production.html and export information from the USA (USDA-APHIS, 2017)). As no quantitative information is available about the import of P4P and berries from neighbouring Belarus and Russia, some extra weight is given for the risk of importing infected materials from those countries, by multiplying the calculated risk by 2.

Thus, the distribution of imported blueberry and cranberry P4P were estimated for individual countries based on blueberry and cranberry production areas (Figure 8 in the conceptual model Section 2.3.2.1), combined with knowledge of the countries that received P4P from the largest blueberry nursery in the USA and information from US State plant certification agencies (USDA APHIS, 2017). The potential presence of *D. vaccinii* in neighbouring countries was taken into account as described above for Belarus and Russia (Table A.59). The same grouping was used of EU MS in four large regions (NW, NE, SW and SE) with similar levels of import of P4P and climate suitability for *D. vaccinii*. And again, the estimated allocations (parameter ***B***1) of imported P4P per country were added for each of the four regions. The distribution of the import of infected plants is considered the same as that of the total number of P4P. Also, the distribution of plug plants and potted plants over the EU countries is considered the same. Thus, imported infected blueberry P4P arrive mostly in the SW (56%), followed by the NE (23.1%) and the NW (20%), while import is minimal in the SE ($<$ 1%). The imported infected cranberry P4P is primarily in the SW and NE (50% each), while the proportions are less than 1% in the NW and SE. We consider these fixed proportions, because they cannot be varied independently, but need to add up to 100%.

A.2.4. Formal model for establishment of *D. vaccinii* from imported infected plants for planting

A.2.4.1. State variables and parameters for establishment from plants in nurseries

Table A.64: State variables of the establishment model for blueberry and cranberry plugs and small potted plants in receiving nurseries. All variables are expressed in numbers of individual plants, considering the whole yearly flow of plug plants from countries with official presence of *D. vaccinii* into the EU

Symbol	Meaning
N_{B0}	Total number of plants infected by *D. vaccinii* that passed into the EU per year
N_{B1a}	Total number of plants infected by *D. vaccinii* that passed into the NW region of the EU per year
N_{B1b}	Total number of plants infected by *D. vaccinii* that passed into the NE region of the EU per year
N_{B1c}	Total number of plants infected by *D. vaccinii* that passed into the SW region of the EU per year
N_{B1d}	Total number of plants infected by *D. vaccinii* that passed into the SE region of the EU per year
N_{B2a}	Total number of plants infected with *D. vaccinii* that pass culling and result in establishment in the NW region of the EU per year
N_{B2b}	Total number of plants infected with *D. vaccinii* that pass culling and result in establishment in the NE region of the EU per year
N_{B2c}	Total number of plants infected with *D. vaccinii* that pass culling and result in establishment in the SW region of the EU per year
N_{B2d}	Total number of plants infected with *D. vaccinii* that pass culling and result in establishment in the SE region of the EU per year

Table A.65: Parameters of the establishment model for blueberry and cranberry plugs and potted plants in nurseries. All parameters are multiplication numbers (mostly proportions, i.e. < 1)

Symbol	Meaning
B_{1a}	Proportion of plants infected with *D. vaccinii* allocated to countries in the NW region of the EU
B_{1b}	Proportion of plants infected with *D. vaccinii* allocated to countries in the NE region of the EU
B_{1c}	Proportion of plants infected with *D. vaccinii* allocated to countries in the SW region of the EU
B_{1d}	Proportion of plants infected with *D. vaccinii* allocated to countries in the SE region of the EU
B_{2abcd}	Proportion of plants infected with *D. vaccinii* that is removed by culling of symptomatic plants; the remaining proportion gets established in the four geographic regions in the EU (same parameter value for all regions)

A.2.4.2. Model equations for establishment from plants in nurseries

The number of founder populations that become established in nurseries is determined only by the removal rate of symptomatic plants that develop during the first 2 months (incubation period) after arrival. The local climate does not affect establishment, because the infections are systemic and the controlled environment with overhead irrigation provides a conducive climate at any location in the EU. The Panel calculated the number of founder populations of *D. vaccinii* resulting from imported infected blueberry and cranberry plants for planting (plug plants) that passed inspection unnoticed and ended up in receiving nurseries using the following formula:

$$N_{B1} = B1 \times (N_{E5})$$

$$N_{B2} = B2 \times N_{B1}$$

Variable N_{B1} is the number of blueberry or cranberry plug plants that are distributed over four regions in the EU according to fixed import proportions ($B1$), with different values for each of the four regions (Table A.59). Variable N_{E5} denotes the number of infected plants per year that passed import inspection in the EU (from the Entry model).

Variable N_{B2} is the estimated number of established founder plants resulting from imported infected plug plants across the EU each year. Parameter $B2$ indicates the probability of establishment of *D. vaccinii* on host plants in the receiving nursery. The calculation is made separately for blueberry and cranberry plants, as well as for each of the four regions in the EU. The resulting numbers of infected plants are summed to obtain the total number of established founder plants resulting from imported infected plug plants in each of the four regions:

$$N_B^{total} = N_B^{blueberry\ pathway} + N_B^{cranberry\ pathway}$$

A.2.4.3. Parameter estimation for establishment from plants in nurseries

As mentioned under the conceptual model Section 2.3.2.1, the probability of establishment of *D. vaccinii* from plug plants and small potted plants in receiving nurseries is considered to be dependent on removal of symptomatic plants only, not on climate suitability. We assume that the median effectiveness of plant removal is 0.5. The removal rates are considered the same for all three scenarios.

Table A.66: Proportions of infected blueberry and cranberry plug plants at the recipient nursery that could be detected visually and removed within 2 months of entry

Percentile	1%	25%	50%	75%	99%
A0 incidence	0.05	0.3	0.5	0.6	0.8
A1 incidence	0.05	0.3	0.5	0.6	0.8
A2 incidence	0.05	0.3	0.5	0.6	0.8

A.2.4.4. State variables and parameters for establishment from plants in production fields

Table A.67: State variables of the establishment model for blueberry and cranberry potted plants and cuttings planted in production fields. All variables are expressed in numbers of individual plants, considering the whole yearly flow of potted plants and field cuttings from countries with official presence of *D. vaccinii* into the EU

Symbol	Meaning
N_{BB0}	Total number of potted plants infected by *D. vaccinii* that passed into the EU per year
N_{BB1a}	Total number of potted plants infected by *D. vaccinii* that passed into the NW region of the EU per year
N_{BB1b}	Total number of potted plants infected by *D. vaccinii* that passed into the NE region of the EU per year
N_{BB1c}	Total number of potted plants infected by *D. vaccinii* that passed into the SW region of the EU per year
N_{BB1d}	Total number of potted plants infected by *D. vaccinii* that passed into the SE region of the EU per year
N_{BB2a}	Total number of potted plants infected with *D. vaccinii* that pass culling in the NW region of the EU per year
N_{BB2b}	Total number of potted plants infected with *D. vaccinii* that pass culling in the NE region of the EU per year
N_{BB2c}	Total number of potted plants infected with *D. vaccinii* that pass culling in the SW region of the EU per year
N_{BB2d}	Total number of potted plants infected with *D. vaccinii* that pass culling in the SE region of the EU per year
N_{BB3a}	Total number of potted plants infected with *D. vaccinii* that passed culling and resulted in establishment in the NW region of the EU per year
N_{BB3b}	Total number of potted plants infected with *D. vaccinii* that passed culling and resulted in establishment in the NE region of the EU per year

Symbol	Meaning
N_{BB3c}	Total number of potted plants infected with *D. vaccinii* that passed culling and resulted in establishment in the SW region of the EU per year
N_{BB3d}	Total number of potted plants infected with *D. vaccinii* that passed culling and resulted in establishment in the SE region of the EU per year

Table A.68: Parameters of the establishment model for blueberry and cranberry potted plants or cuttings planted in the field. All parameters are multiplication numbers (mostly proportions, i.e. < 1)

Symbol	Meaning
BB_{1a}	Proportion of potted plants infected with *D. vaccinii* allocated to countries in the NW region of the EU per year
BB_{1b}	Proportion of potted plants infected with *D. vaccinii* allocated to countries in the NE region of the EU per year
BB_{1c}	Proportion of potted plants infected with *D. vaccinii* allocated to countries in the SW region of the EU per year
BB_{1d}	Proportion of potted plants infected with *D. vaccinii* allocated to countries in the SE region of the EU per year
BB_{2abcd}	Proportion of potted plants infected with *D. vaccinii* remaining after culling of symptomatic plants in the four geographic regions in the EU per year (same parameter value for all regions)
BB_{3a}	Proportion of remaining potted plants infected with *D. vaccinii* resulting in establishment in the NW region in the EU per year
BB_{3b}	Proportion of remaining potted plants infected with *D. vaccinii* resulting in establishment in the NE region in the EU per year
BB_{3c}	Proportion of remaining potted plants infected with *D. vaccinii* resulting in establishment in the SW region in the EU per year
BB_{3d}	Proportion of remaining potted plants infected with *D. vaccinii* resulting in establishment in the SE region in the EU per year

A.2.4.5. Model equations for establishment from plants in production fields

The number of founder populations that become established in open fields is determined by the removal rate of symptomatic plants that develop during the first two month (incubation period) after arrival, and by the local climate. Plant densities surrounding infected imported plants are always high in production fields. The Panel calculated the number of founder populations of *D. vaccinii* resulting from imported infected blueberry and cranberry plants for planting (potted plants or cuttings) that passed inspection unnoticed and ended up in receiving production fields using the following formula:

$$N_{BB1} = BB1 \times (N_{E5})$$

$$N_{BB2} = (1 - BB2) \times BB3 \times N_{BB1}$$

Variable N_{BB1} is the number of blueberry or cranberry potted plants or cuttings that are distributed over four regions in the EU according to fixed import proportions ($BB1$), with different values for each of the four regions (Table A.59). Variable N_{E5} denotes the number of infected plants per year that passed import inspection in the EU (from the Entry model).

Variable N_{BB2} is the estimated number of established founder plants resulting from imported infected potted plants or cuttings across the EU each year. Parameter $BB2$ indicates the probability of establishment of *D. vaccinii* on host plants in the receiving nursery. The calculation is made separately for blueberry and cranberry plants, as well as for each of the four regions in the EU. The resulting numbers of infected plants are summed to obtain the total number of established founder plants resulting from imported infected potted plants (or cuttings) in each of the four regions:

$$N_{BB}^{total} = N_{BB}^{blueberry\ pathway} + N_{BB}^{cranberry\ pathway}$$

A.2.4.6. Parameter estimation for establishment of *D. vaccinii* from P4P in production fields

Plants in production fields that develop symptoms of *D. vaccinii* are removed at a lower rate, because inspection by nursery and production workers will be less intensive under A0 than for plugs that are under intensive scrutiny in the receiving nursery. Under A1, post-entry quarantine will not be in place, and plant removal is likely reduced, while the situation under A2 is likely the same as under A0 (except that potted plants or field-grown cuttings would not be imported anymore). Removal rates are not dependent on country of entry of the imported plants.

Table A.69: Proportions of infected blueberry and cranberry potted plants or cuttings in production fields that could be detected visually and removed within 2 months of entry

Percentile	1%	25%	50%	75%	99%
A0 incidence	0.05	0.15	0.25	0.35	0.5
A1 incidence	0.05	0.10	0.12	0.17	0.25
A2 incidence	0.05	0.15	0.25	0.35	0.5

The residual infected plants (that were not detected and removed) are multiplied by the probabilities of establishment in order to arrive at realistic establishment estimates. Effects of climate are not dependent on regulation scenario.

The probability of establishment of *D. vaccinii* from potted P4P and from cuttings in a production field is affected by the suitability of the local climate for the disease (Figure 5 in Section 2.3.2.1) but not on the density of *Vaccinium* plants (which are assumed not to be limiting). Establishment risk was estimated from climate suitability in individual countries (Table A.62). Again, the EU countries were grouped into four regions (NW, NE, SW and SE), occupying similar total areas. The average risks of establishment were calculated for each region, and these risks were considered the median values for modelling purposes.

Table A.70: Distribution of probabilities of establishment of *D. vaccinii* from blueberry and cranberry P4P in production fields (parameter ***BB*3**) in four geographic regions in the EU, based on climate suitability in EU Regions

Risk of establishment from	Region in EU	Climate suitability (β_3)(a)	Percentiles				
			1%	25%	50%	75%	99%
Blueberry P4P	NW	**0.0773**	0.00	0.04	0.08	0.09	0.1
	NE	**0.2299**	0.06	0.15	0.023	0.40	0.68
	SW	**0.1116**	0.09	0.10	0.11	0.12	0.13
	SE	**0.3032**	0.00	0.15	0.30	0.45	0.56
Cranberry P4P	NW	**0.0773**	0.00	0.04	0.08	0.09	0.1
	NE	**0.2299**	0.06	0.15	0.023	0.40	0.68
	SW	**0.1116**	0.09	0.10	0.11	0.12	0.13
	SE	**0.3032**	0.00	0.15	0.30	0.45	0.56

(a): The climate suitability of Table A.62.

Similar to the *D. vaccinii* establishment from berry waste, no account was taken of clustering of P4P during the transfer and establishment process, i.e. the pathway unit equals the transfer unit, or each infected plant for planting can by itself initiate an established focus of infection. The rationale for this assumption is that the state of being infected is a rare event that is not likely to occur in clusters, due to the high phytosanitary standards in the trade (but with the exception of the rare trade in field-grown cranberry cuttings).

A.3. Spread

A.3.1. Formal model for Spread

For each of four geographic regions in Europe (Figure 4), a spread model is run to estimate the consequences in terms of spread of entry and establishment over a time frame of 5 years. The entry and establishment flows (F_1–F_6) are elaborated in Sections A.3.1 (entry) and A.3.2 (establishment). Here, the further spread of infection in the European territory is estimated. Both human-assisted spread (with plants for planting) and natural spread (with spores: conidia and ascospores) are accounted for. The model calculates the spread within each of four geographic regions, but does not calculate the spread between these four geographic regions.

The spread model is identical for the four regions, but climate is considered in the calculation of spread within production fields and natural *Vaccinium* stands, and between production fields and natural *Vaccinium* stands. Hence, the rate of spread differs between the four regions.

A flow diagram of the spread model is given in Figure A.2.

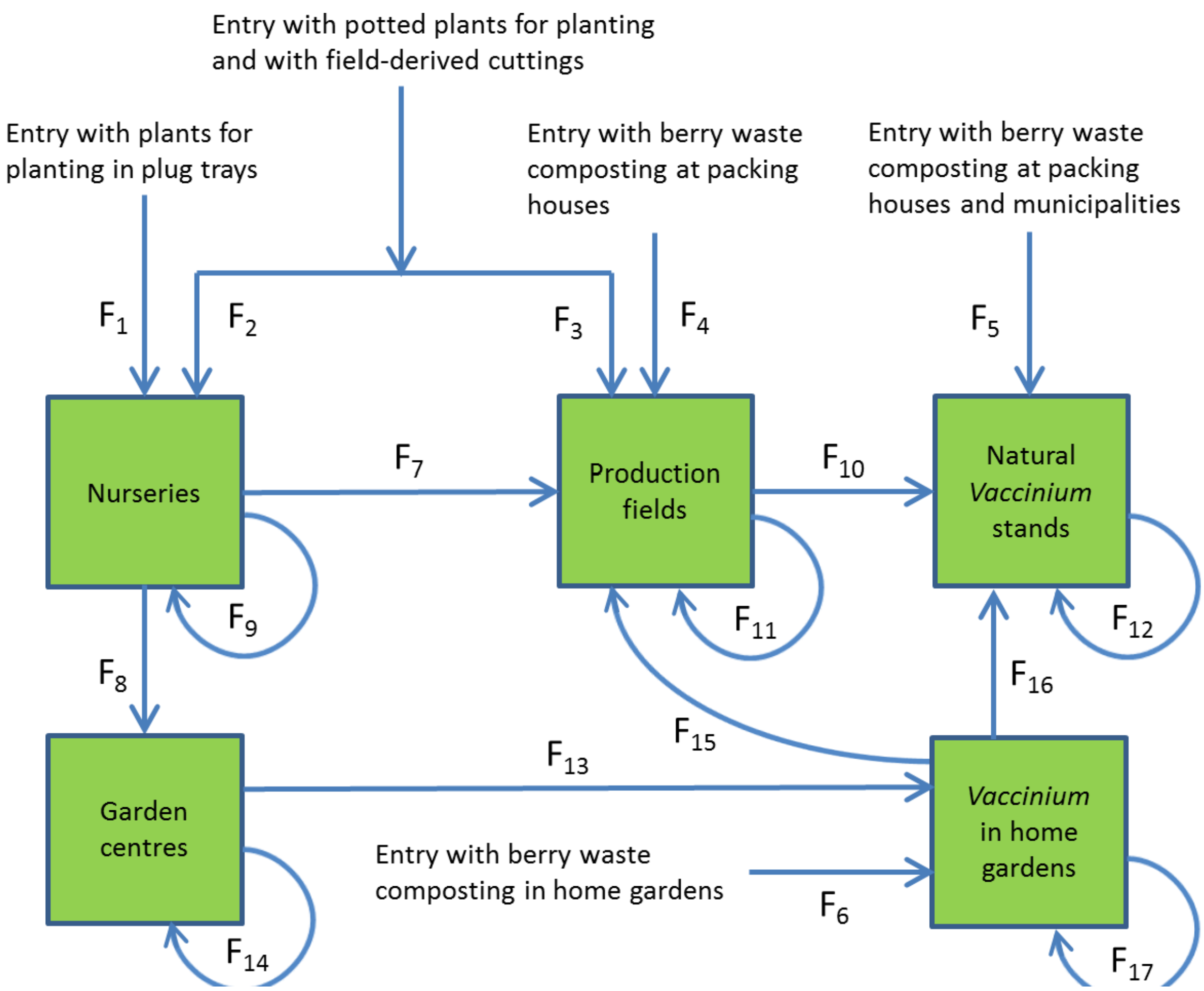


Figure A.2: Flow chart representing the conceptual model for spread. The model comprises five ecological compartments, for each of four geographic regions in the EU: NW, NE, SW and SE. Within each region, the model comprises six flows of entry and establishment (F_1–F_6) and 11 flows of infection between compartments. Parameterisation of the flows is identical for the four regions, except for flows that involve dispersal of spores followed by infection. The parameterisation of these flows takes into account the prevalence of berries in each region, and the average suitability of the climate for *D. vaccinii*

The model calculates the number infected plants in each of five compartments: nurseries nurseries, production fields, natural *Vaccinium* stands, garden centres and home gardens (Figure A.2). Within each compartment, the model calculates the number of infected *Vaccinium* plants. No distinction is made between species of Vaccinium. As a consequence, entry and establishment flows via blueberry and cranberry are summed.

The number of infected plants in the five compartments are represented by the state variables $N_1 - N_5$. Values of the state variable at time $t + 1$ (next year) are calculated on the basis of flows which are based on the values of the state variable at time t (current year). The initial condition for the model is a disease free situation with zero infected plants in all compartments. Hence, the model outcomes represent the number of infected plants in each of the four regions after five years of entry, establishment and spread under each of three scenarios.

Infected plants in nurseries:

$$N_1(t+1) = F_1 + F_2 + F_9$$

Infected plants in production fields:

$$N_2(t+1) = F_3 + F_4 + F_7 + F_{11} + F_{15}$$

Infected plants in natural *Vaccinium* stands:

$$N_3(t+1) = F_5 + F_{10} + F_{12} + F_{16}$$

Infected plants in garden centres:

$$N_4(t+1) = F_8 + F_{14}$$

Infected plants in home gardens:

$$N_5(t+1) = F_6 + F_{13} + F_{17}$$

Flows that are shown in red font are flows of entry and establishment ('primary infections', originating from outside the European territory). Flows that are shown in black are spread flows (secondary infections and survival of infected plants from 1 year to the next).

Survival is explicitly accounted for in the flows; therefore, the state variable does not appear in the right-hand side of the equations.

The 17 flows in the spread model are described in Table A.71.

Table A.71: Flows in the spread model

Symbol	Meaning
F_1	Entry and establishment into nurseries with plants for planting in plug trays (N_{B2} from the establishment model)
F_2	Entry and establishment into nurseries with potted plants for planting and with field-derived cuttings (part of N_{BB2} from the establishment model)
F_3	Entry and establishment into production fields with potted plants for planting and with field-derived cuttings (part of N_{BB2} from the establishment model)
F_4	Entry and establishment in production fields from founder plants infected from berry waste composting at nearby packing houses (part of N_{b2})
F_5	Entry and establishment in natural *Vaccinium* stands from founder plants infected from berry waste composting at packing houses and municipalities by air-borne inoculum (N_{b2})
F_6	Entry and establishment in home gardens from founder plants infected from berry waste composting and air-borne spread in home gardens (part of N_{b2})
F_7	Flow of infected plants from nurseries to production fields
F_8	Flow of infected plants from nurseries to garden centres
F_9	Dynamics of infected plants within nurseries
F_{10}	Flow of infection from production fields to natural *Vaccinium* stands
F_{11}	Dynamics of infection within production fields
F_{12}	Dynamics of infection in natural *Vaccinium* stands
F_{13}	Flow of infected plants from garden centres to home gardens
F_{14}	Dynamics of infection in garden centres

Symbol	Meaning
F_{15}	Flow of infection from home gardens to production fields
F_{16}	Flow of infection from home gardens to natural *Vaccinium* stands
F_{17}	Dynamics of infection in home gardens

Six of the flows (F_1–F_6) represent entry and establishment from outside the EU and were quantified in Section A.1 (Entry) and A.2 (Establishment). The flows F_7–F_{17} represent spread. They were formulated as follows:

Spread from nurseries to production fields (F_7)

$$F_7 = s_1 \times (1 - s_2) \times N_1$$

s_1 is the spread factor from infected plants in nurseries to infected plants in production fields.
s_2 is the proportion of (infected) plants going to garden centres.

Spread from nurseries to garden centres (F_8)

$$F_8 = s_3 \times s_2 \times N_1$$

s_3 is the spread factor from nurseries to garden centres.

Spread and survival of *D. vaccinii* in nurseries (F_9)

$$F_9 = s_1 \times N_1 + s_4 \times N_1$$

s_1 represents spread of infection in a nursery (here considered equal in size to the infection flow to production fields), while s_4 represents survival of an infected plant within a nursery from 1 year to the next.

Spread from production fields to natural *Vaccinium* (F_{10})

$$F_{10} = s_5(\text{climate}) \times N_2$$

where the spread factor s_5 depends on climate suitability for *D. vaccinii*.

Survival and spread of *D. vaccinii* in production fields (F_{11})

$$F_{11} = 1 \times N_2 + s_7(\text{climate}) \times N_2$$

Year to year survival of infected plants in production fields is set to 1; hence, the first term at the right-hand side.
s_7 is the spread of *D. vaccinii* to neighbours within production fields. It depends on climate suitability for *D. vaccinii*.

Survival and spread of *D. vaccinii* in natural *Vaccinium* stands (F_{12})

$$F_{12} = s_8(\text{climate}) \times N_3$$

Spread from garden centres to home gardens (F_{13})

$$F_{13} = s_9 \times N_4$$

Survival and spread of *D. vaccinii* in garden centres (F_{14})

$$F_{14} = (1 - s_9) \times N_4 + s_7 \times N_4$$

The first term is the proportion of plants that is not sold. The second term is spread within nurseries. The same spread factor is used as for production fields.

Spread from home gardens to production fields (F_{15})

$$F_{15} = 0$$

This flow is considered to be negligible and set to zero.

Spread from home gardens to natural *Vaccinium* stands (F_{16})

$F_{16} = 0$

This flow is considered to be negligible and set to zero.

Survival and spread of *D. vaccinii* in home gardens (F_{17})

$F_{17} = N_5$

Survival is near one, but spread is negligible because populations of *Vaccinium* plants in home gardens are too small to allow relevant spread.

A.3.2. Parameter estimation and elicitation for the spread model

1. Entry and establishment into nurseries with plants for planting in plug trays (F_1)

This flow is calculated in the entry section. It includes establishment, which is not determined by environmental factors in this case, but only by the chance of an infected plant being rogued before it is removed. If a plant is not removed, the disease is established by definition. A single infected plant thus acts as a founder population.

2. Entry and establishment into nurseries with potted plants for planting and with field-derived cuttings (F_2)

These flows are calculated in the entry section.

3. Entry and establishment into production fields with potted plants for planting and with field-derived cuttings (F_3)

These flows are calculated in the entry section.

4. Entry and establishment in production fields due to berry waste composting at nearby packing houses (F_4)

These flows are calculated in the entry section.

5. Entry and establishment in natural *Vaccinium* stands due to berry waste composting at packing houses and municipalities by air-borne inoculum (F_5)

These flows are calculated in the entry section.

6. Entry and establishment in home gardens due to berry waste composting and air-borne spread in home gardens (F_6)

These flows are calculated in the entry section.

7. Flow of infection from nurseries to production fields (F_7)

$F_7 = s_1 \times (1 - s_2) \times N_1$

s_1 is the spread factor from infected plants in nurseries to infected plants in production fields.
s_2 is the proportion of (infected) plants going to garden centres.
To elicit a value for s_1, the spread factor from nurseries to production fields, the experts asked the question: Assume one infected plant in a nursery; how many offspring infected plants will there be next year in production fields from this one infected plant in the nursery:

i) Because the infection has spread from field to field by natural means (spores or vectors).
ii) Because infection can spread from plant to plant in the nursery and the grown-up plants are later transplanted in a production field.
iii) Because the infected plants are used as propagating material (as a mother plant) and their offspring is planted in a production field?

Spread by conidia from nursery fields to production fields is very unlikely because conidia are splash dispersed. Therefore, this spread was set to zero. This pathway was not further considered and was set to 0.

The second mechanism was considered plausible. The experts considered a two-year growing up period. The infected plant may be removed before infection is spread to neighbours through conidia. But, an infected plant can also produce spores and infect neighbours. The elicited distribution is:

Table A.72: Distribution of parameter s_1 (spread factor from nurseries to production fields)

	Percentile				
	1	25	50	75	99
Value	0.1	0.75	1	1.5	3

Spread from mother plants depends on the probability that an infected plant is used as a mother plant and the number of offspring that is made of that plant. Multiplication factor is in the order of 30. From a bigger and older mother plant (medium-sized bush), as many as 100–200 cutting can be obtained (Annemiek Schilder), but fewer from younger plants. However, as mother plants are very clean, spread of infection from mother plants was not considered plausible. This pathway was not further considered.

Further evidence considered

When plants come in plug trays, they are grown up in the nursery but not multiplied. It is one in, one out.

With conidia forming fungi, if only one seed is infected, a whole nursery may become infected.

D. vaccinii does not easily make pycnidia on young plants because pycnidia production requires stem cankers.

Infection is promoted by sprinklers. Nurseries have sprinklers.

50% chance an infected plant is rogued before it is sold and moved to a production field. 50% chance it spread inoculums to some nearest neighbours.

Infection is not easy. Only when plants are flowering or when the plants are damaged.

Uncertainties

There is no pertinent evidence. These numbers are based on expert reasoning.

Experts also estimated the proportion of the infected plants going to garden centres.

Table A.73: Proportion going to garden centres (s_2)

	Percentile				
	1	25	50	75	99
Value	0.05	0.08	0.1	0.13	0.2

Evidence: none.

Uncertainty: High, but the sensitivity is expected to be low because of the smallness of the infection flow into nurseries. As a result, virtually all infected import material will go directly to production fields, and not enter into nurseries and from there into garden centres.

8. Flow of infection from nurseries to garden centres (F_8)

$$F_8 = s_3 \times s_2 \times N_1$$

s_3 is the spread factor from nurseries to garden centres.

Here, the experts asked the question: how many offspring infected plants will there be next year in garden centres because infected plants have been produced in the nursery from infected material and transported to a garden centre (propagation).

i) Because the infection has spread from a nursery field to a production field by natural.
ii) Because infection can spread from plant to plant in the nursery and the grown-up plants.
iii) Because the infected plants are used as propagating material (as a mother plant) which is planted in a production field.

Mechanisms 1 and 3 were not considered plausible, following reasoning state when estimating s_1. The second mechanism (spread within the nursery and movement of infected plant material from a nursery to a garden centre) was considered possible. Quality of planting material going to garden centres is generally lower than that of plant material going to production fields. To reflect the lower quality, the 1 percentile was increased compared to the distribution elicited for s_1. No further modification was made to the estimates made for s_1. Hence, the distribution of s_3 is:

Table A.74: Distribution of parameter s_3: spread factor from nurseries to garden centres

	Percentile				
	1	25	50	75	99
Value	0.5	0.75	1	1.5	3

9. Dynamics of infected plants within nurseries (F_9)

$$F_9 = s_1 \times N_1 + s_4 \times N_1$$

s_1 represents spread of infection in a nursery (here considered equal in size to the infection flow to production fields), while s_4 represents survival of an infected plant within a nursery from one year to the next.

s_1 was already estimated above (see Section on *F7*).

For the survival of infected plants from 1 year to the next in a nursery (s_4), the following distribution was elicited.

Table A.75: Distribution of survival of infected plants from one year to the next in a nursery (s_4)

	Percentile				
	1	25	50	75	99
Value	0.1	0.4	0.5	0.6	0.7

Justification: There is inspection. Half of infected plants show symptoms and get removed.

Uncertainties: No evidence, expert judgement.

10. Flow of infection from production fields to natural *Vaccinium* stands (F_{10})

$$F_{10} = s_5(climate) \times N_2$$

where the spread factor s_5 depends on climate suitability for *D. vaccinii*.

To estimate the spread from production fields to natural *Vaccinium* stands, the experts considered the probability of transfer of spores from production fields to natural *Vaccinium* stands, and the suitability of the climate for causing infection and persistence of the pathogen. For the latter, the experts used the climate suitability factor calculated by averaging MMF and MaxEnt (Narouei-Khandan et al., 2017). The latter factor was first rescaled to have an average value of one over the four climatic regions. In the estimation of transfer, the experts did consider 'average' infection conditions. Thus, they estimated the number of infected plants in natural *Vaccinium* stands from one infected plant in a production field under average climatic conditions.

To elicit a coefficient for transfer, the experts imagined one infected plant in a production field and asked the question: how many offspring infected plants will there be next year in nature from this one infected plant in a production field because the infection has spread from field to field by natural means (spores or vectors). The resulting coefficient was:

Table A.76: Coefficient for effective spread of infection through transfer of spores from production fields to natural *Vaccinium* stands (s_5; for 'average' climate)

	Percentile				
	1	25	50	75	99
Value	1/100,000	1/20,000	1/10,000	1/5,000	1/1,000

This factor was then multiplied with scaled climate suitability factors for the four geographic regions.

Table A.77: Distribution of s_5

			Percentile				
			1	**25**	**50**	**75**	**99**
	Overall average multiplier (not specific for zones)		1/100,000	1/20,000	1/10,000	1/5,000	1/1,000
	Region	Climate suitability[(a)]					
Value	NW	0.43	4.3E-06	2.15E-05	0.000043	0.000086	0.00043
Value	NE	1.27	1.27E-05	6.35E-05	0.000127	0.000254	0.00127
Value	SW	0.62	6.2E-06	0.000031	0.000062	0.000124	0.00062
Value	SE	1.68	1.68E-05	0.000084	0.000168	0.000336	0.00168

(a): The scaled climate suitability was derived from the climate suitability in Table A.60 so that the average value for the four regions is 1.0.

Evidence

There is no evidence for substantial spread from production fields to natural areas (e.g. from Latvia or Belarus.

Around the blueberry production fields in Horst (Netherlands) highbush blueberry is becoming a pest (a weed) providing evidence that birds are spreading it?

Twenty outbreaks have been reported in the last 30 years, and 1 interception. Only 1 outbreak (in Latvia) has resulted in spread in a natural area.

Uncertainties

The role of berry eating birds is not known. But spread with birds is a common pathway of spread for fungi, although no information is available for *Phomopsis* species.

11. Dynamics of infection within production fields (F_{11})

$$F_{11} = 1 \times N_2 + s_7(climate) \times N_2$$

Year to year survival of infected plants in production fields is set to 1; hence the first term at the right-hand side.

s_7 is the spread of *D. vaccinii* to neighbours within production fields. It depends on climate suitability for *D. vaccinii*.

To elicit a value for s_7, experts considered one infected plant in a production field and asked the question how many offspring infected plants there will be next year from this one infected plant because the infection has spread to neighbours (short distance dispersal), assuming 'average' climatic conditions across the EU.

As a basis, the same distribution was used as for s_1 (spread in nurseries).

Table A.78: Distribution of s_7 spread factor of *D. vaccinii* in production fields for average climate

	Percentile				
	1	25	50	75	99
Value	0.1	0.75	1	1.5	3

Climate was then taken into account by multiplying the estimated coefficients with a climate suitability factor specific for the geographic region.

Table A.79: Distribution of s_7

			Percentile				
			1	**25**	**50**	**75**	**99**
	Overall average multiplier (not specific for zones)		0.3	0.75	1	1.5	3
	Region	Climate suitability factor[(a)]					
Value	NW	0.43	0.129	0.3225	0.43	0.645	1.29
Value	NE	1.27	0.381	0.9525	1.27	1.905	3.81
Value	SW	0.62	0.186	0.465	0.62	0.93	1.86
Value	SE	1.68	0.504	1.26	1.68	2.52	5.04

(a): The scaled climate suitability was derived from the climate suitability in Table A.60 so that the average value for the four regions is 1.0.

12. Dynamics of infection in natural *Vaccinium* stands (F_{12})

$$F_{12} = s_8 \times N_3$$

where s_8 is a spread factor.

To elicit the value of s_8, the experts considered one infected plant in a natural *Vaccinium* stand and asked the question: how many offspring infected plants will there be next year from this one infected plant:

i) Because the plant has not been removed (survival).
ii) Because the infection has spread to neighbours or afar (short + long distance dispersal).

Literature was used to support estimation of the spread factor. Damicone et al. (1990) estimated the relative rate of disease increase of *Diaporthe phaseolorum* in soybean to range between 0.02 and 0.12 per week in the growing season. For the same pathogen, Subbarao et al. (1992) estimated rates varying from 0.06 to 0.21 per day (Subbarao et al., 1992). The high rate reported by Subbarao was under irrigation, the low rate without irrigation. The low rates of Damicone were under ambient conditions for cultivars differing in resistance. Exponential rates of increase cannot be maintained for long times. Assuming time periods of exponential growth of 30, 40, 50 and 60 days, and taking a mid-point estimate (0.1 d-1) from the data of Subbarao, we obtain spread factors ranging from 20 to 400 (i.e. from exp(30 $\times$ 0.1) to exp(60 $\times$ 0.1)). No winter mortality is accounted for in these calculations. To represent uncertainty, percentile values from 1 to 100 were used. These are multiplied with the climate suitability coefficients to obtain the quantiles for s_8 in each geographic region.

Table A.80: Distribution of s_8

	Region	**Climate suitability**[(a)]	Percentile				
			1	**25**	**50**	**75**	**99**
	Overall average multiplier (not specific for zones)		1	3	10	30	100
Value	NW	0.43	0.43	1.29	4.3	12.9	43
Value	NE	1.27	1.27	3.81	12.7	38.1	127
Value	SW	0.62	0.62	1.86	6.2	18.6	62
Value	SE	1.68	1.68	5.04	16.8	50.4	168

(a): The scaled climate suitability was derived from the climate suitability in Table A.60 so that the average value for the four regions is 1.0.

13. Flow of infection from garden centres to home gardens (F_{13})

$$F_{13} = s_9 \times N_4$$

s_9 is the proportion of (infected) plants that is sold to consumers and planted in home gardens. This proportion should be close to one, but less than one because not all plants in a garden centre may eventually be sold. Plants in poor health may be marked down and sold as well. The following distribution was assumed.

Table A.81: Distribution of s_9, proportion of plants in garden centres sold to consumers and planted in home gardens

	Percentile				
	1	25	50	75	99
Value	0.5	0.75	0.8	0.85	0.95

14. Dynamics of infection in garden centres (F_{14})

$$F_{14} = (1 - s_9) \times N_4 + s_1 \times N_4$$

The first term is the proportion of plants that is not sold. The second term is spread within nurseries.

Here, the experts considered one infected plant in a garden centre and asked the question: how many offspring infected plants will there be next year in garden centres from this one infected plant:

i) Because the plant has not been removed (survival).
ii) Because the infection has spread to neighbours (dispersal).

(Spread to other gardens centres is not considered.)

The same spread factor was used as in nurseries, i.e. s_1, considering that similar conditions of irrigation and surveillance apply.

15. Flow of infection from home gardens to production fields (F_{15})

$$F_{15} = 0$$

To assess this flow, experts considered one infected plant in a home garden, asking the question: how many offspring infected plants will there be next year in production fields from this one infected plant due to natural means (spore dispersal or vectors).

This flow was considered to be negligible and was set to zero.

16. Flow of infection from home gardens to natural *Vaccinium* stands (F_{16})

$$F_{16} = 0$$

To assess this flow, experts considered one infected plant in a home garden, and asked the question: how many offspring infected plants will there be next year in natural *Vaccinium* stands from this one infected plant due to spread by natural means (spore dispersal or vectors).

Evidence

No ascospores are produced on blueberries. Spread is only by conidiospores. These are unlikely to reach nature areas from home gardens.

This flow was thus considered to be negligible and was set to zero.

17. Dynamics of infection in home gardens (F_{17})

To assess this flow, experts considered one infected plant in a home garden, and asked the question: how many offspring infected plants will there be next year in home gardens from this one infected plant due to spread by natural means (spore dispersal or vectors).

Survival of infected was estimated to be near 1.

Spread was not considered to be important because local populations in home gardens are too small to allow relevant spread. Therefore, the flow was estimated as:

$$F_{17} = N_5$$

Appendix B – Description and analysis of the relevant risk reducing options (RRO) for *D. vaccinii*

The Panel reviewed in **Section A** of this Appendix the list of potential RROs and, based on expert judgement, determined those that could be applied as phytosanitary measure to *D. vaccinii* in the three assessed scenarios (**Section B).** In **Section C**, an overview is given of the requirements to guarantee pest freedom of areas, places and consignments, and in **Section D**, an overview is given of the feasibility of eradication of *D. vaccinii* for three different situations.

B.1. Review of risk reducing options

1.01 Growing plants in isolation

The objective of this RRO is to implement exclusion conditions to isolate the crop from pests (e.g. a dedicated structure such a greenhouse). According to EU Directive 2014-98 (Provisions for the certification and marketing of pre-basic, basic and certified fruit plant propagating material and fruit plants intended for fruit production), pre-basic material of *Vaccinium* has to be produced in insect-proof facilities above ground and as potted plants. Thus, this RRO is part of RRO 2.06 (Certification of reproductive material, see below). [Note: other categories of propagated material can be produced in open fields]

1.03 Chemical treatments on crops including reproductive material

A wide array of different fungicides is used on cranberries and blueberries in Canada and the USA. Besides the classical fungicides (copper or sulfur compounds, carbamates, phthalamides and nitrile), newer classes of fungicides are used such as strobilurins, pyrimidines, aniline pyrimidine, diarylamine and triazoles, depending on their registration in a particular production area (Caruso and Ramsdell, 1995; Cline et al., 2000, 2007; Williamson et al., 2013). Cranberry viscid rot and upright dieback can be controlled effectively by regular fungicide applications during bloom and early berry development (Sabaratnam et al., 2014). In areas highly conducive to *P. vaccinii* infection, all cranberry fields are sprayed with fungicides (3–5 sprays per year), while in less conducive areas about half of the fields may be sprayed (1–3 times per year) (P. MacManus, questionnaire on 13/1/2017). Most cranberry fields receive 5–6 sprays per year (A. Schilder, questionnaire 24/11/2016). Highbush blueberries in highly conducive areas receive 7–11 fungicide sprays per year, while lowbush blueberries are sprayed 5–7 times per year (A. Schilder, questionnaire 24/11/2016). In less conducive areas, highbush blueberries receive 2–3 fungicide applications per year (Williamson et al., 2013).

1.05 Cleaning and disinfection of facilities, tools and machinery

Pruning tools (pruning scissors, saws and mechanical pruning machines) provide wounds and may be a pathway of transmission of *D. vaccinii* within a farm. The pathogen can be transmitted on such tools in the form of spores.

Pruning tools and machinery should be cleaned before being moved to a next farm.

Cleaning tools and machinery is regarded as Good Agricultural Practice and is not considered as a RRO in this assessment.

1.07 Use of non-contaminated water

Irrigation is common practice in blueberry and cranberry nurseries and berry production sites. Overhead irrigation may create an ideal environment for spread and survival of *D. vaccinii* in fields where the pest is present. A risk reducing option could be the prohibition for overhead irrigation for nurseries in areas where *D. vaccinii* is present.

1.08 Physical treatments on consignments or during processing

There is no data available on an effective heat treatment for *D. vaccinii* in *Vaccinium*. This RRO is not considered as an RRO in scenarios.

1.10 Waste management

After pruning, the brush debris and cut branches should be removed and shredded or burned if required to prevent pathogen spread (Davies and Crocker, 1994; Caruso and Ramsdell, 1995). Waste management is regarded as Good Agricultural Practice and is not considered as a RRO in this assessment.

1.12 Roguing and pruning

Blueberry bushes are pruned annually, usually in the dormant season. At that time, bushes are thinned out to remove dead and diseased branches (among others infected by *D. vaccinii*), and improve light penetration and flower bud formation in the interior of the plant. Brush pruning (heading-back) can be done mechanically to balance shoot and root size, control plant size, and balance the crop load. It is also used to shape the bush for mechanical harvesting. Brush pruning can be done in the summer. Cranberry plants are also pruned, but primarily to remove infected upright branches (Pesticide Risk Reduction Program, 2007).

Although pruning diseased plant parts may reduce the impact of *D. vaccinii* at harvest, pruning is not considered as an effective risk reducing option to guarantee pest freedom. Asymptomatic plant parts may not be pruned, thus pruning can only delay the onset of plant death.

In the infested nurseries, the most important sanitation measure is the immediate removal and destruction of host plants infected by *D. vaccinii* and the neighbouring plants in the immediate vicinity of the infected plants (e.g. within a radius of 3 m), because the pathogen can be present without showing symptoms. Therefore, the complete removal and destruction of infected bushes is the most appropriate course of action. The cut branches and all the debris should be destroyed by fire or properly buried in sanitary landfills.

1.17 Post-entry quarantine and other restrictions of movement

Plants for planting of *Vaccinium* is listed as a host in the EU emergency measures for *Xylella fastidiosa* (EU/2015/789). As a consequence, there is a prohibition for the import of *Vaccinium* plants from countries where *X. fastidiosa* is present, unless the plant material originates from an officially declared pest-free production place and only consists of *in vitro* plant material. This RRO could be used to exclude certain riskful plant categories from trade such as field grown potted plants or cuttings from production places. [add text explaining why these are riskful]

2.01 Inspection and trapping

Plants intended for planting of *Vaccinium* and fruits of *Vaccinium* are listed in annex V-B of EC/2000/29, therefore, an export inspection, export certificate and import inspection is required. Regular inspection of bushes is needed to detect twig blight, canker and upright dieback in areas where the pathogen is present.

The majority of infected plants and fruits that show disease symptoms are unlikely to escape visual inspection. However, the asymptomatic presence of *D. vaccinii* may occur since the incubation period can be 2–8 weeks. For blueberry plants, it was demonstrated that 5% of healthy looking plants became symptomatic (Milholland, 1982). For cranberry, *D. vaccinii* could be isolated from 90% of apparently healthy vines (Friend and Boone, 1968).

2.02 Laboratory testing

To distinguish *D. vaccinii* from other fungi with similar symptoms laboratory testing with an approved diagnostic protocol may be necessary. Laboratory testing may also be necessary to investigate the asymptomatic presence of *D. vaccinii* in nurseries situated in areas where *D. vaccinii* is present. The Panel has no information if testing for the asymptomatic presence of *D. vaccinii* in nurseries is currently applied. Is testing consignments at import to detect the asymptomatic presence a feasible option?

2.04 Phytosanitary certificates and plant passport

RRO effect covered by inspection 2.01.

2.06 Certification of reproductive material (voluntary/official)

Vaccinium is included in EU Directive 2014-98 (Provisions for the certification and marketing of pre-basic, basic and certified fruit plant propagating material and fruit plants intended for fruit production).

B.2. Summary of relevant RRO’s for the pathway plants for planting (P4P) for each scenario

Note: because the risk assessment revealed that fruit is an insignificant pathway for *D. vaccinii*, only the RROs for the pathway P4P were assessed.

A0 – Current measures for P4P

The relevant RRO's currently applied (scenario A0) are:

1) Certification of reproductive material
2) Fungicide treatments of production fields
3) Inspection of nurseries
4) Roguing in case of a finding of *D. vaccinii*
5) Laboratory testing to verify presence of *D. vaccinii*
6) Restriction to *in vitro* plant material from pest-free areas for *Xylella*
7) Export inspection
8) Import inspection.

A1 – Deregulation of *D. vaccinii* – Measures for P4P

In scenario A1, *D. vaccinii* has no quarantine status. This would imply that inspection for *D. vaccinii* is not obligatory anymore as well as laboratory testing. The certification system for *Vaccinium* would remain in place, as well as fungicidal control of fungi present in nurseries. Pruning and roguing of dead and diseased plants may continue despite the deregulation of *D. vaccinii*.

The relevant RRO's in scenario A1 are:

1) Certification of reproductive material
2) Fungicide treatments of production fields
3) Roguing in case of a finding of *D. vaccinii*
4) Restriction to *in vitro* plant material from pest-free areas for *Xylella*.

A2 – More stringent measures for P4P

Improved guarantees for pest freedom of nurseries in areas where *D. vaccinii* is present can be achieved by restricting the trade to plug plants derived from tissue culture and grown in *D. vaccinii*-free enclosed structures (i.e. this excludes potted plants and cuttings from field grown plants).

The relevant RRO's in scenario A2 are:

1) Certification of reproductive material
2) Fungicide treatments of production fields
3) Inspection of nurseries
4) Roguing in case of a finding of *D. vaccinii*
5) Laboratory testing to verify presence of *D. vaccinii*
6) Restriction to *in vitro* plant material from pest-free areas for *Xylella*
7) Export inspection
8) Import inspection
9) Restriction to trade in plants for planting from pest-free areas or in areas where *D. vaccinii* is present a restriction to trade in plug plants derived from tissue culture and grown in *D. vaccinii*-free enclosed structures. (i.e. this excludes potted plants and cuttings from field grown plants).

B.3. Analysis of possibilities to guarantee Pest Freedom

Pest-free area

Nurseries situated in an officially approved pest-free area (e.g. country, region) can guarantee pest-free propagation material, assuming that a reliable surveillance system is in place to guarantee pest freedom of the area.

Pest-free production place

In areas where *D. vaccinii* is present, for a Pest-Free Production Place (PFPP) the following official measures have to be in place to guarantee pest freedom of the nursery:

- Production under protected cultivation (e.g. greenhouses).
- The nursery is situated in an area that guarantees the absence or low *D. vaccinii* prevalence.
- Regular (i.e. calendar) fungicide treatments of the nursery.
- Inspection for *D. vaccinii* symptoms and testing if necessary.
- In case of a finding *D. vaccinii*, roguing of all plants in the infected production unit and prohibition of movement of all plants in the nursery until no disease symptoms have been detected for one year.

Pest-free consignments

For nurseries where the presence of *D. vaccinii* cannot be fully excluded, pest-free propagative material can be produced with the following possible measures:

- As far as the Panel is aware, there are no physical or chemical treatments available to guarantee pest freedom of *Vaccinium*.
- Therefore, the only reliable measure is the restriction for trade to plants derived from micropropagated plant material (plantlets from tissue culture) and plants from pest-free areas.

B.4. Assessment of feasibility of eradication of an outbreak of *D. vaccinii*

In Table B.1, an overview is given of the RROs that can be applied in eradication of an outbreak of *D. vaccinii* and the constraints that may apply for the specific RRO. In Table 2, an overview is given for the comparison of eradication success for three different outbreak situations.

Table B.1: Overview of the RROs that can be applied in eradication of an outbreak of *D. vaccinii*

Possible RROs	Effect/target	Constraints on effectiveness
Inspection	Detection of symptomatic plants in nursery	No, symptoms are clear
Sampling and testing	Identification of *D. vaccinii* and detection of asymptomatic plants in nursery	A high intensity sampling and testing scheme may be required to verify the absence of asymptomatic plants (i.e. to identify with 99% reliability a level of presence of infected plants of 1% or above and targeted especially at plants displaying suspect symptoms)
Fungicide treatment	Population control	Restricted period of effectiveness: mainly effective in blooming period
Roguing of infected plants and neighbouring plants (e.g. in a zone of 10 m around infected plants?)	Removal of infected plants in production place	No
Restriction of movement of plant material for 1 year (or 2 years?)	If asymptomatic presence of the pathogen is difficult to detect with sampling and testing a restriction of movement of the plants in the affected nursery is necessary to prevent spread of the pest Guarantee of pest freedom of plant lots where infected plants were removed (i.e. no development of symptoms 1–2 years after detection in nursery) Field grown plants can only be traded after it is verified that nursery is declared pest free (i.e. eradication was successful). Exemption for plug plants derived from tissue culture and grown in *D. vaccinii* free enclosed structures	Symptom development of all asymptomatic plants present may take 1 (or 2?) growing season
Surveillance in Buffer zone	Detection of other possible outbreaks in the surrounding area of the production place If new outbreaks are detected the affected production place is not in a pest-free area, until pathogen is eradicated from the area	The appropriate size of the buffer zone. Density and spatial distribution of suitable host plants in environment

Table B.2: Comparison of eradication success for different outbreak situations

Possible RROs	Nursery	Berry production	Natural environment
Inspection			*
Sampling and testing	*	*	***
Fungicide treatment			*
Roguing of infected plants			*
Restriction of movement			*
Surveillance in Buffer zone	*	*	**
Possibility for Eradication success	**High**	**High**	**Low**

Level of constraints on RRO: empty cell: no constrains, *: low, **: medium, ***: high.

Nursery

The probability of successful eradication of an outbreak in a nursery is assessed as high. In general, nurseries have a good intrinsic quality system for the detection and removal of diseased plants. One of the constraints for successful eradication is the detection of asymptomatic plants by sampling and testing. The difficulty in the detection of asymptomatic plants can be circumvented by the removal of all plants surrounding asymptomatic plants and/or a prohibition for movement of plants to allow symptom development of asymptomatic plants. To guarantee pest freedom of the area surrounding the affected nursery, surveillance is necessary for the presence of the pathogen in wild vegetation in a specified buffer zone.

Availability of data: *D. vaccinii* was successfully eradicated from a nursery in Poland (based on survey results in 2016).

Berry production place

In principle, the same eradication measures can be applied in berry production places in comparison to nurseries, including the restriction of movement of berries from the production place until the production place is declared pest free. Therefore, the probability of successful eradication of an outbreak in a berry production place is assessed as high.

Availability of data: *D. vaccinii* was successfully eradicated from a berry production place in The Netherlands in 201 (NPPO 2015).

Natural environment, including home gardens

The probability of successful eradication of an outbreak in the natural environment is assessed as low. The main constraints for eradication of *D. vaccinii* in the natural environment are the density and distribution of suitable wild and ornamental host plants in the environment. This may hamper the detection of all possible host plants and the feasibility to apply the selected RRO measures in the natural environment and home gardens.

Availability of data: After the confirmation of the presence of *D. vaccinii* on wild *Vaccinium*, no attempt was made to eradicate *D. vaccinii* in the natural environment in Latvia (survey results in 2016).

Time steps relevant for control measures for FRUITS pathway

Note: Trade volumes are assumed to remain unchanged. The effect of the control measures is analysed for the four relevant time steps in the entry process.

A0 Current situation

Vaccinium fruit needs an export certificate, however, there are no specific requirements for *D. vaccinii* on fruits, (i.e. there is a general inspection requirement for *Vaccinium* fruit); thus, there is a limited legal basis for rejection of consignments of *Vaccinium* fruit on the basis of the *D. vaccinii* presence (which is listed as IIAI for *Vaccinium* Plants for planting but not for fruits).

1. Export Production Place (step e3)	Pest control measures & sorting (the presence of *D. vaccinii* affects the quality of the fruit, and such berries may be sorted out at export)
2. Export inspection (step e3b)	No rejection of consignments with *D. vaccinii* symptoms
3. Import inspection (step e5)	No rejection of consignments with *D. vaccinii* symptoms
4. EU Packing & Retail Place (step e7 & e8)	Handling of incoming consignment

A1 No quarantine status

No Change compared to A0: *Vaccinium* fruit needs export certificate, no specific requirements for *D. vaccinii*.

No species specific visual symptoms of *D. vaccinii* in production places (testing is needed to verify the presence of *D. vaccinii*)

1. Export Production Place (step e3)	Pest control measures & sorting
2. Export inspection (step e3b)	No rejection of consignments with *D. vaccinii* symptoms
3. Import inspection (step e5)	No rejection of consignments with *D. vaccinii* symptoms
4. EU Packing & Retail Place (step e7 & e8)	Handling of incoming consignment

A2 Specific import requirements for fruit related to *D. vaccinii*

(a) Only fruit produced in pest-free areas *or*

For export countries/areas where *D. vaccinii* occurs pest-free production places in the open field may be difficult to achieve, even with fungicidal treatments a guarantee of pest freedom (absence of spores/conidia on fruit) may be difficult. Production under protected cultivation conditions is theoretically possible (i.e. no field exposure) but considered not to be feasible.

An effective treatment of berry consignments is not available.

Only option for areas where *D. vaccinii* is present:

(b) Fruit for (re)packaging or processing only in EU registered facilities with appropriate hygiene measures.

Conclusion: Option for exporting countries (a) or (b). This should be checked by exporting NPPO and importing NPPO (certificate check for verification of (a) or (b) at import).
Current situation in Belarus, RF and China (*D. vaccinii* presumed to be present) show that guarantee of pest freedom may not always be reliable.

Steps in risk assessment for entry model with FRUIT pathway

Note: 'No Effect' indicates no difference with A0: copy A0 quantile table for A1 and A2 in this step.

AO	Effect of A1 compared to A0	Effect of A2 compared to A0
NE0 – Estimated total number of blueberries (in millions) imported from countries with official presence of *D. vaccinii* into the EU per year	No effect	No effect
e1 – Prevalence level; Proportion of blueberry production fields infected with *D. vaccinii* in countries where *D. vaccinii* is present or presumed to be present	No effect	No effect
e2 – Incidence level; Proportion of blueberry fruit harvested in fields with presence of *D. vaccinii* that are infected with the fungus. This includes latent infections	No effect	No effect
e3 – Proportion of infected berries that are remaining at packing houses before being further shipped for export	No effect	No effect
e3b – Proportion of infected berries removed after export inspection	No effect	No effect
e4 – Multiplier accounting for a change in the number of infected berries during transport from Third countries to the EU, e.g. due to cross-infection or cross-contamination between berries	No effect	No effect

AO	Effect of A1 compared to A0	Effect of A2 compared to A0
e5 – Proportion of infected berries that is intercepted at import inspection	No effect	Import restriction: only fruits from pest-free areas or only fruit for processing
e6 – Multiplier accounting for a change in the number of infected berries during intra-EU transport, e.g. due to cross-infection or cross-contamination between berries	No effect	No effect
e7 – Proportion of infected berries that is removed at packing houses in the EU	No effect	Enhanced removal in registered facilities?
e8 – Proportion of infected berries that is removed at retail in the EU	No effect	No effect
e9 – Proportion of infected berries that is removed by consumers (waste)	No effect	No effect

Time steps relevant for control measures for P4P pathway

Note: Trade volumes are assumed to remain unchanged. The effect of the control measures is analysed for the four relevant time steps in the entry process.

A0 Current situation

D. vaccinii should be absent on *Vaccinium* P4P consignments. For areas where *Xylella fastidiosa* is present, restriction to *in-vitro Vaccinium* only.

Export nursery	Pest control measures & sorting
Export inspection	Rejection of consignments with *D. vaccinii* symptoms
Import inspection	Rejection of consignments with *D. vaccinii* symptoms
EU Nursery	handling of incoming consignment

A1 No quarantine status

Export certificate and inspection of *Vaccinium* remains, but no consignment rejections because of *D. vaccinii* presence.

Export nursery	Fungicidal control for fruit rot pathogens (incl. *D. vaccinii*) remains. Areas where *D. vaccinii* is present do not risk export rejection; increase in *D. vaccinii* presence in export consignments
Export inspection	Export inspection remains, but no rejections on basis of *D. vaccinii* presence
Import inspection	Import inspection remains, but no rejections on basis of *D. vaccinii* presence
EU nursery	No Change

A2 Specific import requirements related to *D. vaccinii*

For export countries/areas where *D. vaccinii* occurs:

- import restriction to P4P derived from meristem culture and produced in protected cultivation conditions (i.e. no field exposure).

Export nursery	Fungicidal control for fruit rot pathogens (incl. *D. vaccinii*) remains. Absence of *D. vaccinii* presence in export consignments
Export inspection	Rejection of consignments with *D. vaccinii* symptoms
Import inspection	Rejection of consignments with *D. vaccinii* symptoms
EU nursery	No change

Appendix C – Tables of data for the opinion

Table C.1: Trade of *Vaccinium* plants for planting (pieces) into the EU

	2000	2001	2002	2003	2004	2006	2007	2008	2009	2010
Country of origin										
Argentina	0	0	1	0	0	0	0	0	0	0
Canada	0	0	0	0	0	0	0	0	0	2
Chile	0	10	0	0	0	0	0	0	0	0
China	0	0	1	0	0	0	0	0	0	0
Japan	0	0	2	0	0	0	0	0	0	0
New Zealand	0	100	0	0	0	0	0	0	0	0
South Africa	0	0	0	600	0	0	0	0	0	15
United States of America	95,895	98,712	69,208	35	1,598	771	27,921	1	7,000	2,200
Total	**95,895**	**99,822**	**69,212**	**635**	**1,598**	**771**	**27,921**	**1**	**7,000**	**2,217**

Source: ISEFOR database.

Table C.2: Import of *Vaccinium* berries into the EU-28 in tonnes

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Country										
Albania	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5
Argentina	481.4	776.6	1,623.9	2,176.9	2,821.1	3,194.1	3,995.9	4,850.5	4,476.2	3,937.7
Australia	80.6	96.2	51.5	72.3	54.9	89.1	58.4	107.1	0.0	2.4
Azerbaijan	0.0	0.0	0.0	0.9	0.0	0.0	0.0	0.0	0.0	0.0
Belarus	1,259.6	1,354.4	2,187.1	2,513.6	323.7	617.9	257.8	1,101.7	242.5	204.0
Bosnia Herzegovina	21.9	51.4	46.5	92.8	42.1	31.1	63.9	79.7	39.5	88.4
Brazil	13.6	18.5	8.5	10.9	8.8	7.9	6.1	5.2	0.9	1.8
Cameroon	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0
Canada	42.5	36.0	240.0	321.6	916.6	553.5	209.2	629.8	358.8	633.4
Chile	918.7	1,620.5	2,844.5	3,823.5	5,414.5	5,364.3	7,253.9	8,898.1	11,894.1	13,577.6
China	0.2	29.0	5.3	6.4	49.3	106.8	0.1	0.0	0.0	12.6
Colombia	1.2	1.8	9.8	16.9	35.2	58.8	0.0	0.0	3.7	0.0
Ecuador	0.0	0.5	0.0	0.4	0.0	9.6	0.0	0.0	6.8	0.0
Egypt	0.0	0.0	0.0	0.0	1.8	0.8	0.2	0.9	0.0	15.5
Ghana	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
Greenland	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
Guatemala	0.0	0.0	1.4	0.0	0.0	0.0	2.1	0.0	0.0	0.8
Honduras	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Iceland	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
India	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4
Indonesia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0
Iran	0.2	0.0	0.2	5.0	0.0	0.0	0.0	0.0	0.0	0.1
Israel	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Kenya	0.0	0.0	0.0	0.0	2.4	0.0	0.0	0.0	0.0	0.0
Lebanon	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
Madagascar	0.0	0.0	0.0	0.0	0.0	19.2	0.0	0.0	0.0	0.0
Mexico	1.7	2.0	12.2	16.8	1.0	3.3	11.8	4.3	75.2	63.4
Montenegro	0.0	0.0	166.0	187.6	68.7	192.2	367.0	234.6	150.2	171.8
Morocco	0.0	0.0	0.0	0.0	214.9	625.7	1,264.8	1,866.9	2,928.0	3,416.1
New Zealand	38.1	130.2	125.2	111.5	96.2	62.6	8.4	9.9	3.7	0.0

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Norway	28.1	11.6	26.5	6.3	1.7	20.7	8.0	11.5	58.3	33.3
Peru	0.0	0.0	0.0	0.0	0.0	0.3	2.1	4.1	40.5	516.7
Russian Federation	4,118.6	3,139.5	2,514.9	473.4	0.0	14.6	10.0	1.5	427.4	516.7
Serbia	148.4	0.0	44.7	0.0	287.1	176.2	313.9	255.1	288.3	426.7
South Africa	125.2	136.8	135.6	147.1	181.4	559.9	740.2	983.4	1,180.1	1,376.6
Switzerland	13.1	1.8	2.7	25.3	1.0	0.5	1.0	0.1	0.0	0.6
Thailand	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0
TFYR of Macedonia	0.0	0.0	0.0	0.0	0.0	19.7	205.7	93.6	48.1	210.1
Tunisia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3
Turkey	9.0	0.0	6.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0
Uganda	0.1	0.0	0.0	1.8	1.3	1.8	0.3	9.3	0.2	3.5
Ukraine	2,794.7	1,960.9	1,219.5	513.6	521.6	514.3	722.6	614.9	793.3	407.9
United Rep. of Tanzania	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
United Arab Emirates	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.2
Uruguay	3.8	16.0	80.7	332.8	578.0	642.3	1,214.2	1,432.4	1,265.2	1,024.5
USA	974.5	1,522.9	1,911.1	1,725.9	1,258.8	1,255.3	1,297.1	1,290.7	1,247.5	1,368.2
Zimbabwe	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.5
Total	**11,075.7**	**10,906.8**	**13,264.9**	**12,583.5**	**12,882.5**	**14,143.3**	**18,014.8**	**22,485.3**	**25,530.0**	**28,023.4**

Source: UN Comtrade database.

Table C.3: Import of blueberries per EU member state in tonnes

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Country										
Austria	1,825	2,114	1,649	1,286	2,124	2,581	2,265	2,591	1,208	3,815
Belgium	24	28	39	130	367	185	448	307	145	584
Bulgaria	NA	NA	0	0	0	0	15	63	15	80
Croatia	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cyprus	NA	NA	1	0	0	0	0	0	1	0
Czech Republic	195	139	151	97	200	133	156	169	217	179
Denmark	198	120	247	255	182	615	790	686	785	636
Estonia	744	1,126	1,312	1,732	1,128	3,248	1,158	1,501	65	23
Finland	506	1,415	356	967	980	1,200	518	113	552	1,049
France	180	263	290	331	1,098	1,519	1,484	2,598	3,400	2,665
Germany	1,514	1,434	1,210	1,773	2,372	3,872	4,815	4,673	6,621	7,121
Greece	0	0	0	0	0	0	0	0	0	0
Hungary	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Ireland	10	20	9	48	3	0	35	3	1	2
Italy	414	347	396	579	907	835	1,300	1,436	1,812	2,117
Latvia	20	21	44	39	50	387	535	60	64	406
Lithuania	1,671	1,669	2,360	2,758	342	1,133	424	1,070	1,102	1,264
Luxembourg	7	7	9	10	11	12	29	39	48	58
Malta	0	0	0	0	1	0	0	0	0	0
Netherlands	201	1,074	660	318	772	676	2,059	3,305	2,499	2,586
Poland	1,551	2,204	1,915	2,278	741	1,108	1,138	1,692	1,342	1,770
Portugal	1	0	1	4	5	3	2	54	96	156
Romania	0	2	1	19	7	3	3	8	13	24
Slovakia	0	2	4	3	5	18	25	40	45	39
Slovenia	149	29	34	23	57	149	100	82	65	94
Spain	112	49	29	63	76	130	438	452	1,089	2,646
Sweden	869	579	1,067	693	119	130	213	319	674	587
United Kingdom	451	1,039	789	2,587	1,158	901	2,007	1,832	3,873	4,793
Total	**10,642**	**13,681**	**12,573**	**15,993**	**12,705**	**18,838**	**19,957**	**23,093**	**25,732**	**32,694**

NA: Not available.
Source: FAOSTAT.

Table C.4: Import of cranberries per EU member state in tonnes

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Country										
Austria	93	72	78	15	40	42	27	18	73	88
Belgium	547	551	645	593	703	748	902	1,418	1,948	2,095
Bulgaria	NA	NA	0	0	0	9	9	8	0	0
Croatia	2	4	4	7	5	4	6	20	35	23
Cyprus	NA	NA	1	0	0	0	0	0	0	0
Czech Republic	15	0	0	0	0	0	0	0	0	0
Denmark	193	13	27	28	102	154	66	79	70	83
Estonia	1	0	2	3	8	1	4	47	1	1
Finland	8	3	14	17	56	61	82	141	149	231
France	51	71	84	42	41	101	55	128	204	209
Germany	223	110	80	181	139	275	539	1,239	1,734	2,340
Greece	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Hungary	NA	0	1	0	0	0	0	0	0	0
Ireland	11	10	15	21	52	22	74	258	146	173
Italy	63	88	112	75	73	204	174	206	149	150
Latvia	94	86	215	227	157	47	250	85	4	2
Lithuania	25	25	40	57	7	13	13	13	82	471
Luxembourg	NA	NA	NA	0	0	0	0	0	0	0
Malta	0	0	0	0	0	1	0	2	2	1
Netherlands	755	1,061	2,310	2,507	3,346	3,463	4,172	6,185	7,397	8,050
Poland	0	0	0	0	0	0	0	0	0	0
Portugal	NA	NA	NA	NA	23	10	135	129	57	2
Romania	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
Slovakia	NA	NA	NA	NA	1	5	7	7	7	3
Slovenia	0	0	0	0	0	0	0	0	1	0
Spain	10	24	12	34	15	301	411	628	321	212
Sweden	60	30	18	12	39	78	94	232	182	267
United Kingdom	2,239	3,454	5,487	6,726	9,586	9,456	10,296	12,665	13,941	14,254
Total	**4,390**	**5,602**	**9,145**	**10,545**	**14,393**	**14,995**	**17,316**	**23,508**	**26,503**	**28,655**

NA: Not available.
Source: FAOSTAT.

Table C.5: Import of cranberries into the EU in tonnes (main producers)

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Country of origin										
Belarus	248.3	254.3	665.0	683.8	123.4	188.7	78.5	388.9	77.6	62.3
Canada	8.4	6.8	73.0	87.5	349.4	169.1	63.7	222.3	114.8	193.5
Chile	181.1	304.3	864.8	1,040.2	2,064.0	1,638.6	2,209.3	3,141.4	3,805.7	4,148.3
TFYR of Macedonia	0.0	0.0	0.0	0.0	0.0	6.0	62.6	33.0	15.4	64.2
USA	192.1	285.9	581.1	469.6	479.8	383.4	395.1	455.7	399.2	418.0

Output of calculations based on Comtrade and FAOSTAT trade data.

Table C.6: Import of blueberries into the EU in tonnes

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Country of origin										
Albania	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
Argentina	386.5	630.8	1,130.2	1,584.7	1,745.7	2,218.4	2,778.9	3,138.1	3,044.0	2,734.6
Australia	64.7	78.1	35.8	52.6	34.0	61.9	40.6	69.3	0.0	1.7
Azerbaijan	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0
Belarus	1,011.3	1,100.1	1,522.1	1,829.8	200.3	429.2	179.3	712.8	164.9	141.7
Bosnia Herzegovina	17.6	41.7	32.4	67.6	26.1	21.6	44.4	51.6	26.9	61.4
Brazil	10.9	15.0	5.9	7.9	5.4	5.5	4.2	3.4	0.6	1.3
Cameroon	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0
Canada	34.1	29.2	167.0	234.1	567.2	384.4	145.5	407.4	244.0	439.9
Chile	737.6	1,316.2	1,979.6	2,783.3	3,350.6	3,725.7	5,044.6	5,756.7	8,088.4	9,429.3
China	0.2	23.6	3.7	4.7	30.5	74.2	0.1	0.0	0.0	8.8
Colombia	1.0	1.5	6.8	12.3	21.8	40.8	0.0	0.0	2.5	0.0
Ecuador	0.0	0.4	0.0	0.3	0.0	6.7	0.0	0.0	4.6	0.0
Egypt	0.0	0.0	0.0	0.0	1.1	0.6	0.1	0.6	0.0	10.8
Georgia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Guatemala	0.0	0.0	1.0	0.0	0.0	0.0	1.5	0.0	0.0	0.6
Honduras	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Iceland	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
India	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
Indonesia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
Iran	0.2	0.0	0.1	3.6	0.0	0.0	0.0	0.0	0.0	0.1
Israel	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Kenya	0.0	0.0	0.0	0.0	1.5	0.0	0.0	0.0	0.0	0.0
Lebanon	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
Madagascar	0.0	0.0	0.0	0.0	0.0	13.3	0.0	0.0	0.0	0.0
Mexico	1.4	1.6	8.5	12.2	0.6	2.3	8.2	2.8	51.2	44.1
Montenegro	0.0	0.0	115.5	136.6	42.5	133.5	255.2	151.8	102.1	119.3
Morocco	0.0	0.0	0.0	0.0	133.0	434.6	879.6	1,207.8	1,991.1	2,372.4
New Zealand	30.6	105.8	87.1	81.2	59.5	43.5	5.8	6.4	2.5	0.0
Norway	22.5	9.4	18.5	4.6	1.1	14.4	5.6	7.4	39.6	23.1

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Peru	0.0	0.0	0.0	0.0	0.0	0.2	1.5	2.7	27.5	358.8
Russian Federation	3,306.7	2,550.0	1,750.3	344.6	0.0	10.1	7.0	1.0	290.7	358.8
Serbia	119.1	0.0	31.1	0.0	177.7	122.4	218.3	165.0	196.0	296.3
South Africa	100.5	111.1	94.4	107.1	112.3	388.9	514.8	636.2	802.5	956.0
Switzerland	10.5	1.5	1.9	18.4	0.6	0.3	0.7	0.1	0.0	0.4
Thailand	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0
TFYR of Macedonia	0.0	0.0	0.0	0.0	0.0	13.7	143.1	60.6	32.7	145.9
Tunisia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9
Turkey	7.2	0.0	4.2	0.0	0.0	0.0	0.1	0.0	0.0	0.0
Uganda	0.1	0.0	0.0	1.3	0.8	1.3	0.2	6.0	0.1	2.4
Ukraine	2,243.8	1,592.7	848.7	373.9	322.8	357.2	502.5	397.8	539.5	283.3
United Rep. of Tanzania	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
United Arab Emirates	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.1
Uruguay	3.1	13.0	56.2	242.3	357.7	446.1	844.4	926.7	860.4	711.5
USA	782.4	1,237.0	1,330.1	1,256.4	779.0	871.9	902.1	835.0	848.4	950.2
Zimbabwe	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.3

Output of calculations based on Comtrade and FAOSTAT trade data.

Table C.7: Export of cranberries per year for the non-EU countries in tonnes

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Country of origin										
Albania	0	0	0	0	2	2	6	9	0	0
Belarus	1,329	1,438	2,478	3,105	690	2,497	1,208	1,526	594	666
Canada	44,972	40,828	47,202	45,316	40,402	41,485	34,493	35,737	58,764	60,107
Chile	10,104	11,938	15,433	20,872	34,707	38,508	55,099	73,760	69,134	81,656
China	0	1	0	0	0	0	0	0	0	0
China, Taiwan Province of	0	1	0	0	0	0	0	0	0	0
Ecuador	0	0	0	0	0	1	0	0	0	0
Egypt	13	177	98	0	0	1	0	13	18	16
Georgia	0	0	0	0	0	0	0	0	0	1
India	9	49	0	49	6	1	0	2	2	1
Kuwait	0	0	0	0	0	30	30	30	30	0
Netherlands	60	151	521	894	799	346	410	1,890	3,994	3,479
Norway	0	0	0	0	8	3	2	8	50	32
Qatar	10	32	23	0	0	0	0	0	0	0
Romania	0	0	48	7	0	0	0	0	0	0
Russian Federation	0	0	25	0	25	10	0	0	0	0
Saudi Arabia	74	36	30	82	0	0	0	0	0	0
Serbia and Montenegro	148	34	0	0	0	0	0	0	0	0
Switzerland	0	0	21	0	5	0	4	2	22	4
The former Yugoslav Republic of Macedonia	20	0	213	213	6	20	283	0	48	314
Tunisia	0	0	2	0	0	0	196	117	0	4
Turkey	0	0	8	0	4	0	1	0	12	8
United Arab Emirates		6	54	277	320	0	0	16	16	16
United Kingdom	0	35	70	119	98	124	147	237	128	134
United States of America	9,121	13,609	12,627	16,128	19,709	14,825	12,603	10,631	9,113	11,115
Total	**65,860**	**68,335**	**78,853**	**87,062**	**96,781**	**97,853**	**104,482**	**123,978**	**141,925**	**157,553**

Source: FAOSTAT.

Table C.8: Export of blueberries per year for the non-EU countries in tonnes

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Country of origin										
Albania	NA	NA	NA	NA	0	0	3	0	0	0
Bosnia and Herzegovina	22	0	0	0	0	0	0	0	0	0
Canada	19,776	15,171	15,959	12,780	17,051	19,249	20,564	20,090	29,713	30,215
China	1	0	0	0	0	0	2	2	0	1
China, Macao SAR	NA	NA	NA	0	NA	NA	NA	NA	NA	NA
China, Taiwan Province of	1	0	0	0	0	0	2	2	0	1
Honduras	0	0	0	0	3	0	0	0	0	0
Jamaica	NA	NA	NA	NA	NA	3	0	11	0	0
Montenegro	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Morocco	0	0	0	0	137	636	1,761	1,501	2,711	4,790
New Zealand	380	561	778	793	587	697	1,190	667	936	1,115
Peru	NA	NA	NA	NA	NA	NA	NA	NA	NA	1,499
Romania	273	529	335	234	339	46	340	378	609	514
Russian Federation	1,692	1,282	2,116	116	0	0	0	0	160	15
Serbia	NA	NA	25	17	215	179	0	0	0	0
Thailand	NA	NA	NA	3	0	0	0	0	0	0
Ukraine	2,384	2,170	0	0	0	0	0	0	0	0
United Kingdom	1	4	13	21	41	31	64	41	56	407
United States of America	16,825	24,342	22,952	29,033	35,773	35,704	40,425	49,036	45,182	48,862
Uruguay	NA	NA	NA	488	0	0	0	0	0	0
Total	**65,860**	**68,335**	**78,853**	**87,062**	**96,781**	**97,853**	**104,482**	**123,978**	**141,925**	**157,553**

NA: Not available.
Source: FAOSTAT.

Table C.9: Import of ‘Other live plants (including their roots), cuttings and slips; mushroom Spawn (CN-code: 0602)’ from non-EU countries. Quantity values are illustrated in 100 kg

	2010	2011	2012	2013	2014	2015
Reporter country						
Austria	3,154	3,102	3,204	1,394	1,201	1,234
Belgium (and LUXBG -> 1998)	21,395	21,670	28,244	28,440	32,197	32,502
Bulgaria	3,963	14,862	26,658	17,540	23,947	29,508
Croatia	4,711	4,672	9,081	7,225	3,400	3,246
Cyprus	20,696	18,589	10,222	6,586	6,970	2,436
Czech Republic (CS-> 1992)	1,017	570	440	816	1,053	815
Denmark	8,621	7,697	8,826	6,090	5,535	6,978
Estonia	0	0	6	1	2	3
Finland	50	63	94	32	38	67
France	18,110	16,419	14,607	10,107	9,791	7,576
Germany (incl. DD from 1991)	45,822	39,700	44,258	38,394	38,322	41,389
Greece	2,822	845	769	1,875	478	888
Hungary	7,861	8,408	5,776	6,979	1,479	2,643
Ireland	1,868	1,228	404	198	58	424
Italy	60,153	60,480	43,061	43,527	35,651	30,681
Latvia	230	414	26	849	266	198
Lithuania	321	735	1,179	399	232	433
Luxembourg	0	582	35	0	0	0
Malta	1	7	0	3	17	2
Netherlands	708,055	673,760	634,206	584,625	570,078	524,464
Poland	1,803	1,297	2,282	5,266	14,772	55,504
Portugal	3,372	1,863	2,977	2,374	1,525	734
Romania	4,922	6,204	13,138	64,267	30,101	11,780
Slovakia	2	45	3	7	85	5
Slovenia	3,175	5,761	5,479	3,406	3,486	4,716
Spain	58,294	49,070	41,949	47,072	52,700	50,422
Sweden	1,462	1,631	2,503	1,220	432	505
United Kingdom	13,776	11,197	9,246	6,239	5,076	4,645
EU28	**995,656**	**950,871**	**908,673**	**884,931**	**838,892**	**813,798**

Source: EUROSTAT.

Table C.10: Proportion of import of 'other live plants' per country

	2010	2011	2012	2013	2014	2015
Reporter country						
Austria	0.3%	0.3%	0.4%	0.2%	0.1%	0.2%
Belgium (and LUXBG -> 1998)	2.1%	2.3%	3.1%	3.2%	3.8%	4.0%
Bulgaria	0.4%	1.6%	2.9%	2.0%	2.9%	3.6%
Croatia	0.5%	0.5%	1.0%	0.8%	0.4%	0.4%
Cyprus	2.1%	2.0%	1.1%	0.7%	0.8%	0.3%
Czech Republic (CS->1992)	0.1%	0.1%	0.0%	0.1%	0.1%	0.1%
Denmark	0.9%	0.8%	1.0%	0.7%	0.7%	0.9%
Estonia	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Finland	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
France	1.8%	1.7%	1.6%	1.1%	1.2%	0.9%
Germany (incl. DD from 1991)	4.6%	4.2%	4.9%	4.3%	4.6%	5.1%
Greece	0.3%	0.1%	0.1%	0.2%	0.1%	0.1%
Hungary	0.8%	0.9%	0.6%	0.8%	0.2%	0.3%
Ireland	0.2%	0.1%	0.0%	0.0%	0.0%	0.1%
Italy	6.0%	6.4%	4.7%	4.9%	4.2%	3.8%
Latvia	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%
Lithuania	0.0%	0.1%	0.1%	0.0%	0.0%	0.1%
Luxembourg	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%
Malta	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Netherlands	71.1%	70.9%	69.8%	66.1%	68.0%	64.4%
Poland	0.2%	0.1%	0.3%	0.6%	1.8%	6.8%
Portugal	0.3%	0.2%	0.3%	0.3%	0.2%	0.1%
Romania	0.5%	0.7%	1.4%	7.3%	3.6%	1.4%
Slovakia	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Slovenia	0.3%	0.6%	0.6%	0.4%	0.4%	0.6%
Spain	5.9%	5.2%	4.6%	5.3%	6.3%	6.2%
Sweden	0.1%	0.2%	0.3%	0.1%	0.1%	0.1%
United Kingdom	1.4%	1.2%	1.0%	0.7%	0.6%	0.6%

Source: EUROSTAT.

Table C.11: Area of production of blueberries in the EU in hectares

	Area of production (ha) of blueberries in the EU			
	2007	2008	2010	2014
Country				
Austria	NA	NA	NA	86
Belgium	NA	NA	NA	NA
Bulgaria	NA	NA	NA	NA
Croatia	NA	NA	NA	NA
Cyprus	NA	NA	NA	NA
Czech Republic	NA	NA	NA	NA
Denmark	20	20	24	30
Estonia	NA	NA	NA	60
Finland	NA	NA	NA	NA
France	328	340	360	416
Germany	1,781	2,050	2,146	2,316
Greece	NA	NA	NA	NA
Ireland	NA	NA	NA	22
Italy	219	243	275	472
Latvia	NA	NA	NA	70
Lithuania	NA	NA	NA	70
Luxembourg	NA	NA	NA	NA
Hungary	NA	NA	NA	NA
Malta	NA	NA	NA	NA
Netherlands	235	243	259	700
Poland	2,713	2,794	3,158	3,740
Portugal	130	134	194	470
Romania	NA	NA	NA	140
Slovenia	NA	NA	NA	NA
Slovakia	NA	NA	NA	NA
Spain	757	850	1,053	1,824
Sweden	32	32	36	44
United Kingdom	NA	NA	NA	380

NA: Not available.
Source: USHBC Report 2014.

Table C.12: Area of production of blueberries in the Europe in hectares

	Area of production (ha) of blueberries in the EU				
	2010	**2011**	**2012**	**2013**	**2014**
Country					
Bulgaria	17	16	15	15	14
Denmark	38	44	46	53	55
France	2,640	2,455	2,458	2,402	2,490
Germany	1,429	1,434	1,835	2,031	2,083
Italy	174	174	175	176	176
Latvia	600	1,000	1,000	1,440	1,400
Lithuania	3,000	2,700	2,600	2,600	2,200
Netherlands	535	584	586	574	639
Norway	23	25	23	25	22
Poland	2,167	2,404	3,126	3,223	3,470
Romania	372	361	280	334	310
Russian Federation	500	500	500	500	500
Sweden	4,470	4,700	5,000	4,675	4,655
Switzerland	46	55	66	73	73
Ukraine	200	200	150	150	150

Source: FAOSTAT, 14 February 2017.

Table C.13: Area of production of cranberries in the EU in hectares

	Area of production (ha) of cranberries in the EU				
	2010	2011	2012	2013	2014
Country					
Austria	NA	NA	NA	NA	NA
Belgium	NA	NA	NA	NA	NA
Bulgaria	76	72	72	80	75
Croatia	NA	NA	NA	NA	NA
Cyprus	NA	NA	NA	NA	NA
Czech Republic	NA	NA	NA	NA	NA
Denmark	NA	NA	NA	NA	NA
Estonia	NA	NA	NA	NA	NA
Finland	NA	NA	NA	NA	NA
France	NA	NA	NA	NA	NA
Germany	NA	NA	NA	NA	NA
Greece	NA	NA	NA	NA	NA
Hungary	NA	NA	NA	NA	NA
Ireland	NA	NA	NA	NA	NA
Italy	NA	NA	NA	NA	NA
Latvia	400	400	400	400	267
Lithuania	NA	NA	NA	NA	NA
Luxembourg	NA	NA	NA	NA	NA
Malta	NA	NA	NA	NA	NA
Netherlands	NA	NA	NA	NA	NA
Poland	NA	NA	NA	NA	NA
Portugal	NA	NA	NA	NA	NA
Romania	81	80	80	80	80
Slovenia	NA	NA	NA	NA	NA
Slovakia	NA	NA	NA	NA	NA
Spain	NA	NA	NA	NA	30
Sweden	NA	NA	NA	NA	NA
United Kingdom	NA	NA	NA	NA	NA

NA: Not available.
Source: FAOSTAT.

Table C.14: Projections of growth of EU blueberry production based on Brazelton Report 2014

	Projections of growth of EU blueberry production	
	Millions of pounds	**tonnes**
Year		
2014	150	67,500
2015	180	81,000
2016	200	90,000
2017	220	99,000
2018	240	108,000
2019	280	126,000

Source: Brazelton Report 2014.

Table C.15: Area of production of blueberries in the EU in hectares (historical and projection data)

Country	2007	2008	2010	2014	2016[(a)]	2018[(a)]	2020[(a)]
Austria	NA	NA	NA	86	94	101	109
Belgium	NA	NA	NA	NA	NA	NA	NA
Bulgaria	NA	NA	NA	NA	NA	NA	NA
Croatia	NA	NA	NA	NA	NA	NA	NA
Cyprus	NA	NA	NA	NA	NA	NA	NA
Czech Republic	NA	NA	NA	NA	NA	NA	NA
Denmark	20	20	24	30	33	36	38
Estonia	NA	NA	NA	60	65	71	76
Finland	NA	NA	NA	NA	NA	NA	NA
France	328	340	360	416	441	466	491
Germany	1,781	2,050	2,146	2,316	2,469	2,621	2,774
Greece	NA	NA	NA	NA	NA	NA	NA
Hungary	NA	NA	NA	NA	NA	NA	NA
Ireland	NA	NA	NA	22	24	26	28
Italy	219	243	275	472	544	617	689
Latvia	NA	NA	NA	70	76	83	89
Lithuania	NA	NA	NA	70	76	83	89
Luxembourg	NA	NA	NA	NA	NA	NA	NA
Malta	NA	NA	NA	NA	NA	NA	NA
Netherlands	235	243	259	700	893	1,230	1,695
Poland	2,713	2,794	3,158	3,740	4,034	4,327	4,621
Portugal	130	134	194	470	621	911	1,338
Romania	NA	NA	NA	140	153	165	178
Slovakia	NA	NA	NA	NA	NA	NA	NA
Slovenia	NA	NA	NA	NA	NA	NA	NA
Spain	757	850	1,053	1,824	2,778	3,572	4,594
Sweden	32	32	36	44	NA	NA	NA
United Kingdom	NA	NA	NA	380	414	448	483

NA: Not available.
(a): Projection.
Source: USHBC Report 2014.

Table C.16: Estimate of blueberry plant needs for Europe per year

	2014[(a)]	2016[(b)]	2018[(b)]	2020[(b)]
Blueberry area	10,840	12,714	14,758	17,293
N. plants/ha	3,000	3,000	3,000	3,000
Renewal of existing berry orchards (ha) – total/15	723	848	984	1,153
New berry orchards (ha)	800	937	1,022	1,268
Total new plantations (ha)	1,523	1785	2,006	2,420
Plants needed/year	**4,568,000**	**5,354,156**	**6,017,573**	**7,261,156**

(a): Base year.
(b): Projection.

Table C.17: Production of blueberries in tonnes

	2010	2011	2012	2013	2014
Country					
Austria	NA	NA	NA	NA	NA
Belgium	100	100	100	100	98
Bulgaria	90	96	NA	NA	NA
Croatia	NA	NA	NA	NA	NA
Cyprus	NA	NA	NA	NA	NA
Czech Republic	NA	NA	NA	NA	NA
Denmark	47	54	57	34	35
Estonia	NA	NA	NA	NA	NA
Finland	NA	NA	NA	NA	NA
France	11,001	9,379	8,161	9,011	9,200
Germany	8,305	6,608	8,843	10,277	12,077
Greece	NA	NA	NA	NA	NA
Hungary	NA	NA	NA	NA	NA
Ireland	NA	NA	NA	NA	NA
Italy	1,620	1,632	1,643	1,655	1,667
Latvia	600	1,000	1,000	1,110	1,000
Lithuania	600	1,000	1,000	1,110	1,000
Luxembourg	NA	NA	NA	NA	NA
Malta	NA	NA	NA	NA	NA
Netherlands	600	1,000	1,000	1,110	1,000
Poland	9,195	8,595	11,251	12,731	12,469
Portugal	247	251	255	254	267
Romania	2,277	2,229	1,746	2,103	1,968
Slovakia	NA	NA	NA	NA	NA
Slovenia	NA	NA	NA	NA	NA
Spain	1,700	5,000	5,500	5,500	5,000
Sweden	2,550	2,600	3,000	2,733	2,675
United Kingdom	NA	NA	NA	NA	NA

NA: Not available.
Source: FAOSTAT.

Table C.18: Production of cranberries in tonnes

	2010	2011	2012	2013	2014
Country					
Austria	NA	NA	NA	NA	NA
Belgium	95	93	90	90	90
Bulgaria	90	96	NA	NA	NA
Croatia	NA	NA	NA	NA	NA
Cyprus	NA	NA	NA	NA	NA
Czech Republic	NA	NA	NA	NA	NA
Denmark	NA	NA	NA	NA	NA
Estonia	NA	NA	NA	NA	NA
Finland	NA	NA	NA	NA	NA
France	46	48	49	51	53
Germany	NA	NA	NA	NA	NA
Greece	NA	NA	NA	NA	NA
Hungary	NA	NA	NA	NA	NA
Ireland	NA	NA	NA	NA	NA
Italy	NA	NA	NA	NA	NA
Latvia	976	791	676	618	617
Lithuania	NA	NA	NA	NA	NA
Luxembourg	NA	NA	NA	NA	NA
Malta	NA	NA	NA	NA	NA
Netherlands	NA	NA	NA	NA	NA
Poland	NA	NA	NA	NA	NA
Portugal	NA	NA	NA	NA	NA
Romania	642	639	549	621	563
Slovakia	NA	NA	NA	NA	NA
Slovenia	NA	NA	NA	NA	NA
Spain	100	100	100	100	100
Sweden	NA	NA	NA	NA	NA
United Kingdom	NA	NA	NA	NA	NA

NA: Not available.
Source: FAOSTAT.

Table C.19: Surveillance results of *Diaporthe vaccinii* from EU member states

Country	Crop	Location	No. of inspected companies/sites	No. of visual inspections	No. of samples	Positive samples
Belgium	*Vaccinium corymbosum*	23 (out of 31) companies with blue berry fruit production (*Vaccinium corymbosum*)	23		14[(a)]	0
Netherlands	*Vaccinium*	Nursery	9		1	0
	Vaccinium corymbosum	Open field	35		6	0
	Vaccinium myrtillus	Forest	72		20	0
Latvia	*Vaccinium plants (cranberries, blueberries)*	*Vaccinium* plants (cranberries, blueberries) in nurseries, productions sites and marshes		60	53	3[(b)]
Czech Republic	*Vaccinium* (European and American cultivars)	Plants for planting of *Vaccinium* (European and American cultivars) and in natural vegetation of the entire territory of CZ. Fruits on the market were also included in the survey		76	22	0
Germany	*Vaccinium*	21 fruit production of blueberries, twelve private gardens, 19 nurseries and 26 garden centres	66	88	45	0
Poland	*Vaccinium myrtillus, Vaccinium vitis-idaea, Vaccinium corymbosum, Vaccinum corymbosum, Vaccinium ovatum, Vaccinium angustifolium, Vaccinium macrocarpon, Vaccinum oxycoccos*			455	4[(c)]	0
Sweden	*Vaccinum* spp.	Nurseries		90	6	0
	Vaccinum spp.	Garden Centres		100	11	0
	Vaccinum spp.	Other sites, berry producer		–	2	0
Lithuania				53	24	0

(a):14 samples were collected from 12 companies.
(b): Two positive samples were found in cranberry production sites and one positive sample was found in blueberry production site.
(c): Samples were taken only from *Vaccinium corymbosum*.

Table C.20: Areas with natural *Vaccinium* plants (in km^2) in the EU Member States (based on the presence of *V. myrtillus* and *V. vitis*-idea)

	Areas with natural *Vaccinium* plants
Country	
AT Austria	51,453
BE Belgium	6,409
BG Bulgaria	22,612
CZ Czech Republic	26,291
DE Germany	98,566
DK Denmark	4,481
EE Estonia	26,418
ES Spain	60,147
FI Finland	267,272
FR France	96,657
GR Greece	1
HR Croatia	6,437
HU Hungary	431
IE Ireland	18,356
IT Italy	64,918
LT Lithuania	21,458
LU Luxembourg	916
LV Latvia	34,018
NL Netherlands	3,024
PL Poland	95,908
PT Portugal	170
RO Romania	47,005
SE Sweden	36,1784
SI Slovenia	8,708
SK Slovakia	11,022
UK United Kingdom	71,247

Table C.21: *Diaporthe vaccinii* interceptions on consignments from third countries reported in EUROPHYT (data extracted from EUROPHYT, June 2014, for 2016 data checked till (including) the week 39

Year	Country	Origin	Intercepted commodity	Number of interceptions	Volume of the consignments (11) pieces	Volume of the intercepted part (12) pieces	Volume of contaminated part (13) pieces
1996	Italy	United States of America	*Vaccinium* sp. (INTENDED FOR PLANTING: NOT YET PLANTED)				

Table C.22: Current distribution of *Diaporthe vaccinii* n the risk assessment area, based on EPPO Global Database

Current situation	Member state	State
Absent, no pest record	Austria	
Absent, no pest record	Belgium	
Absent, pest eradicated	Germany	
Present, restricted distribution	Latvia	
Absent, pest eradicated	Lithuania	
Absent, pest eradicated	Netherlands	
Absent, pest eradicated	Poland	
Absent, pest no longer present	Romania	
Absent, pest no longer present	United Kingdom	
Absent, pest no longer present	United Kingdom	England
Absent, pest no longer present	United Kingdom	Scotland

Table C.23: Effectiveness of import inspections for scenarios A0 and A1

Effectiveness of phytosanitary measures or certification schemes on pest abundance at import[(a)]					
Quantile (percentile)	Reduction factor		Quantile (percentile)	Multiplier	
	A0-PW1	A1-PW1		A0-PW1	A1-PW1
Lower (1%)	0.4	0.4	Upper (99%)	0.6	0.6
Q1 (25%)	0.6	0.6	Q3 (75%)	0.4	0.4
Median (50%)	0.67	0.67	Median (50%)	0.33	0.33
Q3 (75%)	0.75	0.75	Q1 (25%)	0.25	0.25
Upper (99%)	0.9	0.9	Lower (1%)	0.1	0.1

(a): The assessment model uses a multiplier which is calculated as one minus the estimated effectiveness factor. A value for an upper quantile for effectiveness corresponds to a lower quantile for the multiplier, and vice versa.

Appendix D – Maps

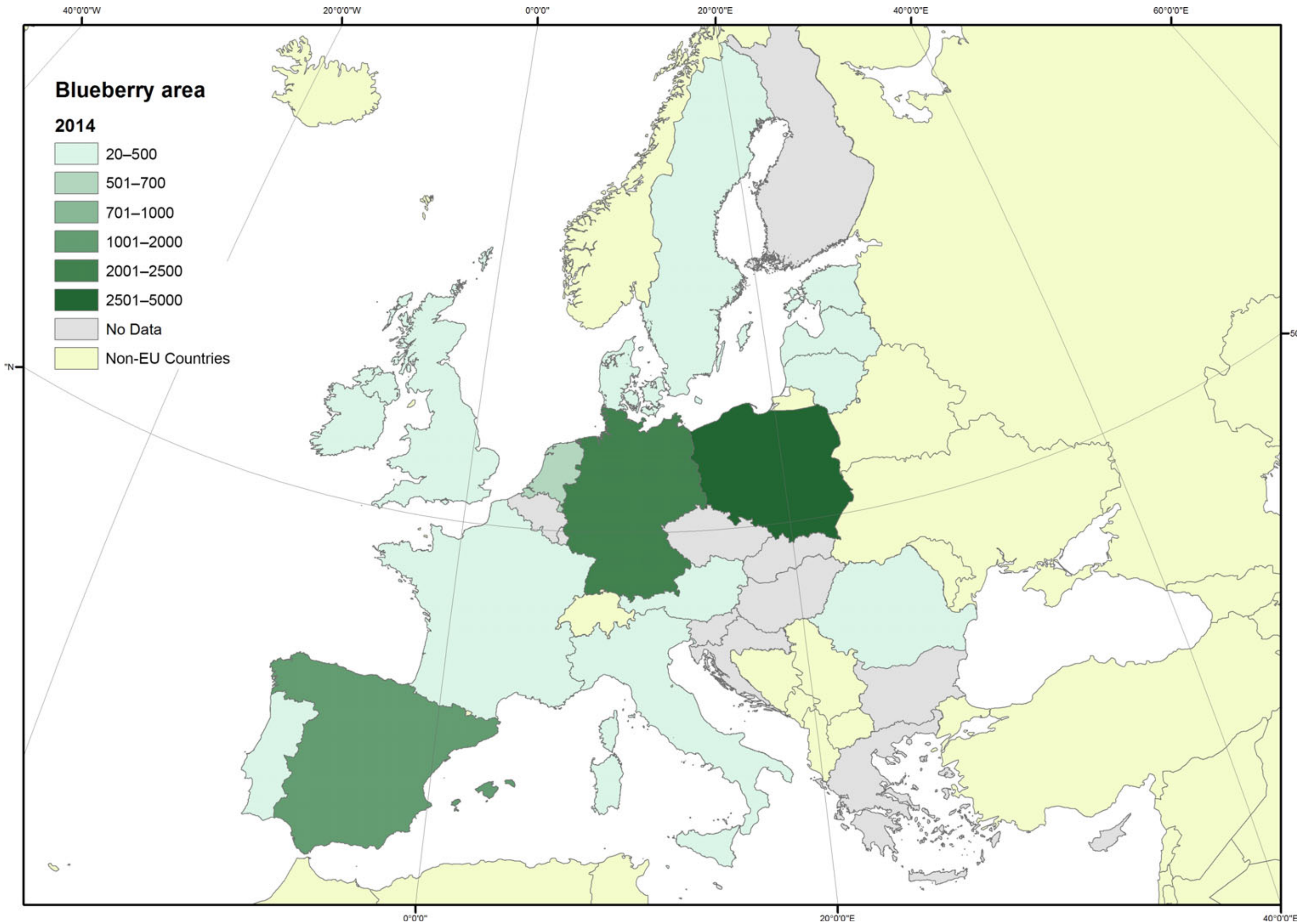
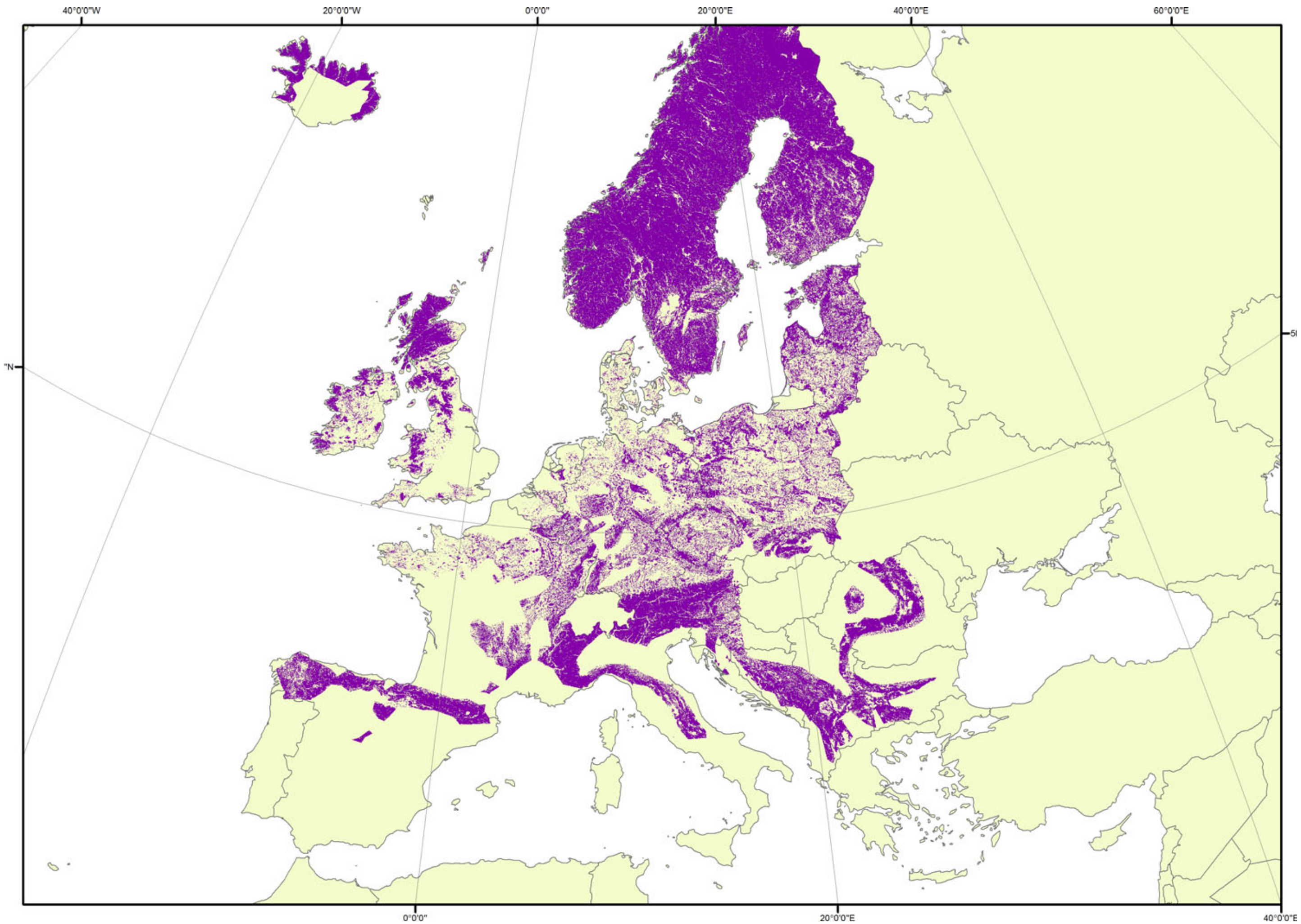


Figure D.1: Blueberry cultivated areas in EU countries in 2014. Values are in ha. (Data source: US Highbush Blueberry Council report, 2015)



The dotted area represents the potential occurrence of the two above listed species.

Figure D.2: Distribution of *Vaccinium* species (based on *V. myrtillus and V. vitis-idea* maps) in natural and semi-natural vegetation (based on Corine Land Cover map)

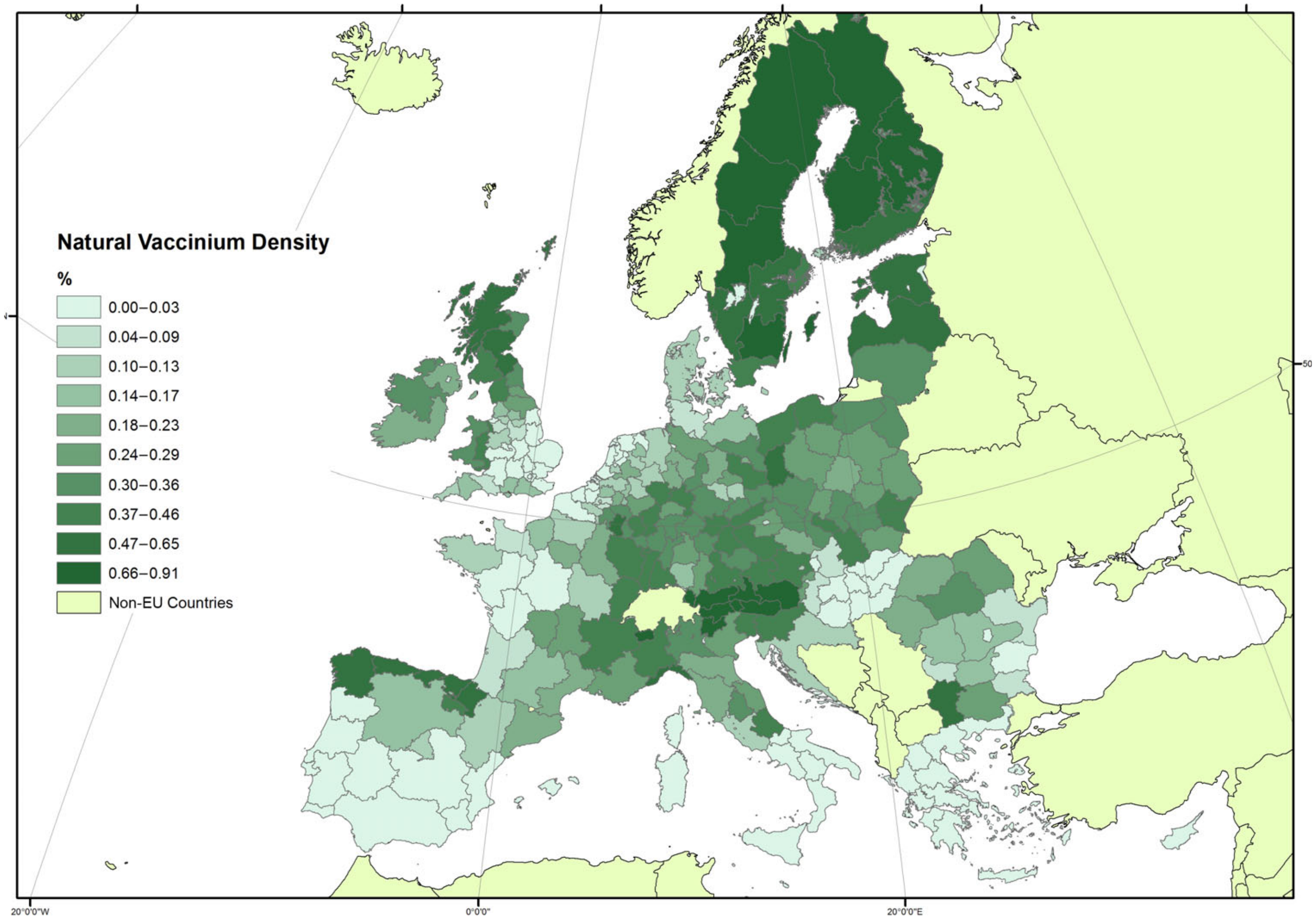


Figure D.3: Relative cover of *Vaccinium* species at NUTS 2 level (based on the map reported in Figure 3)

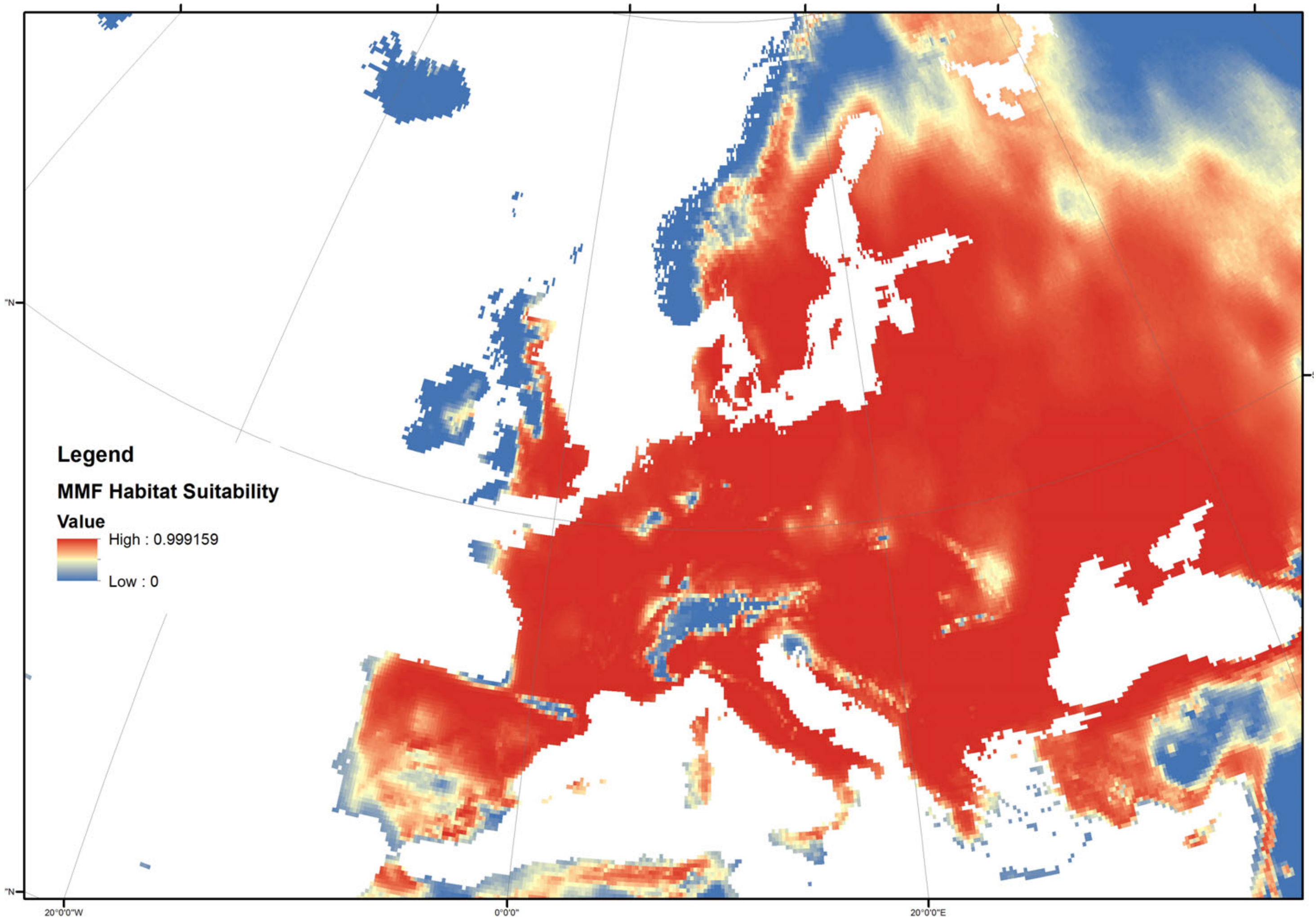


Figure D.4: Suitability of climatological conditions for the potential establishment of *D. vaccinii* in Europe based on the MMF model. (Narouei-Khandan et al., 2017). Lower values indicate lower risk

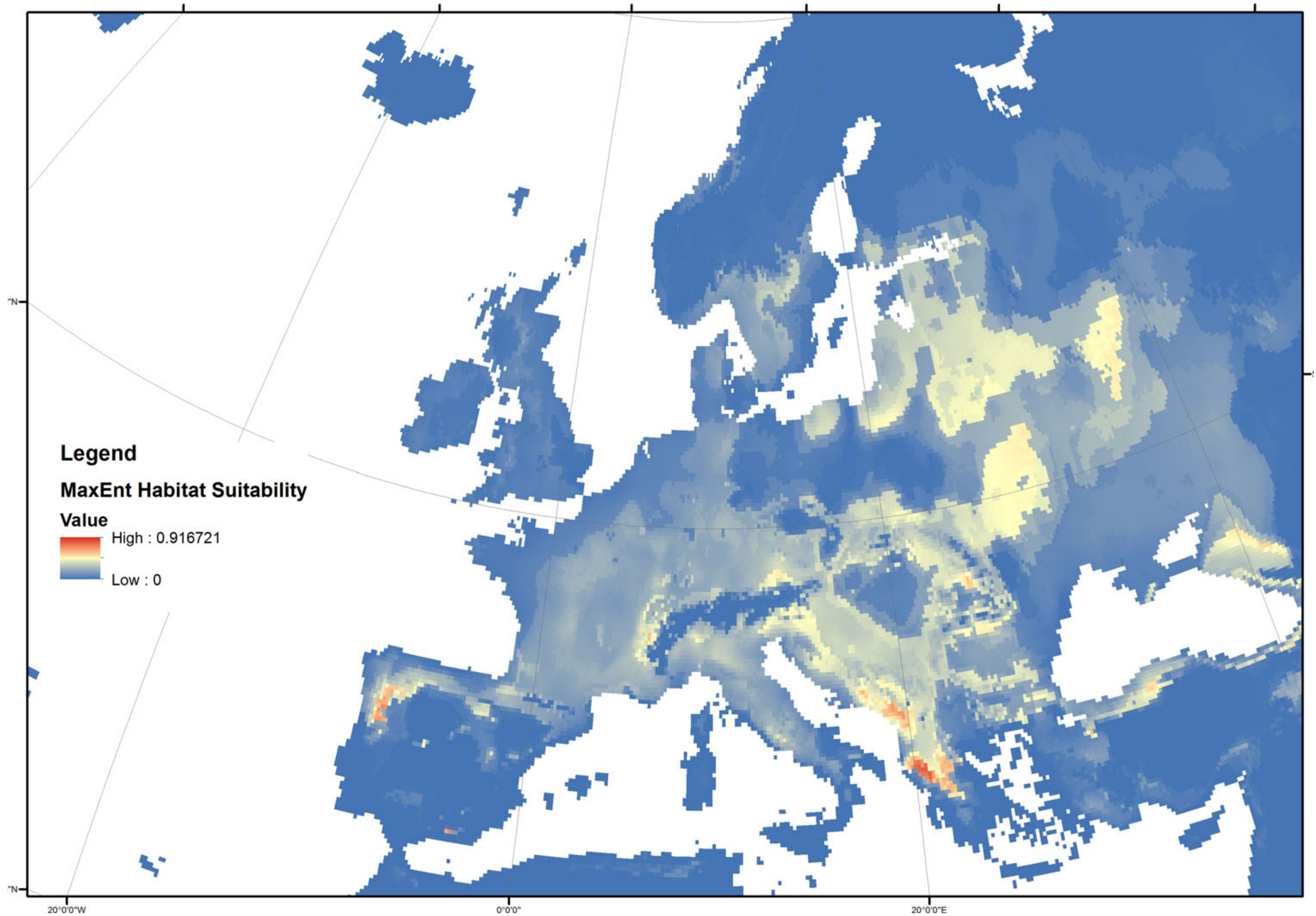


Figure D.5: Suitability of climatological conditions for the potential establishment of *D. vaccinii* in Europe based on the MaxEnt model. (Narouei-Khandan et al., 2017). Lower values indicate lower risk

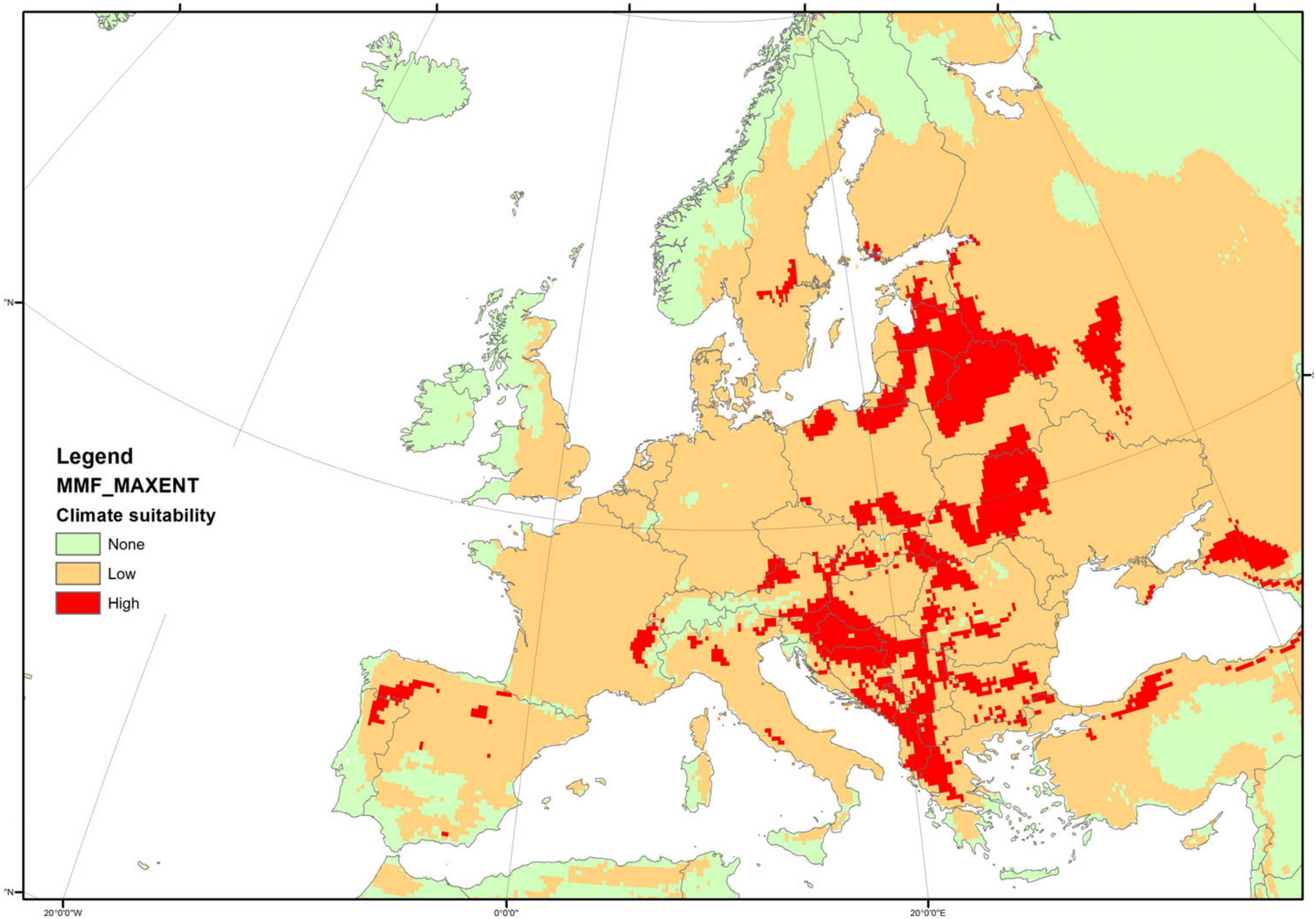


Figure D.6: Suitability of climatological conditions for the potential establishment of *D. vaccinii* in Europe at NUTS2 level, based on the combined risks calculated with the correlative models MaxEnt and Multi-model Framework (Narouei-Khandan et al., 2017)

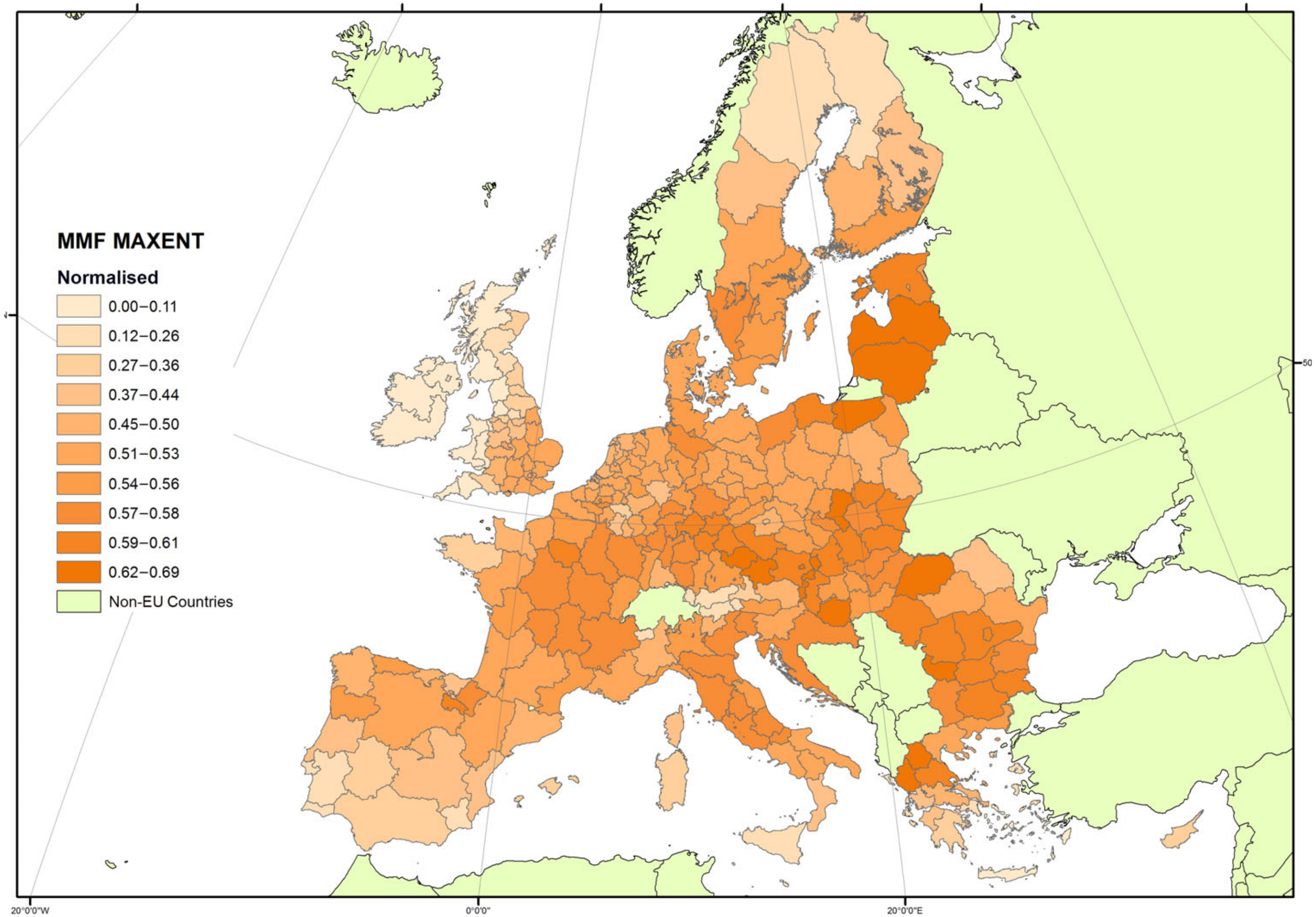


Figure D.7: Suitability of climatological conditions for the potential establishment of *D. vaccinii* in Europe at NUTS2 level, based on the combined risks calculated with the correlative models MaxEnt and Multi-model Framework (Narouei-Khandan et al., 2017)

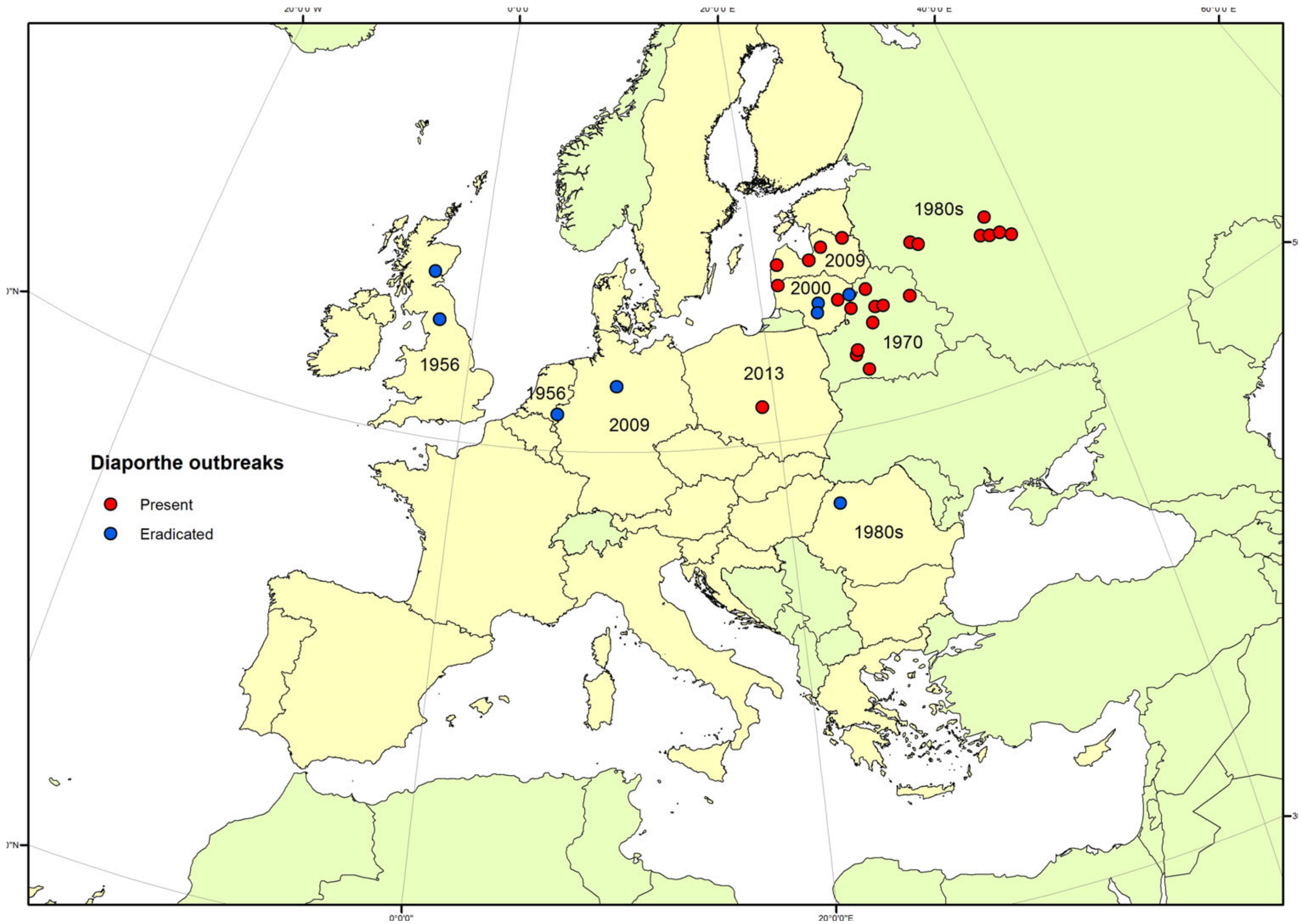


Figure D.8: Locations where *D. vaccinii* has been detected in Europe. In blue are the locations where the pest has been eradicated, in red all the other locations

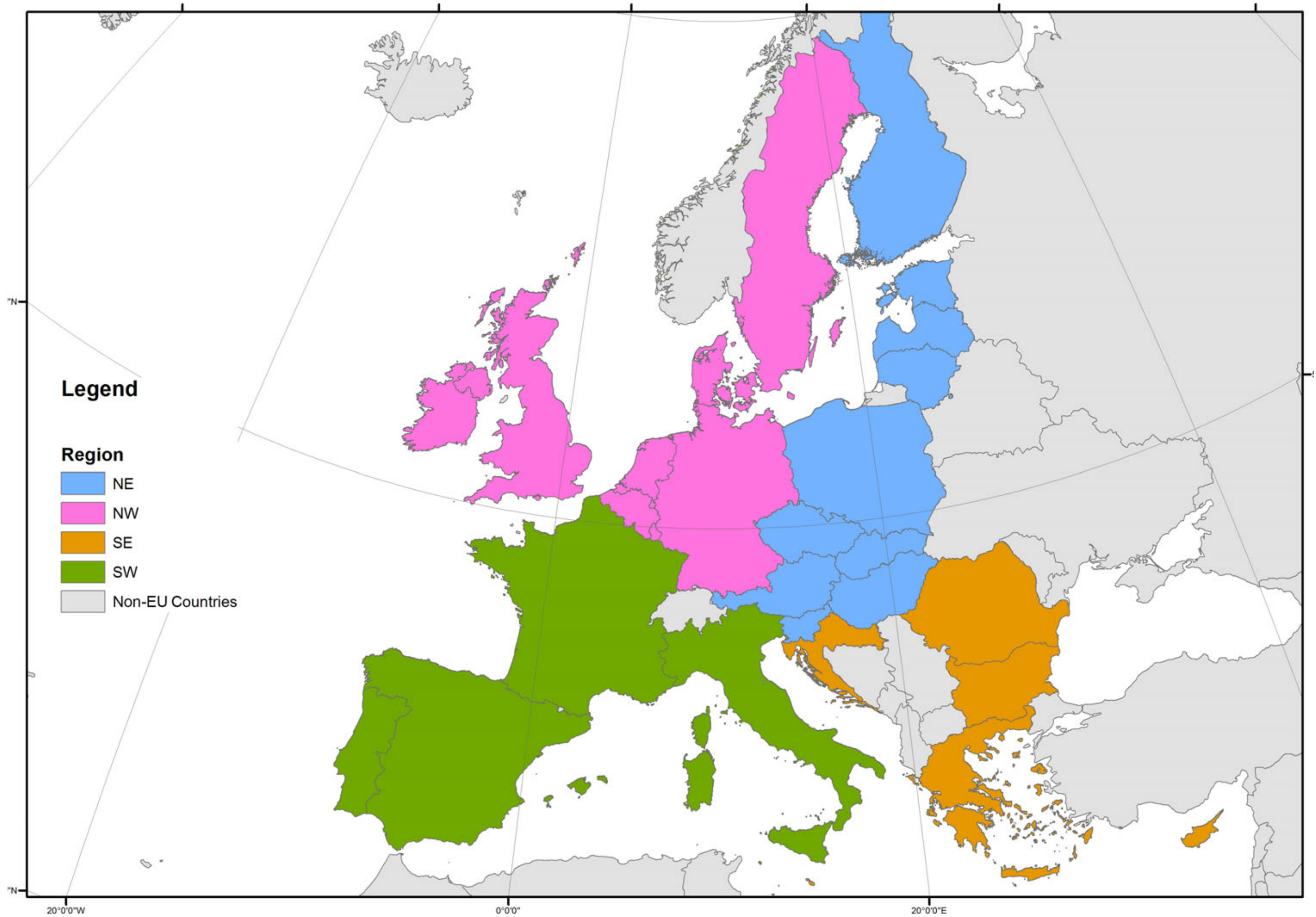


Figure D.9: EU regions used for the establishment assessment. The four regions are characterised by different level of climate suitability

Appendix E – Sensitivity analysis

In the graphs reported in this appendix is shown the decomposition of the uncertainty for various combinations of pathways and sub-steps. All these combinations refer to the A0 scenario.

As example, from the graph reported below, we can see that for the Entry of *D. vaccinii*-infected blueberry plugs, the factor having the largest contribution to the overall uncertainty is e1_plug_blue_HR that is the proportion of blueberry production fields infected with *D. vaccinii* in the High-Risk countries. The second factor (N0_plug_blue_LR) is the number of plugs imported from the Low-Risk countries (Figure E.1).

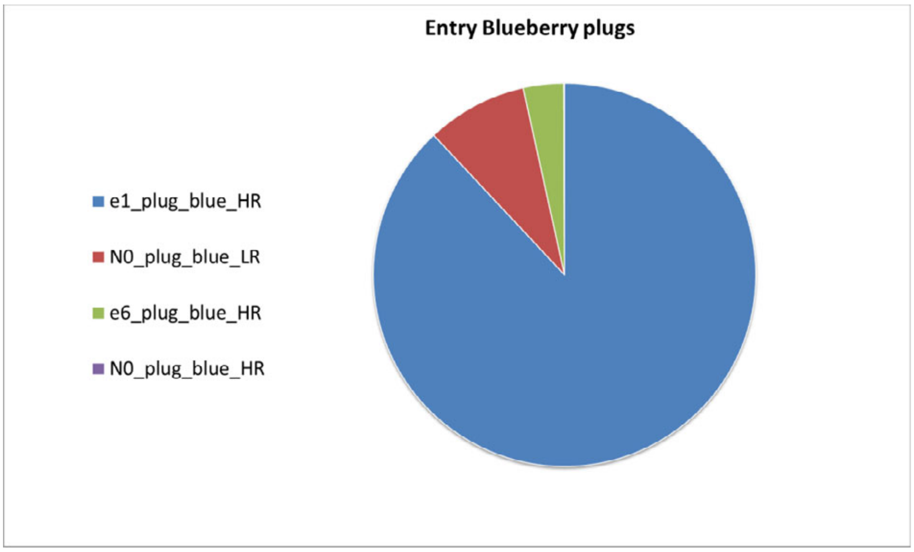
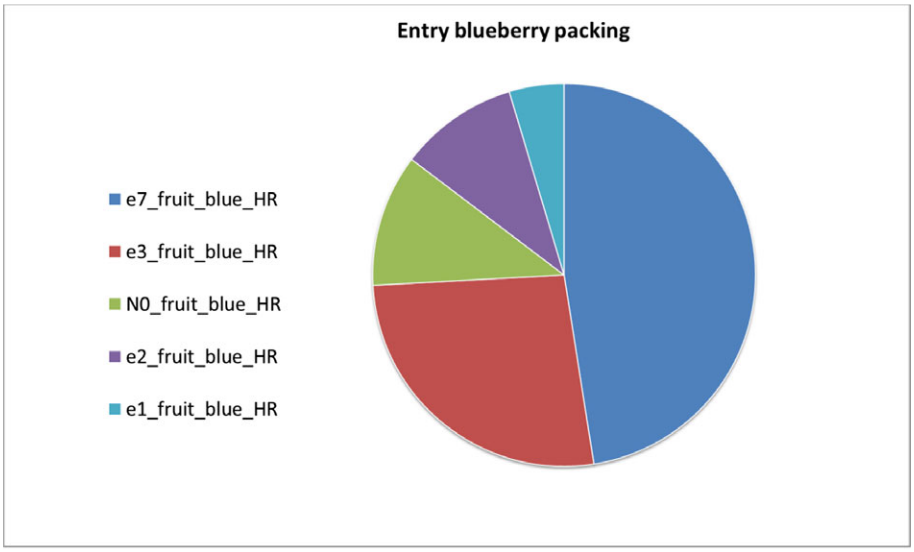


Figure E.1: Example of sensitivity analysis

Rules for the interpretation of parameter names:

fruit = berry pathway
plug = plugs pathway
pot = potted plants and cuttings pathways
blue = blueberry
cran = cranberry
HR = High-Risk areas (as defined in the PRA)
LR = Low-Risk areas (as defined in the PRA)
N0, etc. = values (i.e. number of imported blueberry fruits) as defined in the Appendix A
e1, e2, ..., eX = parameters (i.e. Proportion of fields having *D. vaccinii* in the countries of origin under A0) as defined in the Appendix A.


Entry blueberry packing
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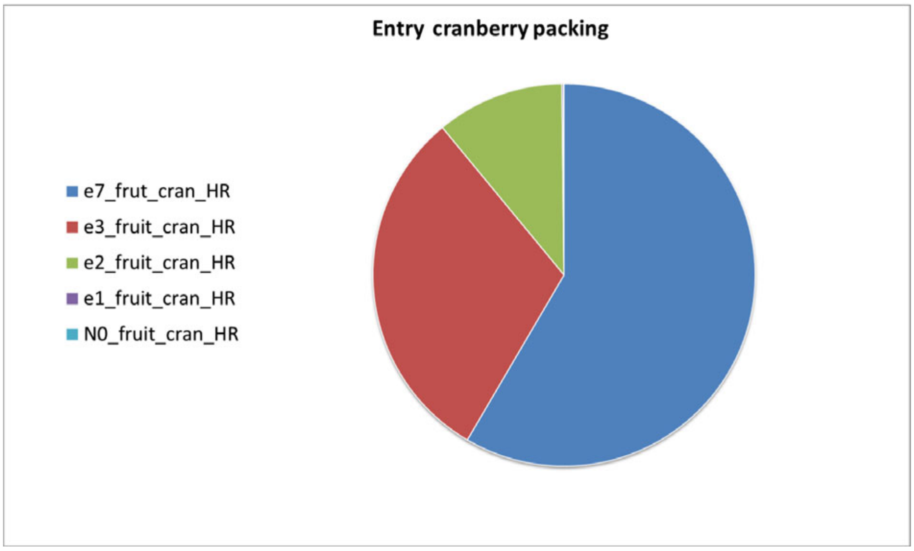
e3_fruit_blue_HR
N0_fruit_blue_HR
e2_fruit_blue_HR
e1_fruit_blue_HR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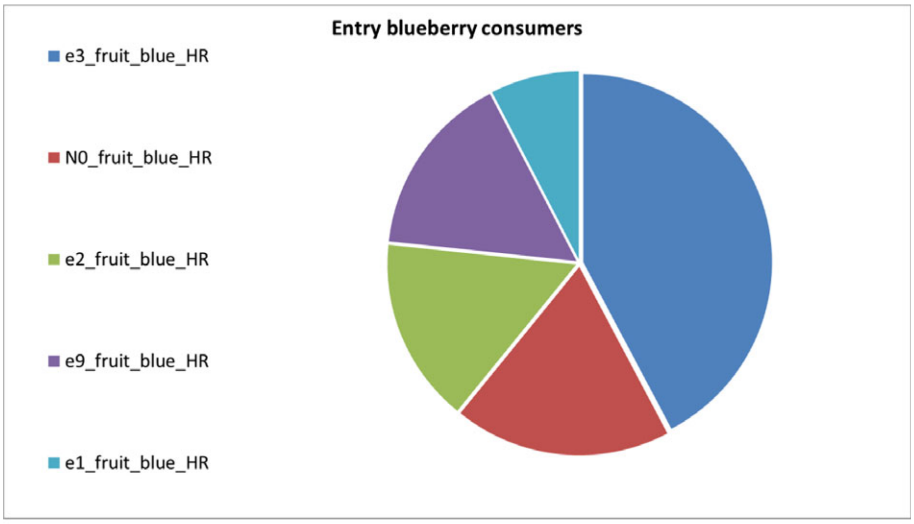
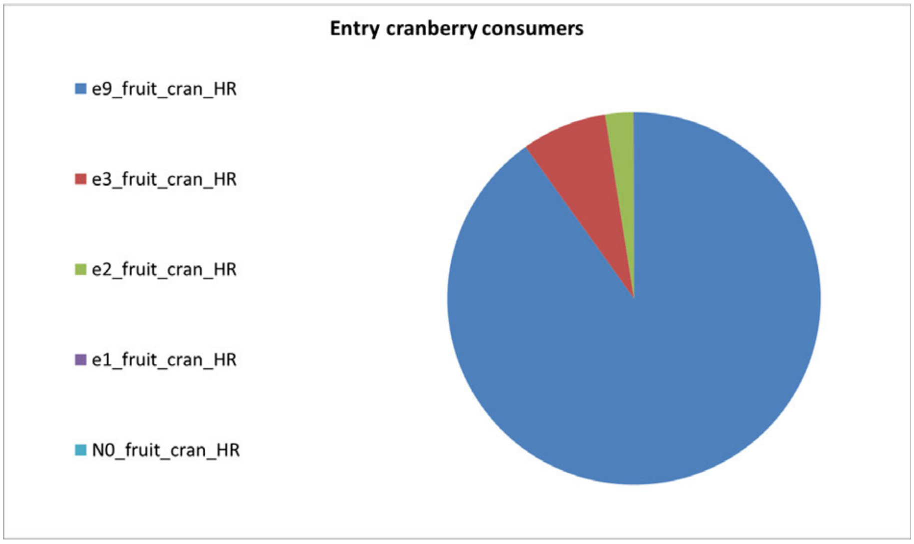
e2_fruit_cran_HR
e1_fruit_cran_HR
N0_fruit_cran_HR


Entry blueberry consumers
e3_fruit_blue_HR
N0_fruit_blue_HR
e2_fruit_blue_HR
e9_fruit_blue_HR
e1_fruit_blue_HR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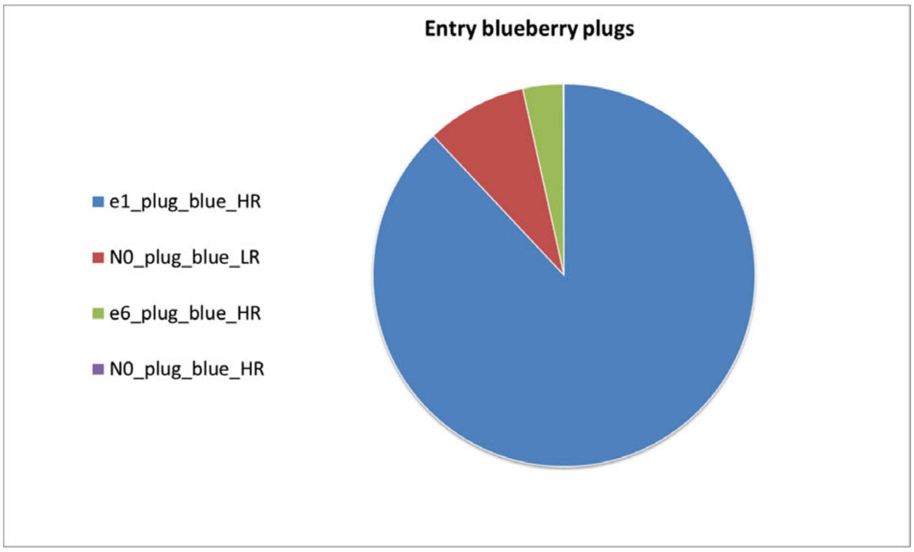
N0_fruit_cran_HR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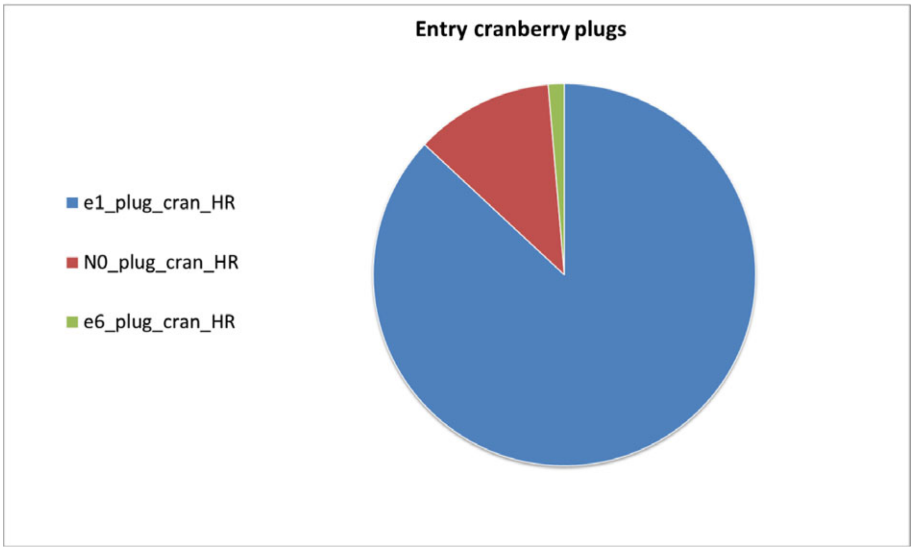
e6_plug_blue_HR
N0_plug_blue_HR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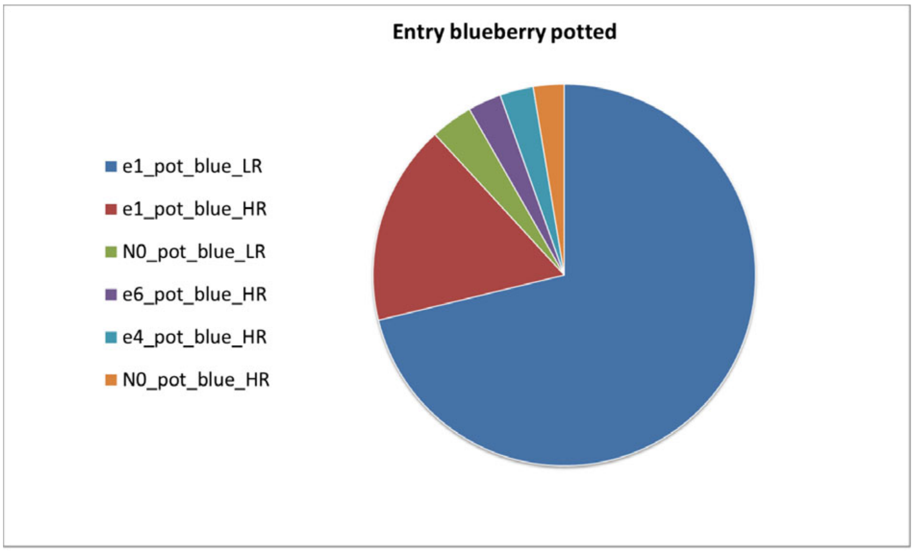
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e6_pot_blue_HR
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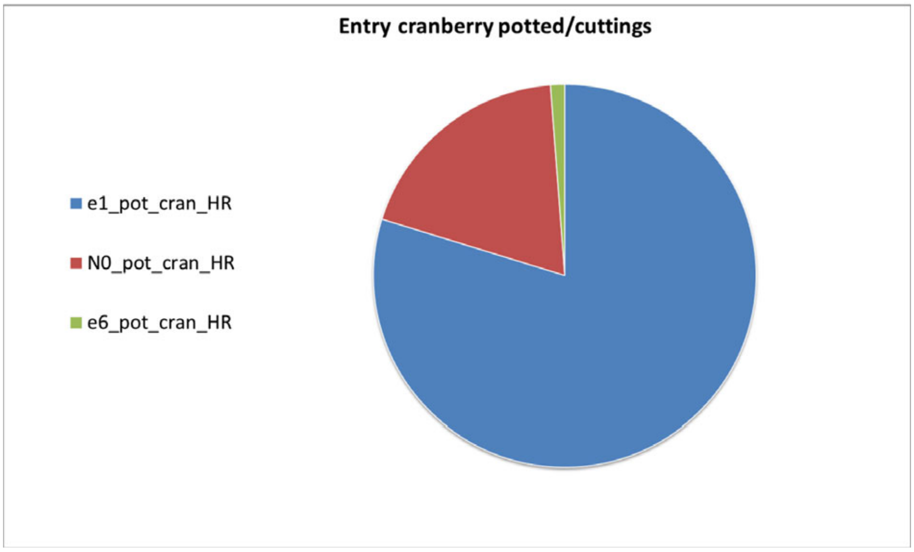
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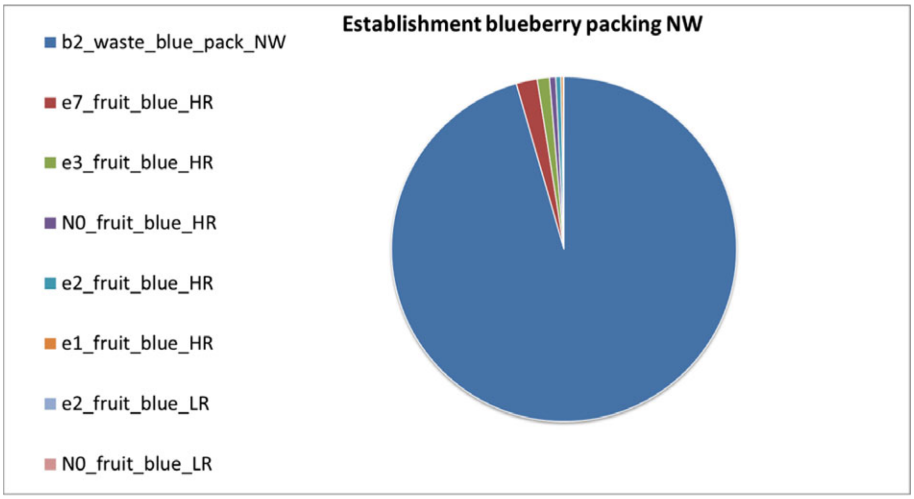
N0_pot_cran_HR
e6_pot_cran_HR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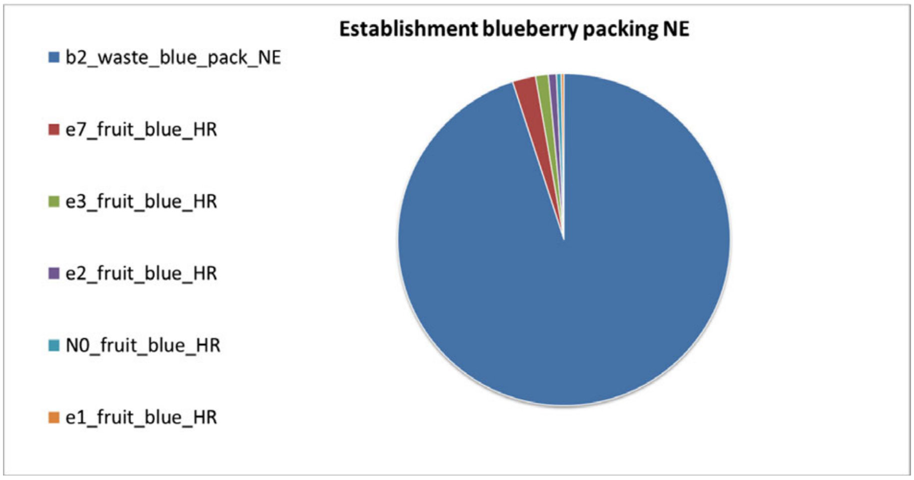
N0_fruit_blue_LR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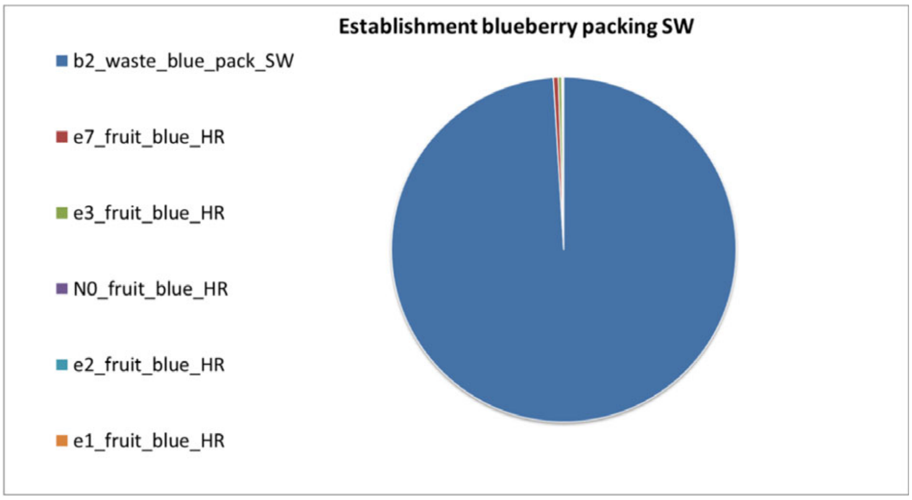
N0_fruit_blue_HR
e1_fruit_blue_HR


Establishment blueberry packing SW
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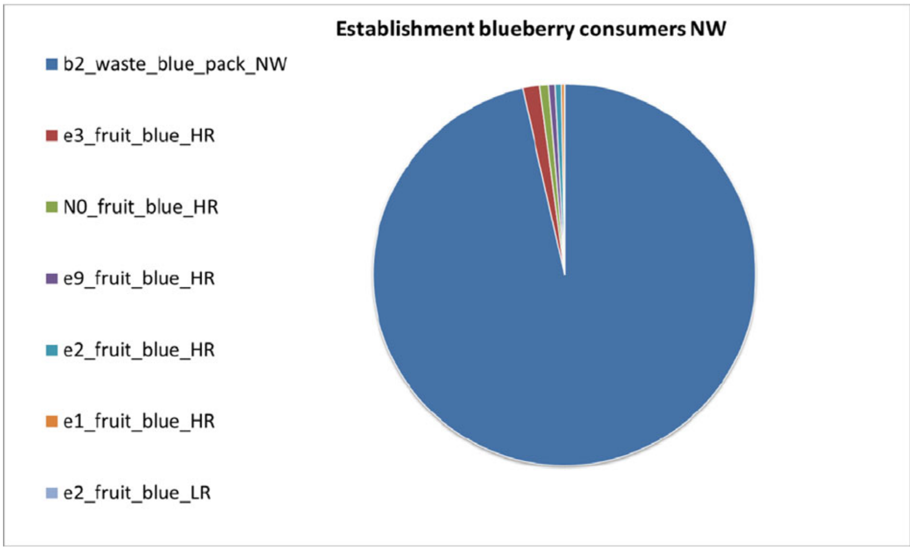
e1_fruit_blue_HR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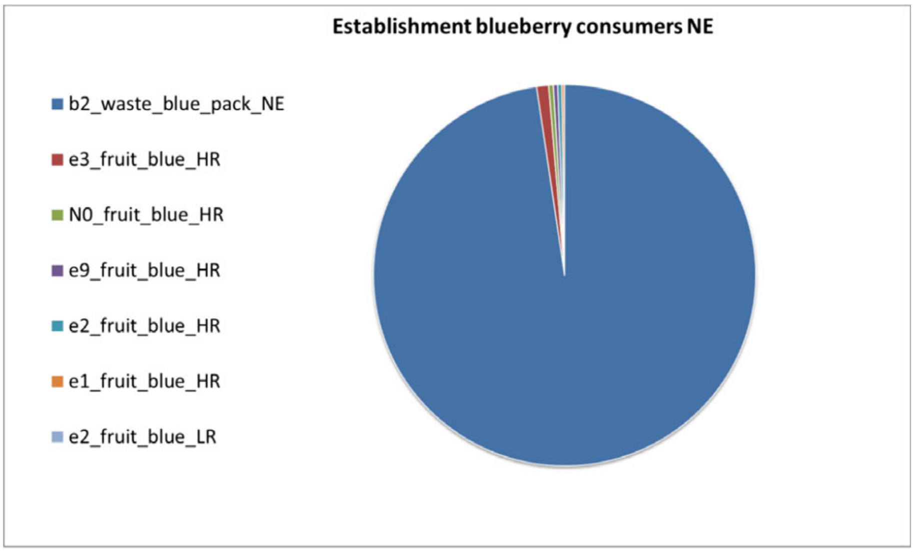
e2_fruit_blue_LR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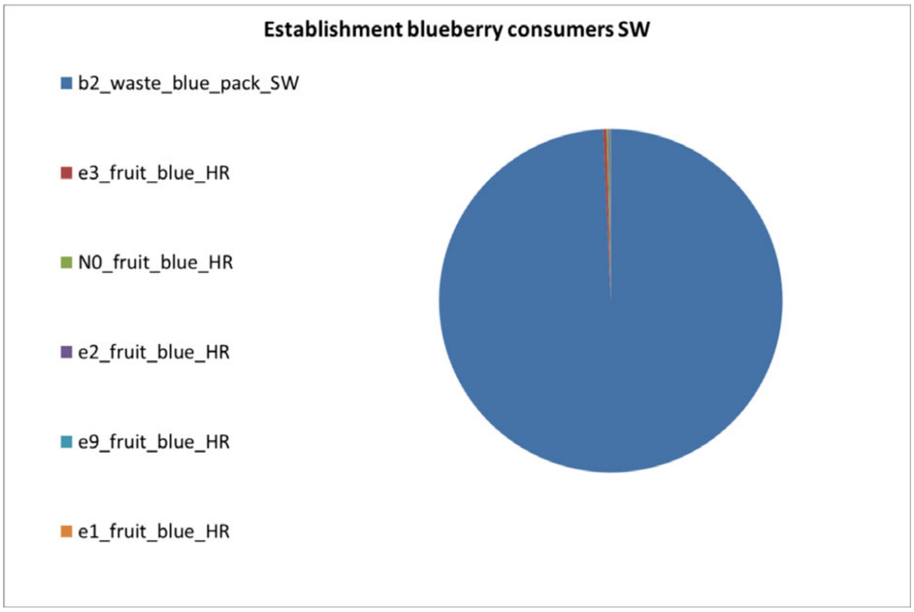
e2_fruit_blue_LR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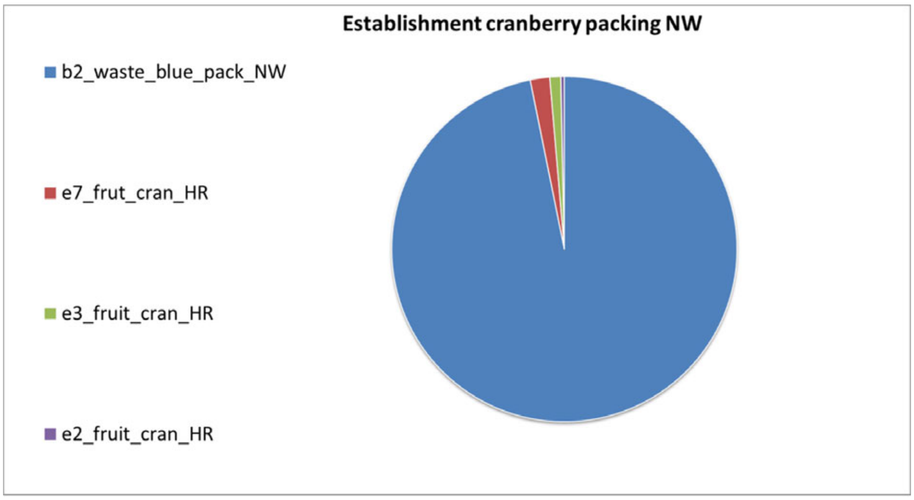
e2_fruit_blue_HR
e9_fruit_blue_HR
e1_fruit_blue_HR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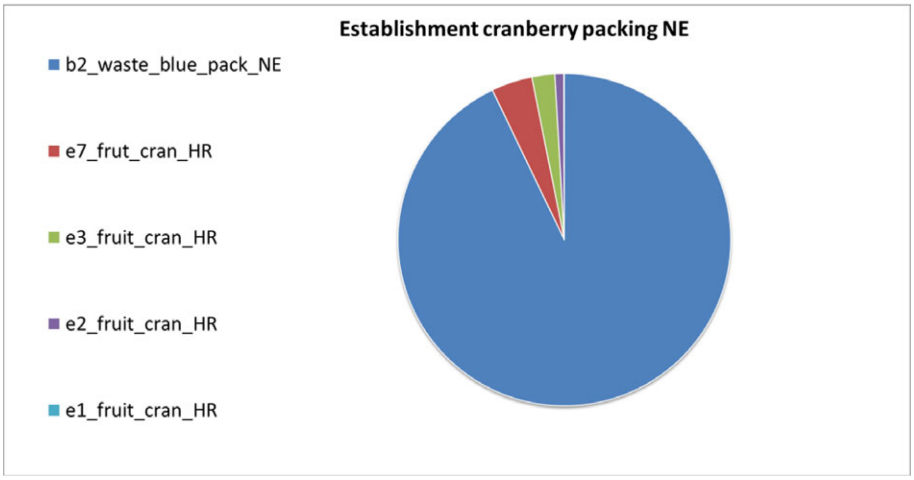
e2_fruit_cran_HR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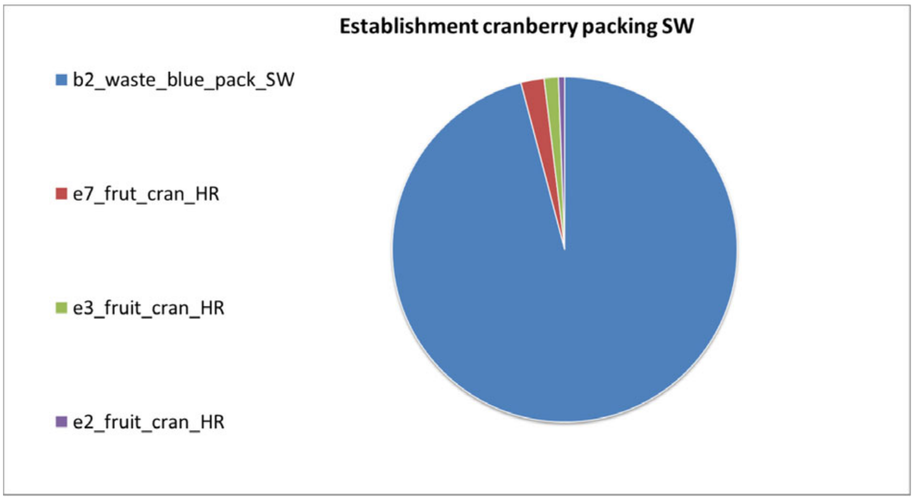
e1_fruit_cran_HR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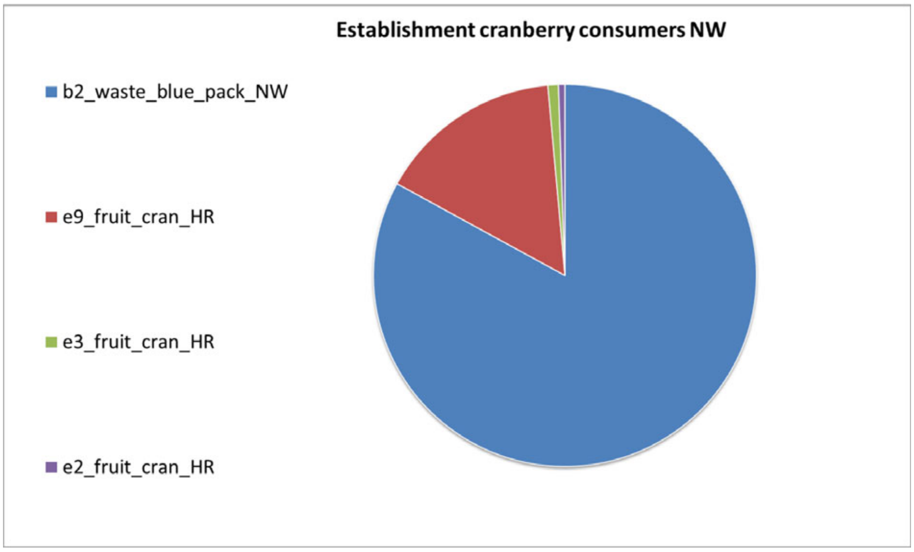
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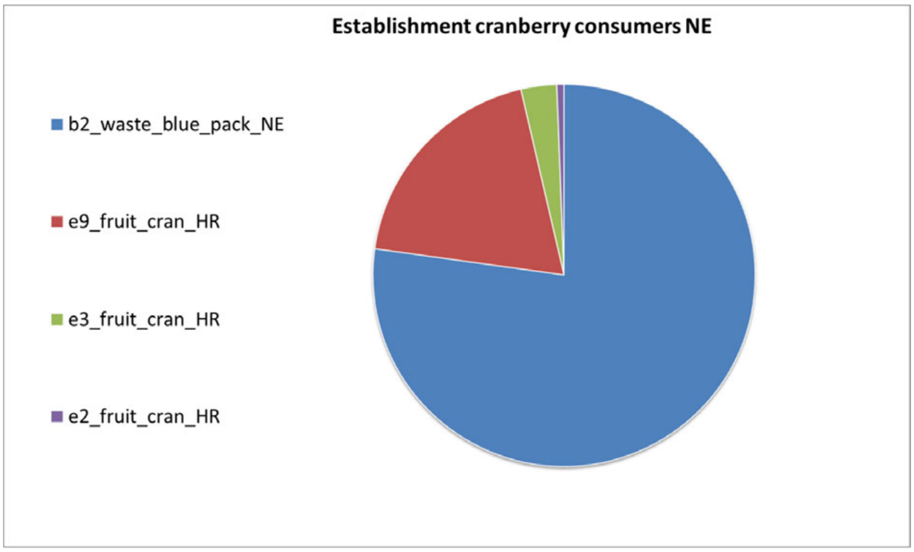
e2_fruit_cran_HR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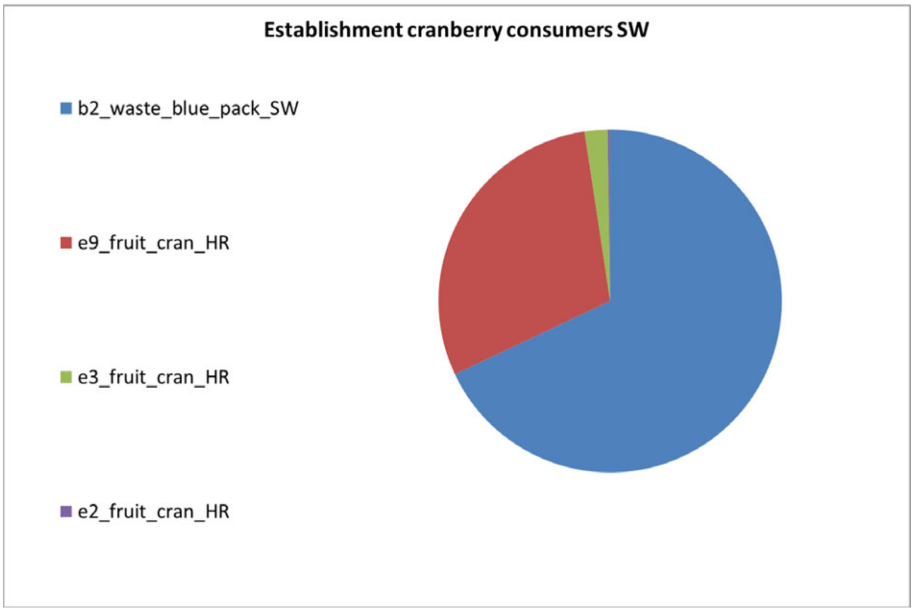
e2_fruit_cran_HR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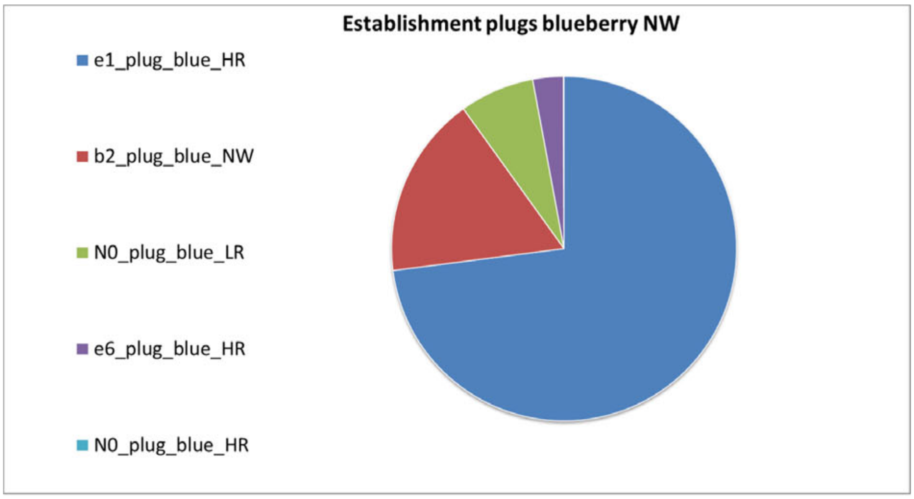
e2_fruit_cran_HR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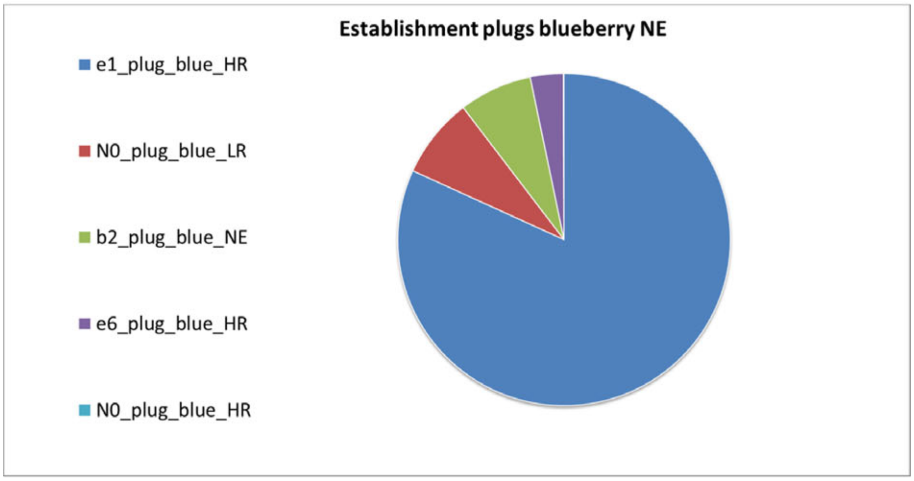
N0_plug_blue_HR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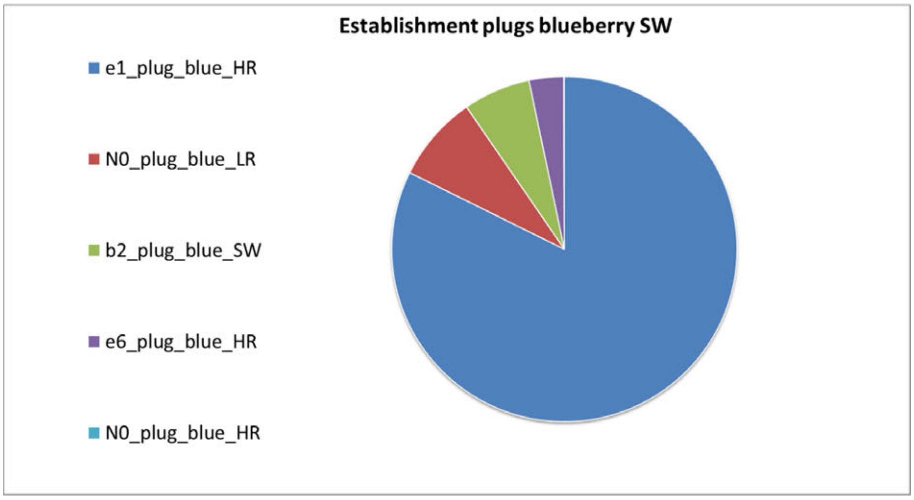
e6_plug_blue_HR
N0_plug_blue_HR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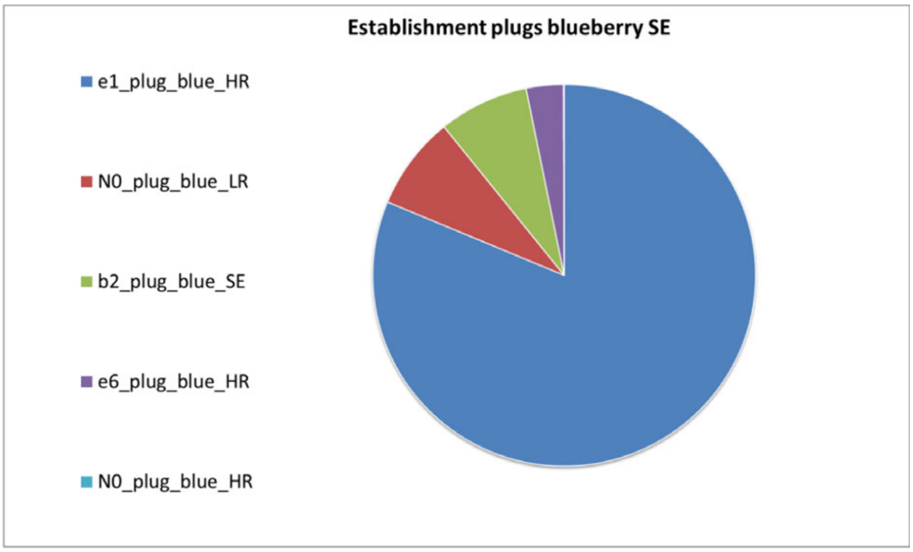
b2_plug_blue_SW
e6_plug_blue_HR
N0_plug_blue_HR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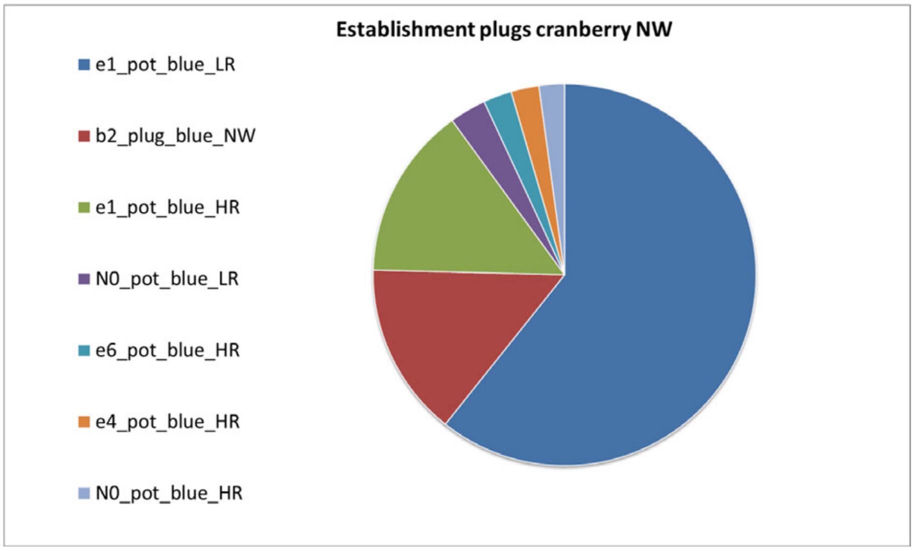
N0_plug_blue_HR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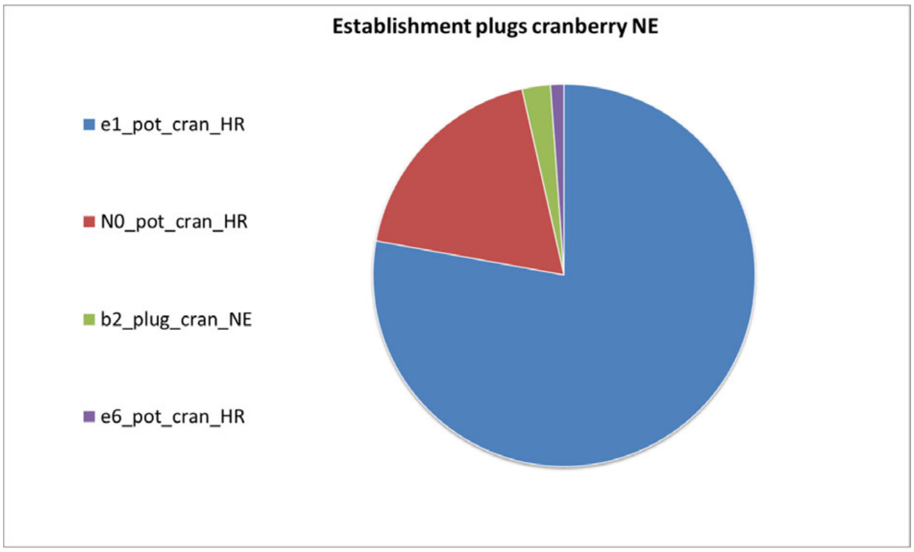
b2_plug_blue_NW
e1_pot_blue_HR
N0_pot_blue_LR
e6_pot_blue_HR
e4_pot_blue_HR
N0_pot_blue_HR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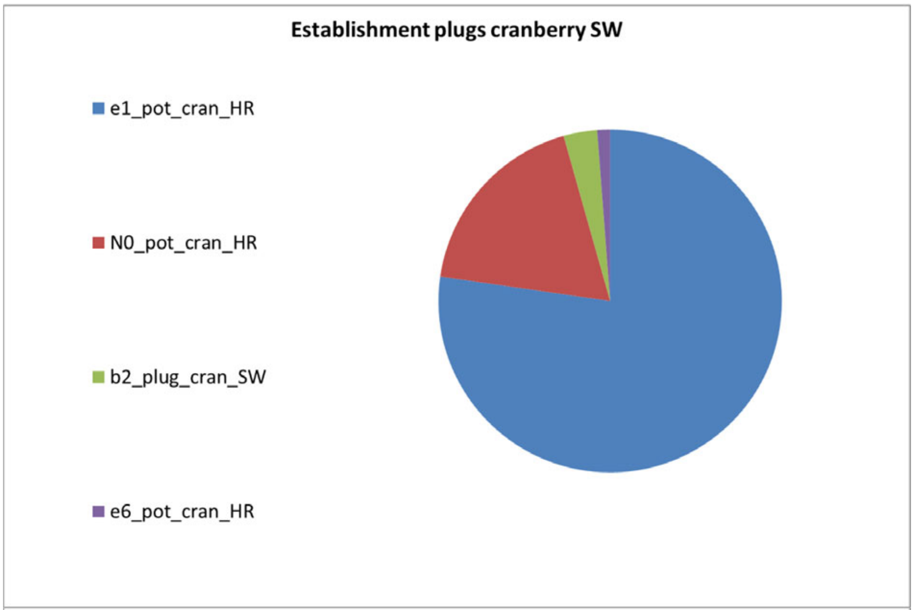
b2_plug_cran_NE
e6_pot_cran_HR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N0_pot_cran_HR
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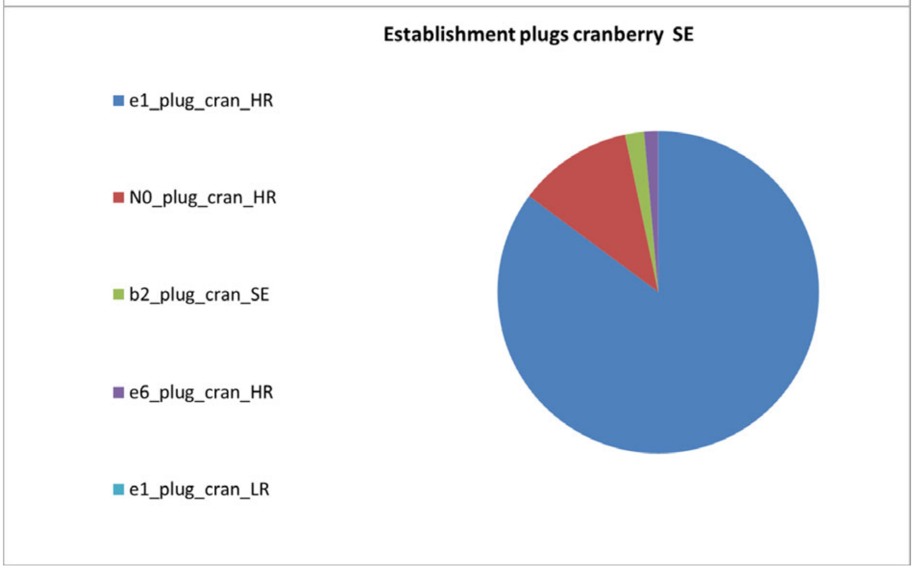
e6_pot_cran_HR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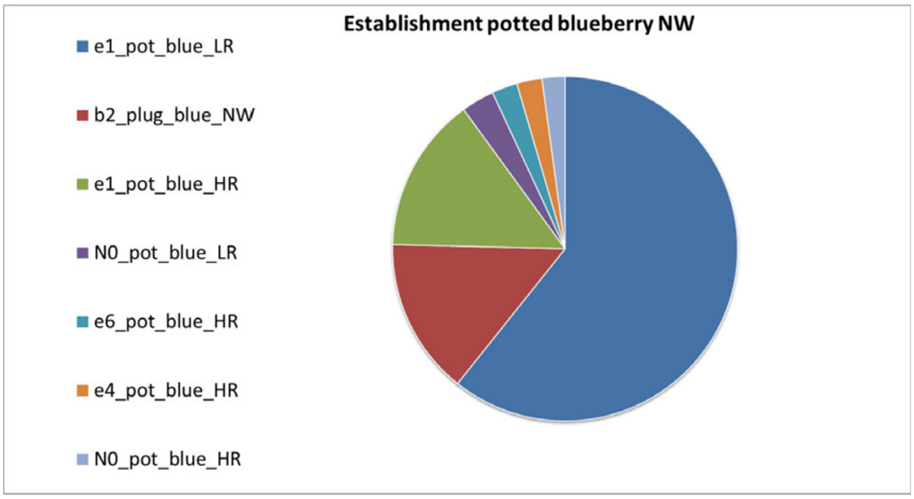
e1_plug_cran_LR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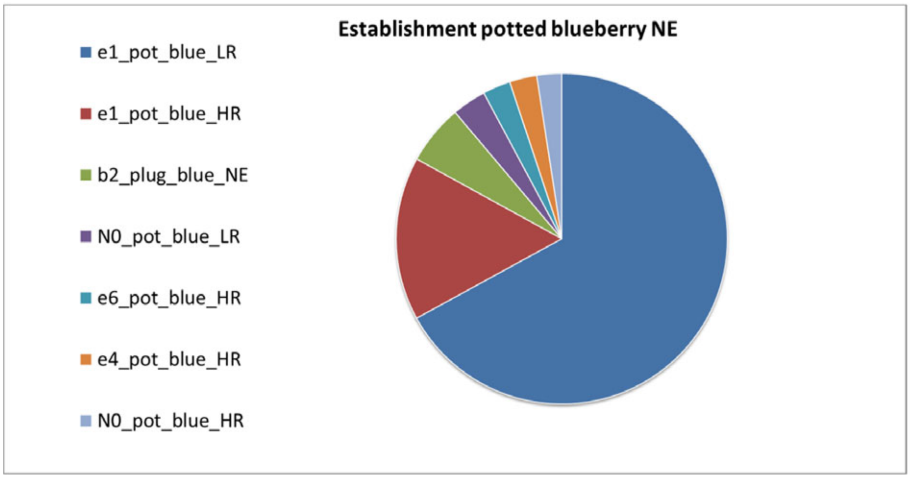
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b2_plug_blue_NE
N0_pot_blue_LR
e6_pot_blue_HR
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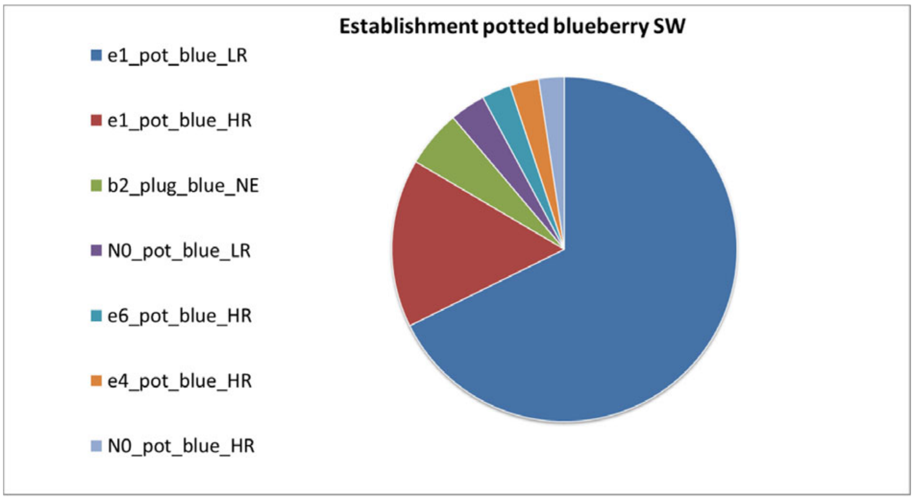
N0_pot_blue_HR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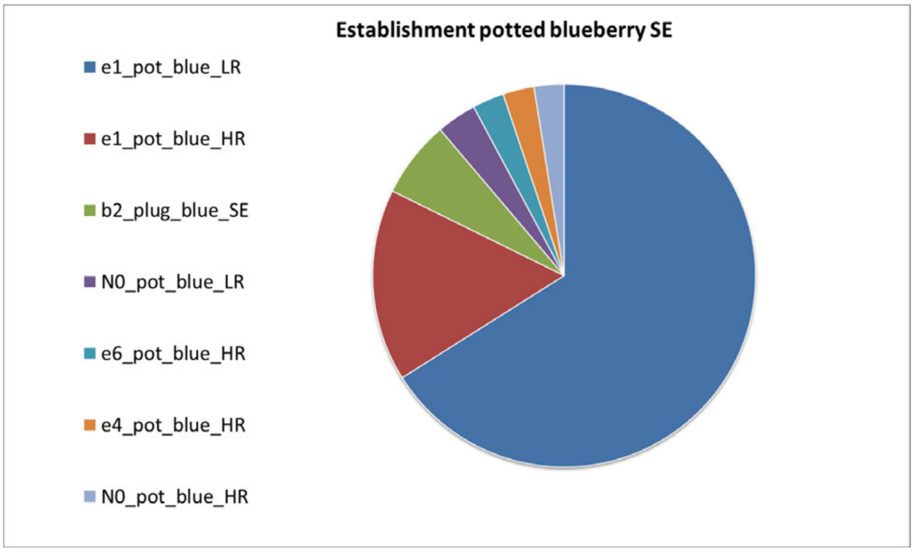
N0_pot_blue_HR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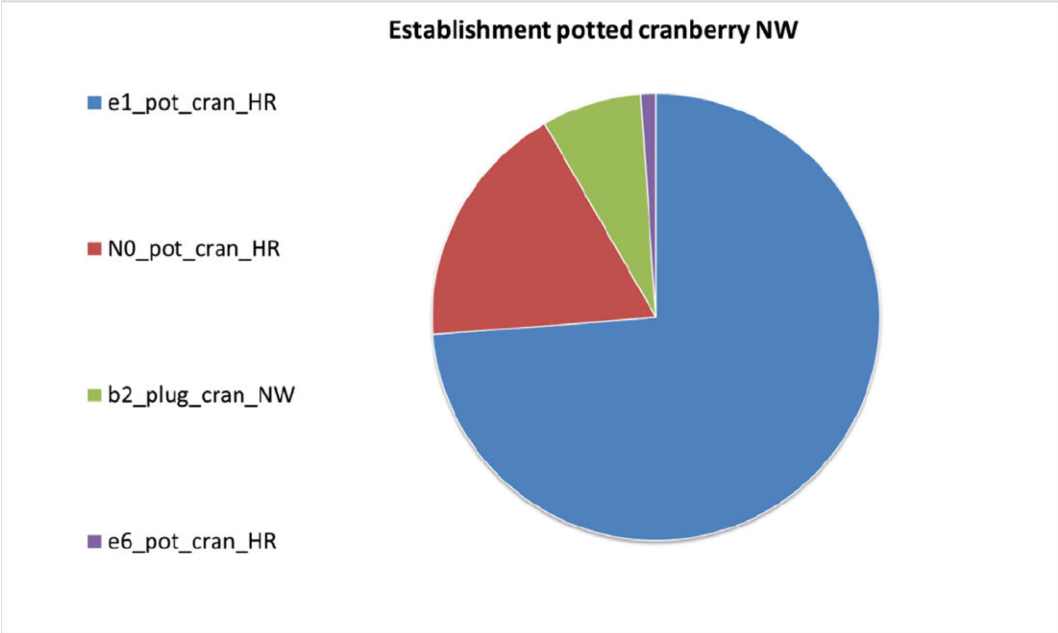
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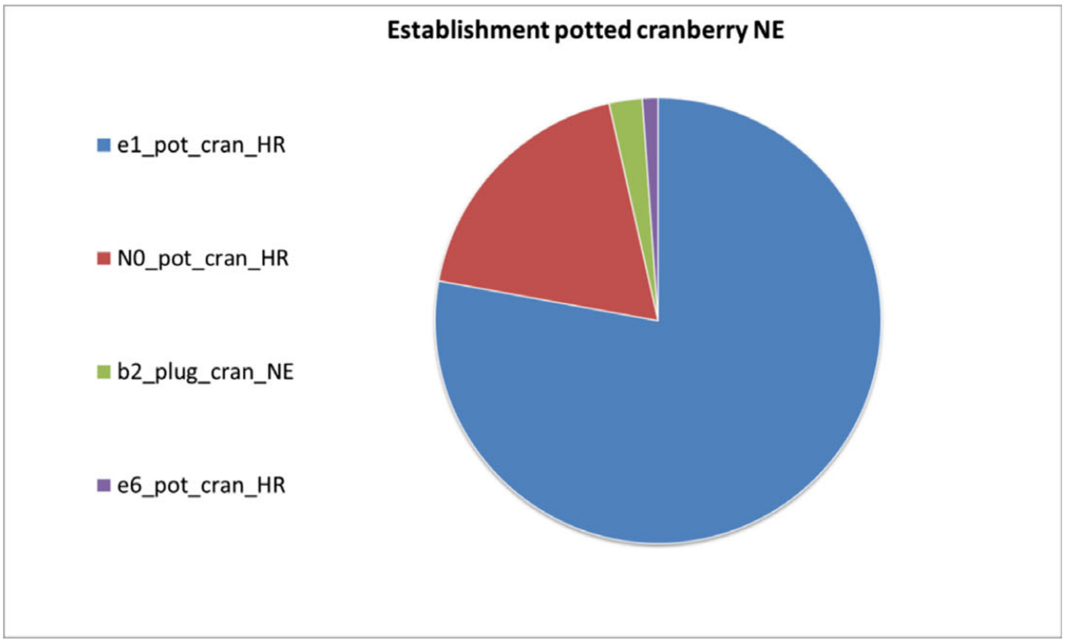
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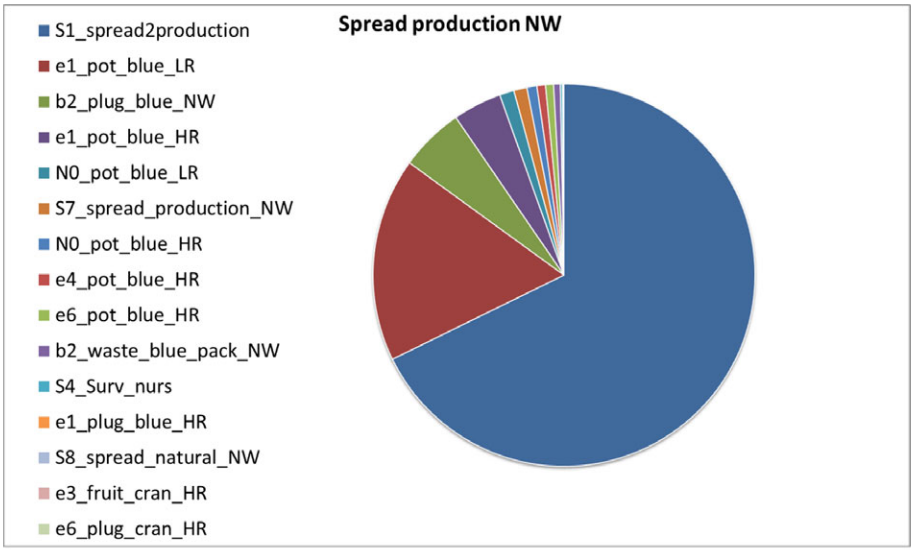
e6_pot_cran_HR


Spread production NW
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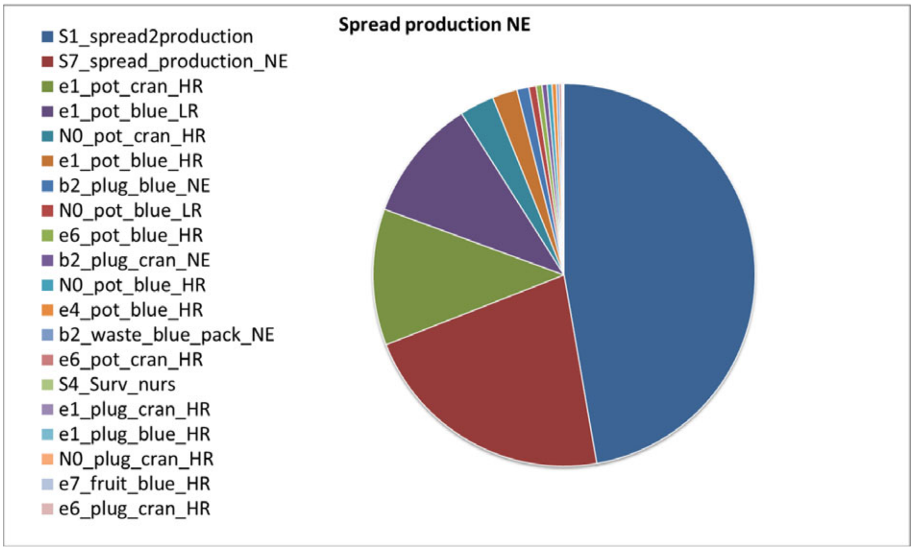
e1_pot_blue_LR
b2_plug_blue_NW
e1_pot_blue_HR
N0_pot_blue_LR
S7_spread_production_NW
N0_pot_blue_HR
e4_pot_blue_HR
e6_pot_blue_HR
b2_waste_blue_pack_NW
S4_Surv_nurs
e1_plug_blue_HR
S8_spread_natural_NW
e3_fruit_cran_HR
e6_plug_cran_HR


Spread production NE
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S7_spread_production_NE
e1_pot_cran_HR
e1_pot_blue_LR
N0_pot_cran_HR
e1_pot_blue_HR
b2_plug_blue_NE
N0_pot_blue_LR
e6_pot_blue_HR
b2_plug_cran_NE
N0_pot_blue_HR
e4_pot_blue_HR
b2_waste_blue_pack_NE
e6_pot_cran_HR
S4_Surv_nurs
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N0_plug_cran_HR
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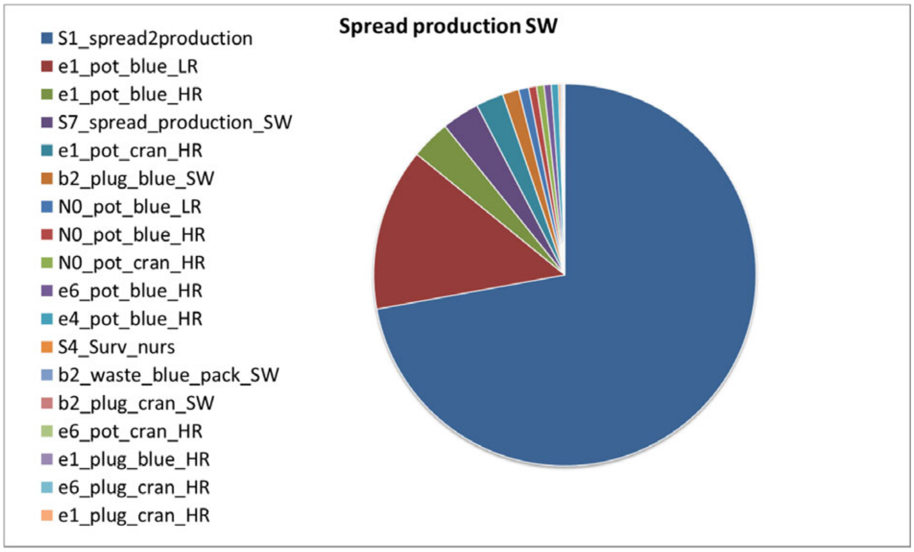
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b2_plug_blue_SW
N0_pot_blue_LR
N0_pot_blue_HR
N0_pot_cran_HR
e6_pot_blue_HR
e4_pot_blue_HR
S4_Surv_nurs
b2_waste_blue_pack_SW
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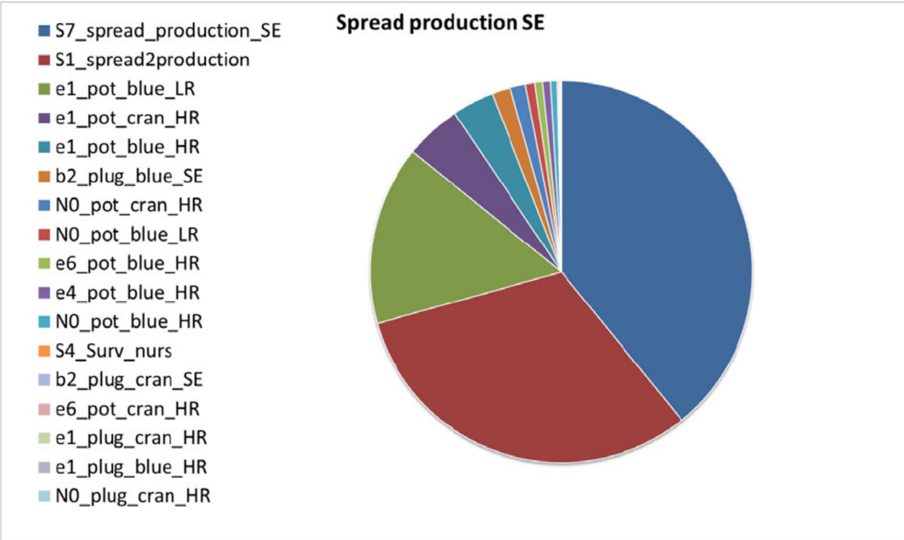
Spread production SE
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S1_spread2production
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e1_pot_blue_HR
b2_plug_blue_SE
N0_pot_cran_HR
N0_pot_blue_LR
e6_pot_blue_HR
e4_pot_blue_HR
N0_pot_blue_HR
S4_Surv_nurs
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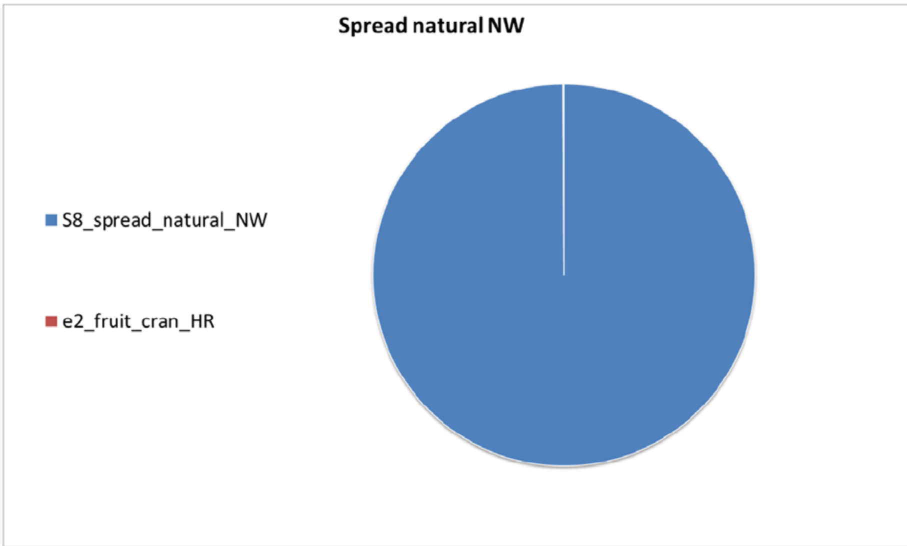
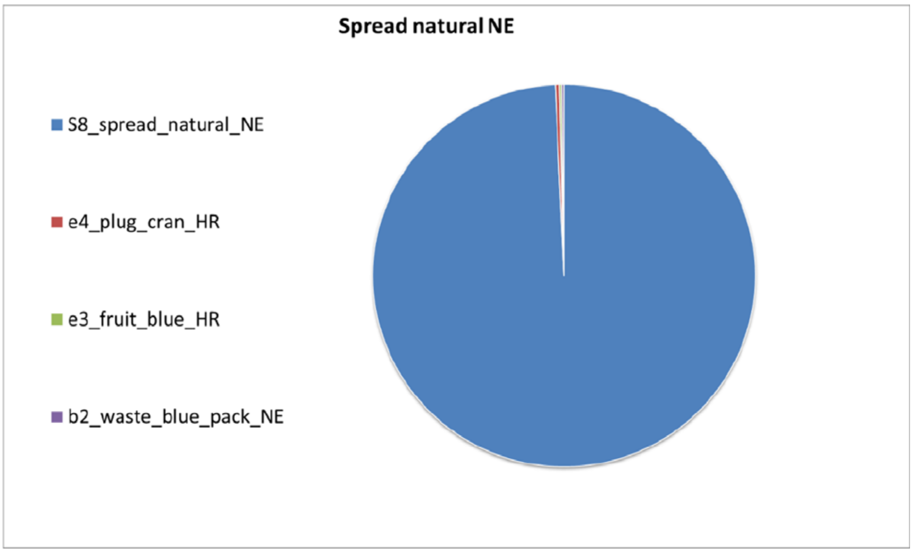
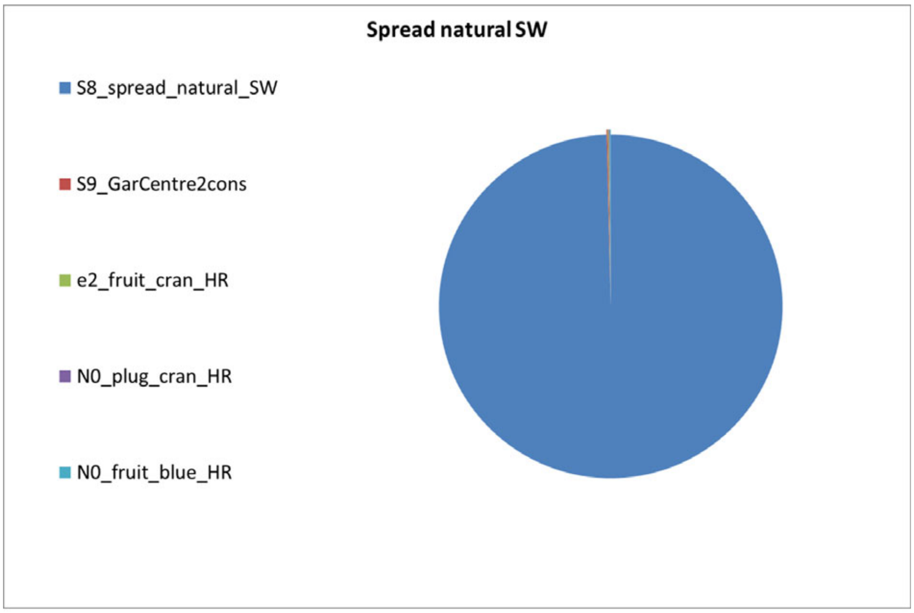

Spread natural NW
S8_spread_natural_NW
e2_fruit_cran_HR


Spread natural NE
S8_spread_natural_NE
e4_plug_cran_HR
e3_fruit_blue_HR
b2_waste_blue_pack_NE


Spread natural SW
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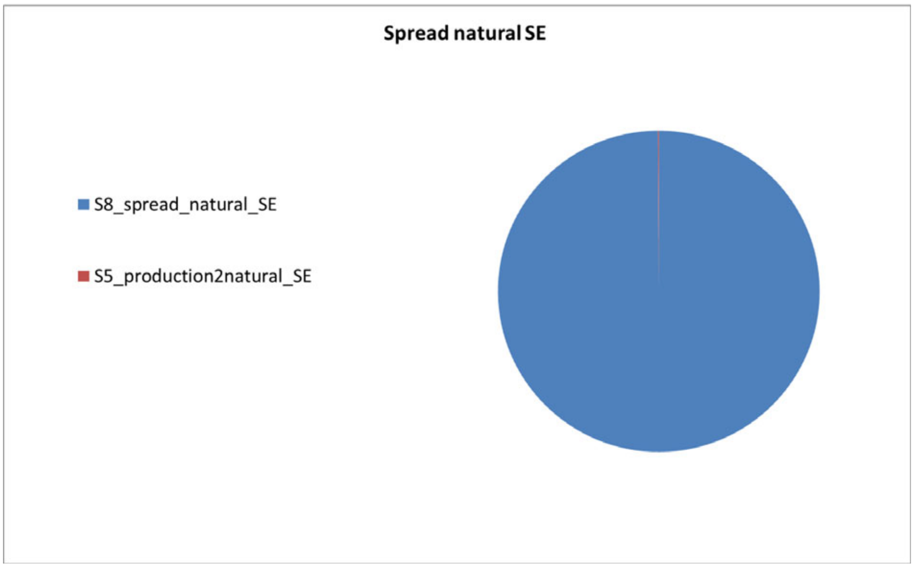
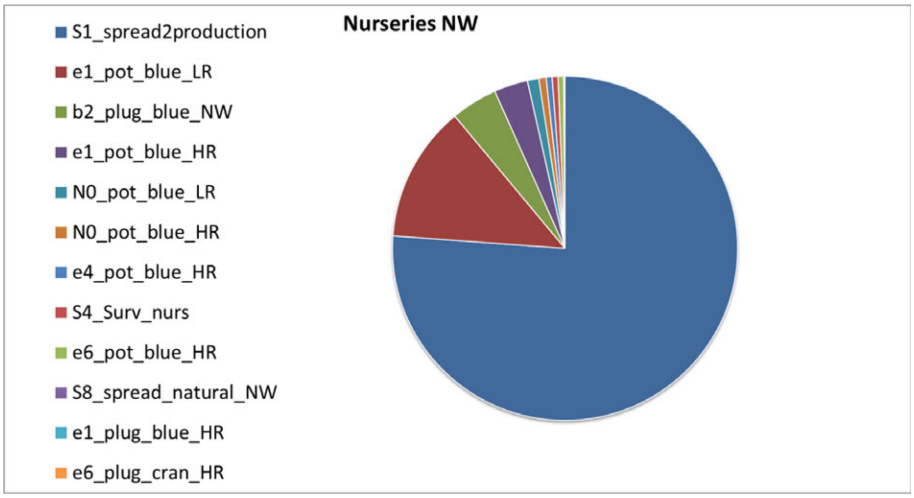
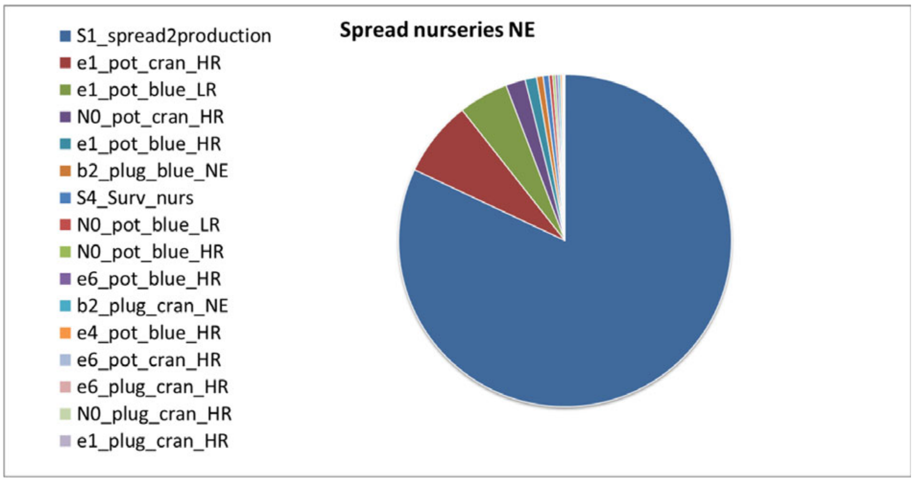
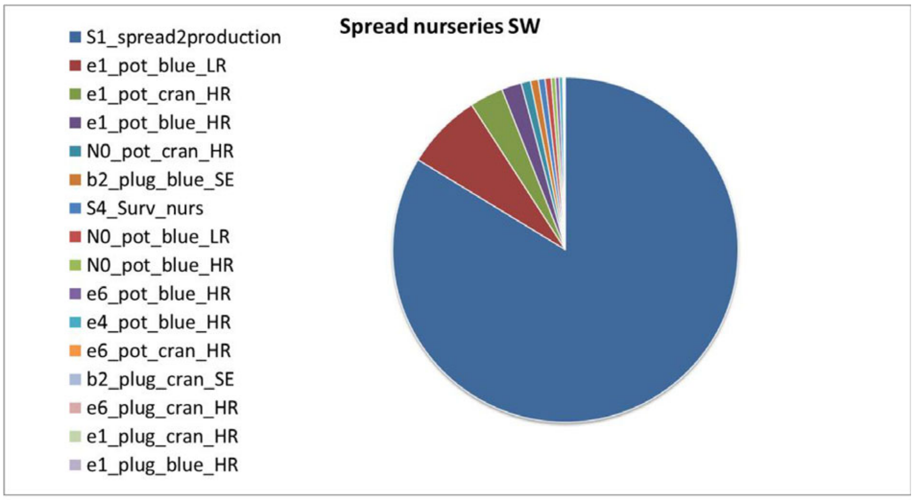
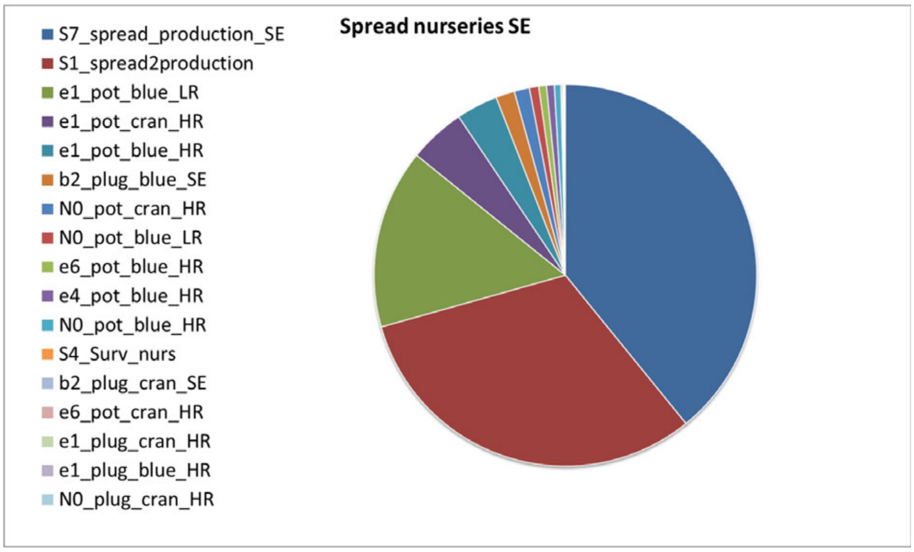
S9_GarCentre2cons
e2_fruit_cran_HR
N0_plug_cran_HR
N0_fruit_blue_HR

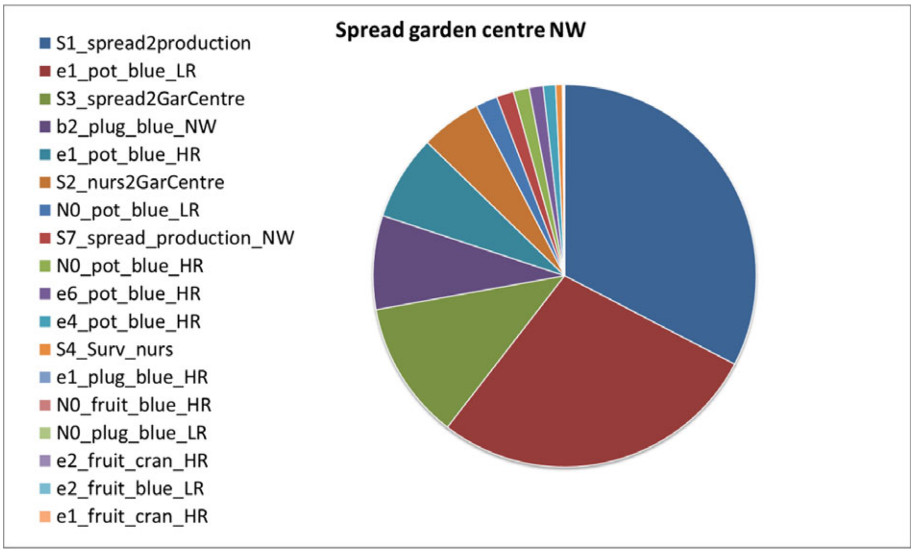

Spread natural SE
S8_spread_natural_SE
S5_production2natural_SE

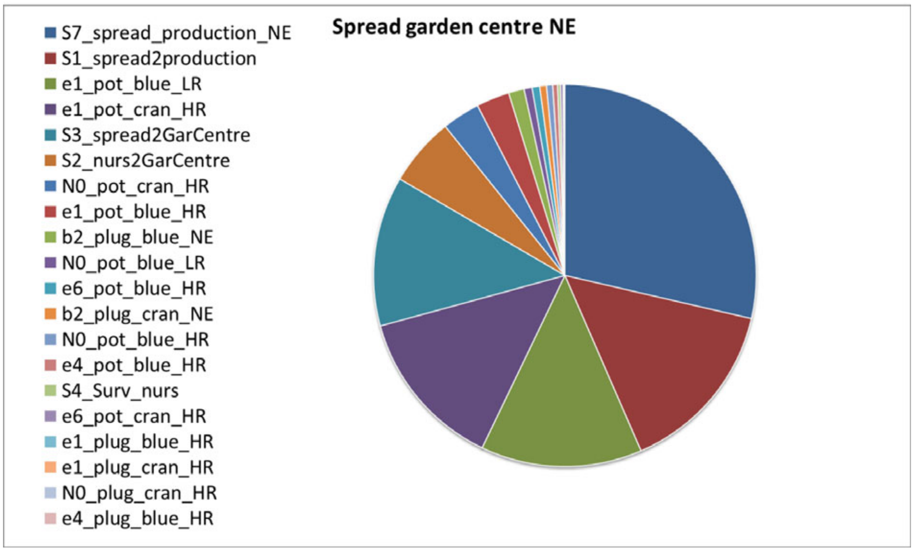

Nurseries NW
S1_spread2production
e1_pot_blue_LR
b2_plug_blue_NW
e1_pot_blue_HR
N0_pot_blue_LR
N0_pot_blue_HR
e4_pot_blue_HR
S4_Surv_nurs
e6_pot_blue_HR
S8_spread_natural_NW
e1_plug_blue_HR
e6_plug_cran_HR

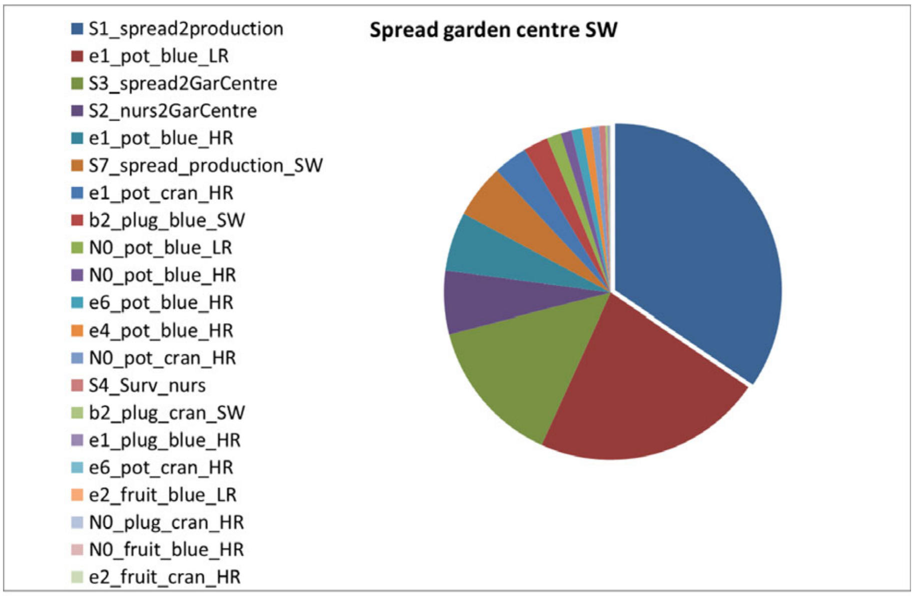

Spread nurseries NE
S1_spread2production
e1_pot_cran_HR
e1_pot_blue_LR
N0_pot_cran_HR
e1_pot_blue_HR
b2_plug_blue_NE
S4_Surv_nurs
N0_pot_blue_LR
N0_pot_blue_HR
e6_pot_blue_HR
b2_plug_cran_NE
e4_pot_blue_HR
e6_pot_cran_HR
e6_plug_cran_HR
N0_plug_cran_HR
e1_plug_cran_HR

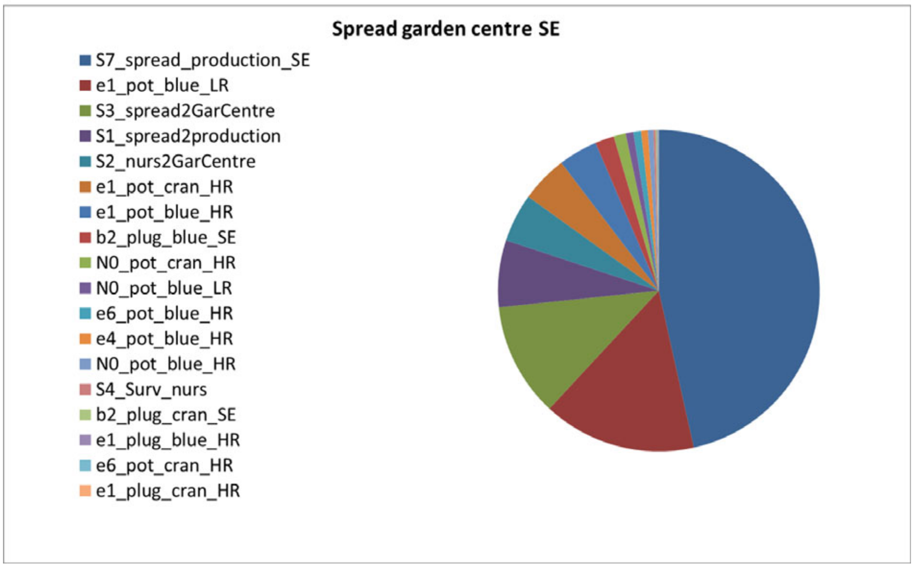

Spread nurseries SW
S1_spread2production
e1_pot_blue_LR
e1_pot_cran_HR
e1_pot_blue_HR
N0_pot_cran_HR
b2_plug_blue_SE
S4_Surv_nurs
N0_pot_blue_LR
N0_pot_blue_HR
e6_pot_blue_HR
e4_pot_blue_HR
e6_pot_cran_HR
b2_plug_cran_SE
e6_plug_cran_HR
e1_plug_cran_HR
e1_plug_blue_HR

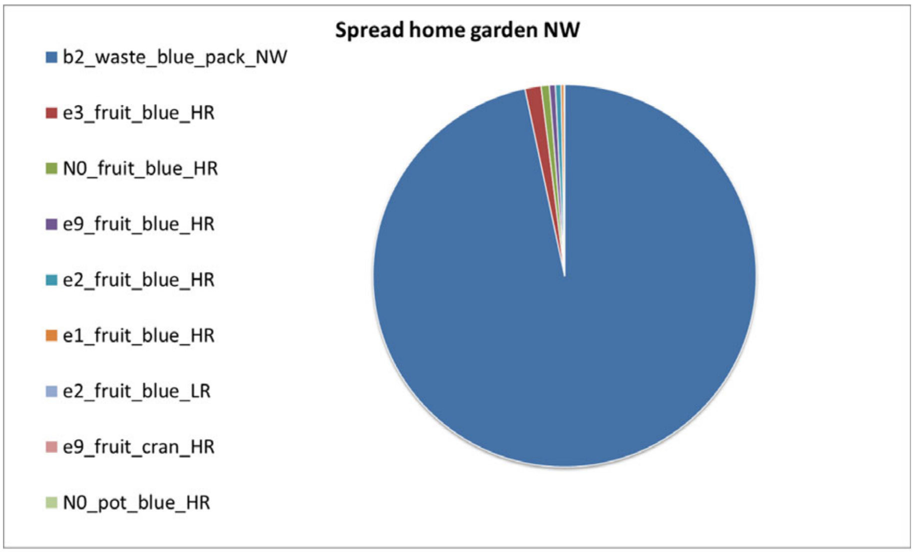

Spread nurseries SE
S7_spread_production_SE
S1_spread2production
e1_pot_blue_LR
e1_pot_cran_HR
e1_pot_blue_HR
b2_plug_blue_SE
N0_pot_cran_HR
N0_pot_blue_LR
e6_pot_blue_HR
e4_pot_blue_HR
N0_pot_blue_HR
S4_Surv_nurs
b2_plug_cran_SE
e6_pot_cran_HR
e1_plug_cran_HR
e1_plug_blue_HR
N0_plug_cran_HR

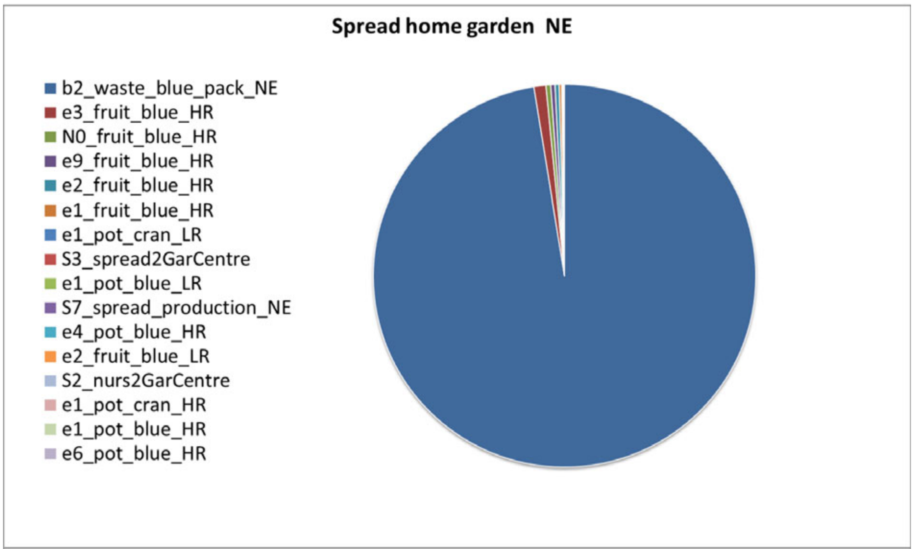

Spread garden centre NW
S1_spread2production
e1_pot_blue_LR
S3_spread2GarCentre
b2_plug_blue_NW
e1_pot_blue_HR
S2_nurs2GarCentre
N0_pot_blue_LR
S7_spread_production_NW
N0_pot_blue_HR
e6_pot_blue_HR
e4_pot_blue_HR
S4_Surv_nurs
e1_plug_blue_HR
N0_fruit_blue_HR
N0_plug_blue_LR
e2_fruit_cran_HR
e2_fruit_blue_LR
e1_fruit_cran_HR

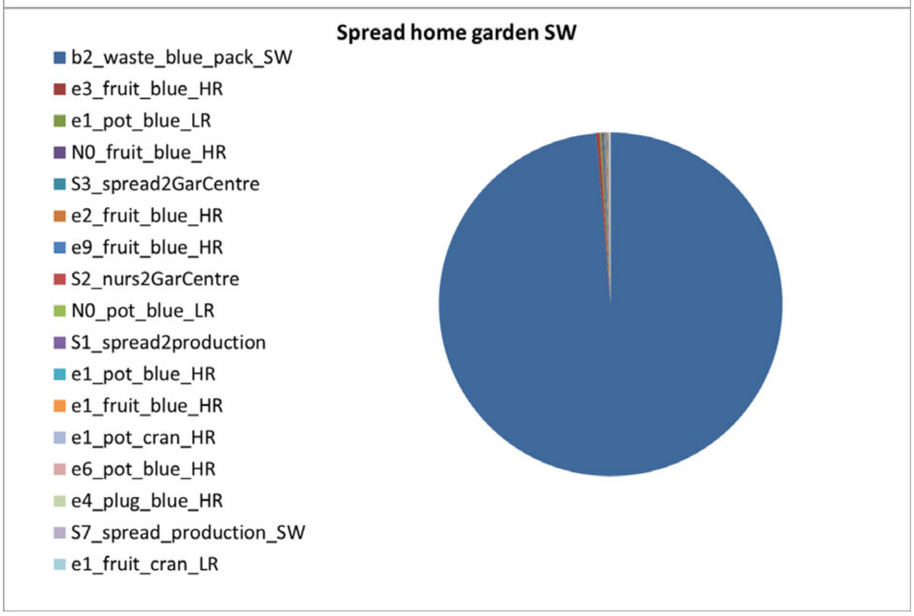

Spread garden centre NE
S7_spread_production_NE
S1_spread2production
e1_pot_blue_LR
e1_pot_cran_HR
S3_spread2GarCentre
S2_nurs2GarCentre
N0_pot_cran_HR
e1_pot_blue_HR
b2_plug_blue_NE
N0_pot_blue_LR
e6_pot_blue_HR
b2_plug_cran_NE
N0_pot_blue_HR
e4_pot_blue_HR
S4_Surv_nurs
e6_pot_cran_HR
e1_plug_blue_HR
e1_plug_cran_HR
N0_plug_cran_HR
e4_plug_blue_HR


Spread garden centre SW
S1_spread2production
e1_pot_blue_LR
S3_spread2GarCentre
S2_nurs2GarCentre
e1_pot_blue_HR
S7_spread_production_SW
e1_pot_cran_HR
b2_plug_blue_SW
N0_pot_blue_LR
N0_pot_blue_HR
e6_pot_blue_HR
e4_pot_blue_HR
N0_pot_cran_HR
S4_Surv_nurs
b2_plug_cran_SW
e1_plug_blue_HR
e6_pot_cran_HR
e2_fruit_blue_LR
N0_plug_cran_HR
N0_fruit_blue_HR
e2_fruit_cran_HR


Spread garden centre SE
S7_spread_production_SE
e1_pot_blue_LR
S3_spread2GarCentre
S1_spread2production
S2_nurs2GarCentre
e1_pot_cran_HR
e1_pot_blue_HR
b2_plug_blue_SE
N0_pot_cran_HR
N0_pot_blue_LR
e6_pot_blue_HR
e4_pot_blue_HR
N0_pot_blue_HR
S4_Surv_nurs
b2_plug_cran_SE
e1_plug_blue_HR
e6_pot_cran_HR
e1_plug_cran_HR


Spread home garden NW
b2_waste_blue_pack_NW
e3_fruit_blue_HR
N0_fruit_blue_HR
e9_fruit_blue_HR
e2_fruit_blue_HR
e1_fruit_blue_HR
e2_fruit_blue_LR
e9_fruit_cran_HR
N0_pot_blue_HR


Spread home garden NE
b2_waste_blue_pack_NE
e3_fruit_blue_HR
N0_fruit_blue_HR
e9_fruit_blue_HR
e2_fruit_blue_HR
e1_fruit_blue_HR
e1_pot_cran_LR
S3_spread2GarCentre
e1_pot_blue_LR
S7_spread_production_NE
e4_pot_blue_HR
e2_fruit_blue_LR
S2_nurs2GarCentre
e1_pot_cran_HR
e1_pot_blue_HR
e6_pot_blue_HR


Spread home garden SW
b2_waste_blue_pack_SW
e3_fruit_blue_HR
e1_pot_blue_LR
N0_fruit_blue_HR
S3_spread2GarCentre
e2_fruit_blue_HR
e9_fruit_blue_HR
S2_nurs2GarCentre
N0_pot_blue_LR
S1_spread2production
e1_pot_blue_HR
e1_fruit_blue_HR
e1_pot_cran_HR
e6_pot_blue_HR
e4_plug_blue_HR
S7_spread_production_SW
e1_fruit_cran_LR

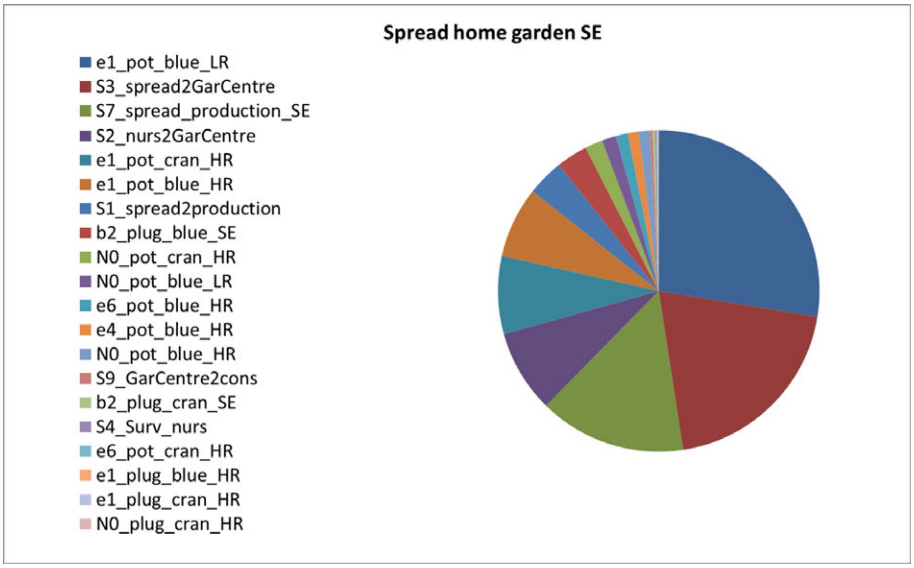


Figure E.2: Sensitivity analysis

Annex A – *Diaporthe vaccinii* @Risk file

Annex A can be found in the online version of this output ('Supporting information' section): https://doi.org/onlinelibrary.wiley.com/doi/10.2903/j.efsa.2017.4924/abstract