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SCIENTIFIC OPINION

Scientific Opinion on the risk to plant health posed by *Xylella fastidiosa* in the EU territory, with the identification and evaluation of risk reduction options[1]

EFSA Panel on Plant Health (PLH)[2,3]

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ABSTRACT

The EFSA Panel on Plant Health conducted a pest risk assessment and an evaluation of risk reduction options for *Xylella fastidiosa*. *X. fastidiosa* has been detected in olive in the EU with a distribution restricted to the region of Apulia in Italy and is under official control. *X. fastidiosa* has a very broad host range, including many common cultivated and wild plants. All xylem fluid-feeding insects in Europe are considered to be potential vectors. *Philaenus spumarius* (Hemiptera: Aphrophoridae), a polyphagous spittlebug widespread in the whole risk assessment area, has been identified as a vector in Apulia. The probability of entry of *X. fastidiosa* from countries where *X. fastidiosa* is reported is very high with plants for planting and moderate with infectious insect vectors carried with plant commodities or travelling as stowaways. Establishment and spread in the EU is very likely. The consequences are considered to be major because yield losses and other damage would be high and require costly control measures. The systematic use of insecticides for vector control may create environmental impacts. With regard to risk reduction options, strategies for the prevention of introduction and for the containment of outbreaks should focus on the two main pathways (plants for planting and infectious insect vectors) and combine the most effective options in an integrated approach. For plants for planting, these could be pest-free production areas, surveillance, certification, screened greenhouse production, vector control and testing for infection and, for some plant species, treatments (e.g. thermotherapy). To prevent entry of the infectious vectors, insecticide treatments and inspection of consignments and production sites are required. The Panel has also reviewed the effectiveness of risk reduction options for *X. fastidiosa* and its vectors listed in Directive 2000/29/EC and in the EU emergency measures. The Panel recommends the continuation and intensification of research on the host range, epidemiology and control of the Apulian outbreak.

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KEY WORDS

Xylella fastidiosa, *Philaenus spumarius*, olive, risk assessment, risk reduction

SUMMARY

Following a request from the European Commission, the EFSA Panel on Plant Health was asked to deliver a scientific opinion on the pest risk posed by *Xylella fastidiosa* for the European Union territory and to identify risk management options and evaluate their effectiveness in reducing the risk to plant health posed by the organism. In particular, the Panel was asked to provide an opinion on the effectiveness of the current EU requirements against *X. fastidiosa*, which are laid down in Council Directive 2000/29/EC and the EU emergency measures against *X. fastidiosa* (Decision 2014/497/EU), in reducing the risk of introduction of this pest into, and its spread within, the EU territory.

The current distribution of *X. fastidiosa* in the EU is restricted to one strain within one province of the Apulia region in south Italy, where several thousand hectares of olive plantations are affected, and it is under official control. *X. fastidiosa* is also reported in Apulia on *Prunus cerasifera*, *Prunus dulcis*, *Nerium oleander*, *Acacia saligna*, *Polygala myrtifolia*, *Westringia fruticosa*, *Spartium junceum* and *Vinca* spp. The genotype of *X. fastidiosa* of the Apulian outbreak has been attributed to the subspecies *pauca*. Nevertheless, this pest risk assessment considers all subspecies of *X. fastidiosa.*

X. fastidiosa presents a major risk to the EU territory because it has the potential to cause disease in the risk assessment area once it establishes, as hosts are present and the environmental conditions are favourable. *X. fastidiosa* may affect several crops in Europe, such as citrus, grapevine and stone fruits (almond, peach, plum), but also several tree and ornamental plants, for example oak, sycamore and oleander. *X. fastidiosa* has a very broad host range, including many cultivated and wild plants common in Europe. There is some host differentiation between the generally accepted four subspecies of *X. fastidiosa* with regard to symptomatic hosts; there is, however, high uncertainty with regard to the potential host range of *X. fastidiosa* in the European flora as a wide range of European wild plant species have never been exposed to the bacterium and it is not known whether they would be hosts, and, if so, whether they would be symptomatic or asymptomatic.

All xylem fluid-feeding insects in Europe are considered to be potential vectors. Members of the families Cicadellidae, Aphrophoridae and Cercopidae are vectors in the Americas and, hence, should be considered to be potential vectors in Europe. The Cicadidae and Tibicinidae should also be considered potential vectors. The hemipteran *Philaenus spumarius* has been identified as a vector in Apulia, Italy.

With regard to the assessment of the risk to plant health for the EU territory, the conclusions are as follows:

The probability of entry for plants for planting from countries where *X. fastidiosa* is reported is rated very likely because:

- The association with the pathway at origin is rated as very likely for plants for planting because (1) plants for planting have been found to be a source of the bacterium for outbreaks, (2) host plants can be asymptomatic and often remain undetected, (3) a very large number of plant species are recorded as hosts and (4) very high quantities of plants for planting are imported from countries where *X. fastidiosa* is reported.

- The ability of the bacteria surviving during transport is very likely.

- The probability of the pest surviving any existing management procedure is very likely.

- Additionally, the probability of transfer to a suitable host is rated as very likely, based on the intended use of the plant material for planting (rootstocks) or grafting (scions, budwood) and because host plants are extensively present in the risk assessment area. Insect vectors are also distributed throughout the risk assessment area.

The likelihood of entry for the infectious insect vectors is moderately likely because the pest:

- is often associated with the pathway at the origin;
- is moderately able to survive during transport or storage;
- is affected by the current pest management procedures existing in the risk assessment area;
- has some limitations for transfer to a suitable host in the risk assessment area.

Entry is considered to have medium uncertainty because the distribution of *X. fastidiosa* in the countries of origin is not fully known, knowledge of host plant susceptibility is only partial and only a few interceptions of infected plants have been made, taking into account also the difficulty of detecting contaminated but asymptomatic plants. The difficulties in assessing precisely the quantities of plants for planting imported within the EU are also a matter of uncertainty. Additionally, only limited data are available on vectors' capacity to survive long-distance transportation on their own in vehicles and they are restricted to only one species, *Homalodisca vitripennis*. Similarly, only limited data are available on vectors' autonomous dispersal capacity, and they concern only *H. vitripennis.* There are no data in the EUROPHYT database on the interception of vectors.

The probability of establishment, following an entry of *X. fastidiosa*, is rated as very likely, based on the very high probability that the pathogen will find a suitable host owing to the very large range of host plants and potential host plants, and to the wide distribution and polyphagy of known and potential vectors. Other elements taken into account are the high probability of finding a climatically suitable environment with few adverse abiotic factors and no known effective natural enemies of *X. fastidiosa.* The information available regarding winter recovery in infected plants mostly relates to grapevine and the subspecies *fastidiosa*. The lack of effective cultural practices or control measures also increases the probability of establishment.

The uncertainty level for establishment is rated as low, based on the fact that *X. fastidiosa* is already reported in Apulia. There is no uncertainty regarding the availability of a wide range of host plants, but questions remain regarding the susceptibility of the indigenous European flora. There is one confirmed vector species (*P. spumarius*) that is widespread, abundant and polyphagous; a large range of additional potential vectors has yet to be studied. Suitable climates are available in the risk assessment area. There is a lack of data regarding the overwintering capacity at low temperature and, more generally, regarding the range of temperatures over which the bacteria can thrive, and this makes it very difficult to assess the northernmost limit to its distribution in the EU.

The probability of spread from established infestations of *X. fastidiosa* is rated as very likely because of the large number of confirmed or potential host plants and the abundance and widespread distribution of known (*P. spumarius*) or potential vectors. Spread over short to long distances by human assistance is very likely: this may occur via infected plants for planting or by passive transport of infectious insects in vehicles. Infectious vectors may spread locally by flying or be passively transported longer distances by wind.

Concerning the spread, uncertainty is rated as medium. The contributions of human- and wind-mediated spread mechanisms are still uncertain. There is a lack of data on how far the insect vectors can fly. There is also a lack of precise indications on how current farming practices could have an impact on potential insect vectors and limit the spread of the disease.

The overall potential consequences of *X. fastidiosa* in the European territory are rated as major considering the severe losses on olive in the Apulian outbreak, on citrus in South America and on grapes in North America. In commercial crops, when conditions are suitable for symptom expression and efficient insect vectors are present, yield losses and damage would be high and imply costly

control measures. The disease also has a negative social impact since it is not readily controllable in smallholdings and family gardens. Depending on the host range of the *X. fastidiosa* subspecies introduced, major crops, ornamental plants or forest trees could be affected, as in other areas of the world. In addition to these elements, the use of insecticide may have environmental impacts. Breeding and nursery activities might also be affected.

The uncertainty for the consequences is rated as low, based on a worst-case scenario approach. The exact host range of a given strain, the lack of knowledge on the potential vectors in the risk assessment area and the agro-ecological complexity of the diseases shall nevertheless be taken into account.

With regard to risk reduction options, the Panel reached the following conclusions.

A thorough review of the literature yielded no indication that eradication is a successful option once the disease is established in an area. Past attempts, in Taiwan and in Brazil, proved unsuccessful, probably because of the broad host range of the pathogen and its vectors. Therefore, the priority should be to prevent introduction. Strategies for preventing the introduction from areas where the pathogen is present and for the containment of outbreaks should focus on the two main pathways (plants for planting and infectious insects) and be based on an integrated system approach, combining, when applicable, the most effective options (e.g. pest-free areas, surveillance, certification, screen house production, control of vectors and testing for plant propagation material, preparation, treatment and inspection of consignments for the pathway of the infectious vectors).

For the plants for planting pathway, some risk reduction options have been considered to be more effective at reducing the likelihood of introduction of *X. fastidiosa* and/or infective insect vectors:

- Prohibiting the import of *X. fastidiosa* host species plants for planting would be highly effective but its application would be constrained by the very wide potential host range of this pathogen and the large trade volumes. This is, however, a feasible option for high-risk commodities.

- Limiting the import of plants for planting to pest-free areas of origin is considered to be highly effective, but pest-free production sites are assessed as having lower effectiveness unless combined with other measures (e.g. screen house production, certification and testing, vector control) in an integrated approach.

- Certification schemes, growing plants under exclusion conditions and vector control in nurseries have high effectiveness, particularly when combined in an integrated approach.

- Among consignment treatments, the thermotherapy of dormant plants has been applied effectively to control *X. fastidiosa* in grapevine plants for planting. This practice is already applied to control other pathogens in *Vitis* plant propagation material. The import of dormant plants for planting is also effective in preventing the introduction of exotic sharpshooter vectors species that lay eggs only on leaves or green tissues, but it is not effective against the sharpshooters that lay eggs on wood, unless combined with thermotherapy.

- Specific insecticide treatments of consignments of plants for planting can effectively reduce the likelihood of infective insect vectors being carried together with traded plants.

For the infective insect vectors, the likelihood of entry with other plant material such as cut flowers or green foliage can be reduced by appropriate treatment of the consignments and by an integrated approach in production sites free of *X. fastidiosa.*

The Panel has also reviewed the effectiveness of risk reduction options for *X. fastidiosa* and its vectors listed in the Directive 2000/29/EC[4] and in EU Implementing Decision 2014/497/EU[5] for this pathogen.

With regard to Directive 2000/29/EC, the Panel concluded that:

- The prohibition of introduction of *Citrus*, *Fortunella*, *Poncirus* and their hybrids, other than fruit and seeds, and *Vitis*, other than fruit, originating in third countries is an effective measure to prevent the introduction of *X. fastidiosa* with these species from countries where *X. fastidiosa* is present. However, restrictions on the introduction of *Prunus* do not reduce the risks of introduction of *X. fastidiosa* since *Prunus* plants free from leaves, flower and fruit can still be imported and harbour the bacterium. Furthermore, many other host plants can still be imported and may carry the bacterium, as shown by the recently documented introductions of coffee plants that harbour *X. fastidiosa.*

- The exemption from official registration for small producers whose entire production and sale of relevant plants are intended for final use by persons on the local market and who are not professionally involved in plant production could facilitate the local dissemination of the pathogenic agent considering the very wide host range of *X. fastidiosa.*

With regard to Implementing Decision 2014/497/EU, the Panel concluded that:

- The exemption of seeds is scientifically justified.

- There is very high uncertainty on the host range of the strain of *X. fastidiosa* occurring in Apulia because research is still ongoing. More generally, the host range of *X. fastidiosa* is still uncertain. It is very likely that the bacterium has a wider host range than the species listed in the emergency measures. Nevertheless, some of the already known host plants of the Apulian strain are not mentioned in the implementing decision (i.e. plants of the genera *Acacia*, *Polygala*, *Spartium* and *Westringia*).

- The reinforcement of conditions for imports from third countries is assessed as effective, but only some genera of host plants are included (*Catharanthus*, *Nerium*, *Olea*, *Prunus*, *Vinca*, *Malva*, *Portulaca*, *Quercus* and *Sorghum*), which mitigates the effectiveness of that measure.

- There is a need for detailed and harmonised protocols for survey, sampling and testing, with at least guidelines regarding minimum requirements to be achieved in demarcated areas, buffer zones and areas not known to be infected.

- Asymptomatic hosts, asymptomatic infections or low infections can escape surveys based solely on visual inspection and even based on laboratory tests as early infections or heterogeneous distribution of the bacterium in the plant may lead to false-negative results.

- There is a need to reduce the infectious insect vector populations (e.g. by vector control, vegetation management, inoculum reduction by removal of infected plants) in the outbreak area and to prevent their movement from infected plants. Special care is necessary when removing infected plants or weeds, for instance, as this may result in movement of infectious insect vectors.

[4] 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.

[5] Commission Implementing Decision of 23 July 2014 as regards measures to prevent the introduction into and the spread within the Union of *Xylella fastidiosa* (Well and Raju).

- The ban on planting of "specified plants" in demarcated areas is appropriate, but all known host plants should be considered.

- Public awareness of diseases that can infect plants in gardens or natural or unmanaged environments is important, and awareness-raising activities should be organised for all people in demarcated areas or buffer zones and their vicinity.

The Panel recommends the continuation and intensification of research activities on the host range, epidemiology and control of the Apulian outbreak of *X. fastidiosa*. Based on the knowledge acquired by this research, uncertainties could be substantially reduced and a more thorough assessment of the risk and of the mitigation measures could be conducted for the Apulian strain of *X. fastidiosa*.

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BACKGROUND AS PROVIDED BY THE EUROPEAN COMMISSION

The current European Union plant health regime is established by Council Directive 2000/29/EC 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.l).

The Directive lays down, amongst others, the technical phytosanitary provisions to be met by plants and plant products and the control checks to be carried out at the place of origin on plants and plant products destined for the Union or to be moved within the Union, the list of harmful organisms whose introduction into or spread within the Union is prohibited and the control measures to be carried out at the outer border of the Union on arrival of plants and plant products.

Xylella fastidiosa (Wells et al., 1987) is a vector-transmitted bacterial plant pathogen associated with important diseases in a wide range of plants. It causes Pierce's disease in grapevine (*Vitis vinifera*), which is described as a major constrain for commercial grapevine production in parts of the USA and tropical America. Numerous species of xylem sap-sucking insects (leafhoppers/Cicadellidae) are known to be vectors of this bacterium.

Xylella fastidiosa is a regulated harmful organism in the European Union, listed in Annex I, Part A, Section I to Council Directive 2000/29/EC as a harmful organism not known to occur in any part of the Union, whose introduction into, and spread within, all Member States is banned. Non-European Cicadellidae known to be vectors of Pierce's disease, caused by *Xylella fastidiosa*, are also listed in Annex I, Part A, Section I to Council Directive 2000/29/EC.

Given the recent identification of the presence of this bacterium in Italy there are still many open issues that are currently being addressed, such as the extent of the outbreak area, the identification of insect vectors, and of the host plants providing the main source of inoculum for the further spread of the bacterium. The link between *Xylella fastidiosa* and the rapid decline symptoms observed in old olive trees also needs to be clarified.

However, there is an urgent need to put in place measures to prevent the spread of this harmful organism into other parts of the Union through the movement of relevant plants, plant parts and other products.

TERMS OF REFERENCE AS PROVIDED BY THE EUROPEAN COMMISSION

EFSA is requested, pursuant to Article 22(5.b) and Article 29(1) of Regulation (EC) No 178/2002, to deliver within 12 months an overall scientific opinion in the field of plant health. Specifically, EFSA is requested to prepare a pest risk assessment of *Xylella fastidiosa* and its insect vectors, to identify risk management options and to evaluate their effectiveness in reducing the risk to plant health posed by this organism.

EFSA is also requested to carry out an evaluation of the EU phytosanitary requirements against these organisms, which are laid down in Council Directive 2000/29/EC and in possible future EU emergency legislation. This scientific opinion, which should take into account data on *Xylella fastidiosa* that will be produced in the current EU outbreak area, will be relevant for the evaluation and fine-tuning of EU measures against this harmful organism.

ASSESSMENT

1. Introduction

1.1. Purpose

This document presents a pest risk assessment prepared by the EFSA Scientific Panel on Plant Health (hereinafter referred to as the Panel) for *Xylella fastidiosa*, in response to a request from the European Commission. The opinion includes identification and evaluation of risk reduction options in terms of their effectiveness in reducing the risk posed by this organism.

1.2. Scope

The risk assessment is for *Xylella fastidiosa* Wells et al., 1987. The exotic vectors of *X. fastidiosa* are discussed in the pest categorisation and considered as a pathway for the assessment of the probability of entry and for the identification and evaluation of effectiveness of related risk reduction options. The known and the potential European vectors are discussed in the pest categorisation and considered in the assessment of the probability of establishment and spread as well as in the identification and evaluation of related risk reduction options.

The pest risk assessment area is the territory of the European Union (hereinafter referred to as the EU) with 28 Member States (hereinafter referred to as EU MSs), restricted, however, to the area of application of Council Directive 2000/29/EC, which excludes Ceuta and Melilla, the Canary Islands and the French overseas regions and departments.

2. Methodology and data

2.1. Methodology

2.1.1. The guidance documents

The risk assessment has been conducted in line with the principles described in the document 'Guidance on a harmonised framework for pest risk assessment and the identification and evaluation of pest risk management options' (EFSA PLH Panel, 2010a). The evaluation of risk reduction options has been conducted in line with the principles described in the above mentioned guidance (EFSA PLH Panel, 2010a), as well as with the 'Guidance on methodology for evaluation of the effectiveness of options to reduce the risk of introduction and spread of organisms harmful to plant health in the EU territory' (EFSA PLH Panel, 2012).

In order to follow the principle of transparency described under Paragraph 3.1 of the Guidance document on the harmonised framework for risk assessment (EFSA PLH Panel, 2010a), "… Transparency requires that the scoring system to be used is described in advance. This includes the number of ratings, the description of each rating …", the Panel has developed rating descriptors to provide clear justification when a rating is given, which are presented in Appendix E of this opinion.

When expert judgements and/or personal communications are used, justification and evidence are provided to support the statements. Personal communications have been considered only when in written form and supported by evidence, and when other sources of information were not publicly available.

2.1.2. Methods used for conducting the risk assessment

The Panel conducted the risk assessment considering the scenario of absence of specific requirements against *X. fastidiosa* and its exotic vectors. All the data on import trade and interceptions presented in this document were nevertheless obtained under the current scenario with phytosanitary regulations

currently in place in the EU; thus, these data should be interpreted with caution because quantities of imported products may change if the phytosanitary regulations are removed.

The conclusions for entry, establishment, spread and impact are presented separately. The descriptors for qualitative ratings given for the probabilities of entry and establishment and for the assessment of impact are shown in Appendix E.

2.1.3. Methods used for evaluating the risk reduction options

The Panel identifies potential risk reduction options and evaluates them with respect to their effectiveness and technical feasibility, i.e. consideration of technical aspects that influence their practical application. The evaluation of effectiveness of risk reduction options in terms of the potential cost-effectiveness of measures and their implementation is not within the scope of this evaluation by the Panel.

The descriptors for qualitative ratings given for the evaluation of the effectiveness and technical feasibility of risk reduction options are shown in Appendix E.

2.1.4. Level of uncertainty

For the risk assessment conclusions on entry, establishment, spread and impact and for the evaluation of the effectiveness of the management options, the levels of uncertainty were rated separately.

The descriptors used to assign qualitative ratings to the level of uncertainty are shown in Appendix E.

2.2. Data

2.2.1. Literature search

A literature search of the following information sources was carried out to identify publications relating to *Xylella fastidiosa*: ISI Web of Knowledge (Web of Science™ Core Collection (1975–present); BIOSIS Citation Index℠ (1926–present); CABI: CAB Abstracts® (1910 to the present); Chinese Science Citation Database℠ (1989–present); Current Contents Connect® (1998–present); Data Citation IndexSM (1900–present); FSTA®—the food science resource (1969–present); MEDLINE® (1950–present); SciELO Citation Index (1997–present); and Zoological Record® (1864–present). Web-based utilities, e.g. Google Scholar, and the grey literature were also searched to identify technical reports, conference proceedings, etc. Expert knowledge was solicited and the websites of relevant national authorities (eg. Biosecurity Australia, United States Department of Agriculture (USDA) Animal and Plant Inspection Service (APHIS) were consulted.

The objective of the literature search was to retrieve the scientific literature and the scientific evidence required to:

- perform the risk assessment (vectors, entry, establishment, spread, impact and control measures);
- elaborate a comprehensive list of the host plant species of *Xylella fastidiosa* (a detailed description of the extensive approach used for this search is presented in Appendix A). For this part, and extensive literature search (ELS) was carried out (refer to Appendix A for the search algorithm and details).

2.2.2. Data collection

For the purpose of this opinion, the following data were collected and considered:

- For the evaluation of the probability of entry, the EUROPHYT database was consulted, searching for pest-specific and/or host-specific notifications on interceptions. EUROPHYT is a web-based network launched by DG Health and Consumers Protection, and is a sub-project of PHYSAN (Phyto-Sanitary Controls) specifically concerned with plant health information. The EUROPHYT database manages notifications of interceptions of plants or plant products that do not comply with EU legislation.

- For the evaluation of the probability of entry and spread of the organism in the EU, the EUROSTAT database was consulted in order to obtain information on trade movements for the relevant pathways.

- A database produced by the EU project ISEFOR[6] was also consulted to extract information on genera of plants for planting hosts of *X. fastidiosa* which are imported to the EU from third countries where *X. fastidiosa* is reported. This database includes data on imports into 14 EU countries during varying time intervals. While the information is not exhaustive, the database provides nevertheless useful information on the range of hosts of *X. fastidiosa* in the international trade of plants for planting.

3. Pest risk assessment

3.1. Pest categorisation

3.1.1. Identity of the pest

Xylella fastidiosa is the causal agent of Pierce's disease of grapevine, phony peach disease, plum leaf scald, almond, elm, oak, American sycamore, mulberry and maple leaf scorch, and citrus variegated chlorosis disease, among other diseases. The causal agents of those diseases were previously considered to be different pathogens, but *Xylella fastidiosa* is now considered to be the unique causal agent.

The valid scientific name is *Xylella fastidiosa* Wells et al., 1987.

Kingdom: *Bacteria*
Phylum: *Proteobacteria*
Class: *Gamma Proteobacteria*
Order: *Xanthomonadales*
Family: *Xanthomonadaceae*
Genus: *Xylella*
Species: *X. fastidiosa*

3.1.1.1. Taxonomy

Xylella fastidiosa is a gammaproteobacterium in the family Xanthomonadaceae. It was initially thought to be a virus, but in the 1970s it was shown to be a bacterium (Purcell, 2013). It was first described and named in 1987 (Wells et al., 1987). To date, the genus *Xylella* consists of only one species, *X. fastidiosa*. Nevertheless, *X. fastidiosa* has substantial genotypic and phenotypic diversity, and a wide host range (Schuenzel et al., 2005; Nunney et al., 2013).

There are four accepted subspecies of *X. fastidiosa* — *fastidiosa*, *pauca*, *multiplex* and *sandyi* (Schaad et al., 2004; Schuenzel et al., 2005)—although only two, subspecies *fastidiosa* and subspecies *multiplex*, are so far considered valid names by the International Society of Plant Pathology Committee on the Taxonomy of Plant Pathogenic Bacteria (ISPP-CTPPB) (Bull et al., 2012). The current distribution of subspecies has been assessed and is presented in Figure 1.

[6] http://www.isefor.com/

Subspecies *fastidiosa* is the best-characterised group, and the only genetic group causing disease in grapevines in the USA (Pierce's disease) (Nunney et al., 2010) (Figure 1D). The subspecies *fastidiosa* is more diverse in Central America; thus, it has been suggested that its presence in the USA is the consequence of an introduction (Nunney et al., 2010). The introduction of ssp. *fastidiosa* in Taiwan has led to an epidemic in grapevine (Su et al., 2013).

Isolates within ssp. *pauca* causing citrus variegated chlorosis in Brazil are reasonably well characterised (Nunney et al., 2012a) (Figure 1E). The genotype present in Italy is a recombinant of alleles within subspecies *pauca* (Maria Saponari and Donato Boscia, National Research Council, Institute for Sustainable Plant Protection, Bari, Italy, personal communication, 2014; Cariddi et al., 2014).

The subspecies *multiplex* appears, so far, to have the widest host range in terms of plant species expressing disease symptoms (Nunney et al., 2013) (Figure 1C). It is subdivided into various subgroups, which are mostly associated with specific host plants (Nunney et al., 2013). The presence of subspecies *multiplex* in Brazil is considered to be the result of an introduction from the USA associated with plums (Nunes et al., 2003; Almeida et al., 2008; Nunney et al., 2012b). Interestingly, Nunney et al. (2012b) raised the hypothesis of a recent inter-subspecies recombination between the sympatric *X. fastidiosa* subsp. *pauca* and subsp. *multiplex* in South America to explain why host plants such as citrus or coffee, which have been cultivated there for about 250 years, have been affected for only the last 25 years.

Isolates from the subspecies *sandyi* are poorly characterised (Figure 1F) and their biology is not well understood (Yuan et al., 2010).

In addition to the four generally accepted subspecies (*fastidiosa*, *multiplex*, *pauca* and *sandyi*), several strains have been identified which have not yet been allocated to a recognised entity. A fifth proposed subspecies, which includes isolates causing disease in a tree, *Chitalpa tashkentensis* (Bignoniaceae), in New Mexico, USA, is not generally accepted because its phylogenetic placement is still in doubt and it may fall within one of the other currently accepted subspecies (Randall et al., 2009). There are no other records of this genotype, or reports of its occurrence. More recently, another subspecies has been proposed, subspecies *morus*, associated with isolates in the USA colonising mulberry (Nunney et al. 2014b). This subspecies, proposed based on multilocus sequence typing (MLST) data, is recombinogenic with alleles from subspecies *fastidiosa* and *multiplex* (Nunney et al, 2014a). A report from Taiwan (Leu and Su, 1993; Su et al., 2012) describing a genotype of *X. fastidiosa* causing a disease in pear classifies the agent as *X. fastidiosa* based on its 16S rDNA sequence. As its biology is not fully understood, and as it is genetically substantially distinct from all other already known *X. fastidiosa* genotypes, this pathogen would certainly be assigned to a new subspecies or even to a new species; however, this would require additional research.

Genotypic assignment to subspecies has been helpful in allowing inferences about the general biology of isolates. For example, isolates collected from symptomatic grapevines in California fall within subspecies *fastidiosa*, while those collected from almond trees fall within subspecies *fastidiosa* and *multiplex* (Almeida and Purcell, 2003). The isolates collected from almonds that belong to subspecies *fastidiosa* are capable of causing disease in grapevines and almond trees, while those belonging to subspecies *multiplex* cause disease only in almonds. However, MLST also allows the grouping of genotypes that are biologically distinct within the various *X. fastidiosa* subspecies. For example, within subspecies *pauca*, there are biologically and genetically distinct genotypes that cause disease in citrus and coffee (Almeida et al., 2008). In this specific case, there is no cross-infection (Almeida et al., 2008), although one coffee genotype isolate from citrus has been reported (Nunney et al., 2012a); it is relevant to note that citrus and coffee often occur in sympatry and share some insect vectors, so that it is possible that this isolation was not of epidemiological relevance. Therefore, although genotyping allows for robust genetic and phenotypic inference, biological (e.g. experimental cross-

infection assays) and epidemiological studies (surveys that type field isolates) are important to determine the phenotypic characteristics of individual isolates.

There are numerous genotyping schemes that have been used to discriminate *X. fastidiosa*, providing resolution at different levels of genetic diversity (Almeida et al., 2008; Yuan et al., 2010). The decision as to which typing protocols to use depends on the question being asked. At the broader level of subspecies and host plant *X. fastidiosa* genotype association, MLST has been shown to be a robust approach to study the diversity of *X. fastidiosa* (Nunney et al., 2012a). This approach is based on the sequencing of fragments of seven housekeeping genes distributed throughout the genome (Maiden et al., 1998). With this now commonly used approach, individual isolates can be assigned to subspecies.

Although there is also infra-subspecies diversity (Nunney et al., 2013), the robustness of infra-subspecies data, especially in the context of host plant–pathogen genotype associations, is still being assessed by the scientific community and is currently considered as weak because the available data are limited (Yuan et al., 2010; Almeida and Retchless, 2013). The examples cited above of the subspecies *morus* in USA and of the subspecies *pauca* in Italy highlight the importance of homologous recombination on the evolution of *X. fastidiosa* and partly explain why this opinion addresses the *X. fastidiosa* as a species rather than individual subspecies.

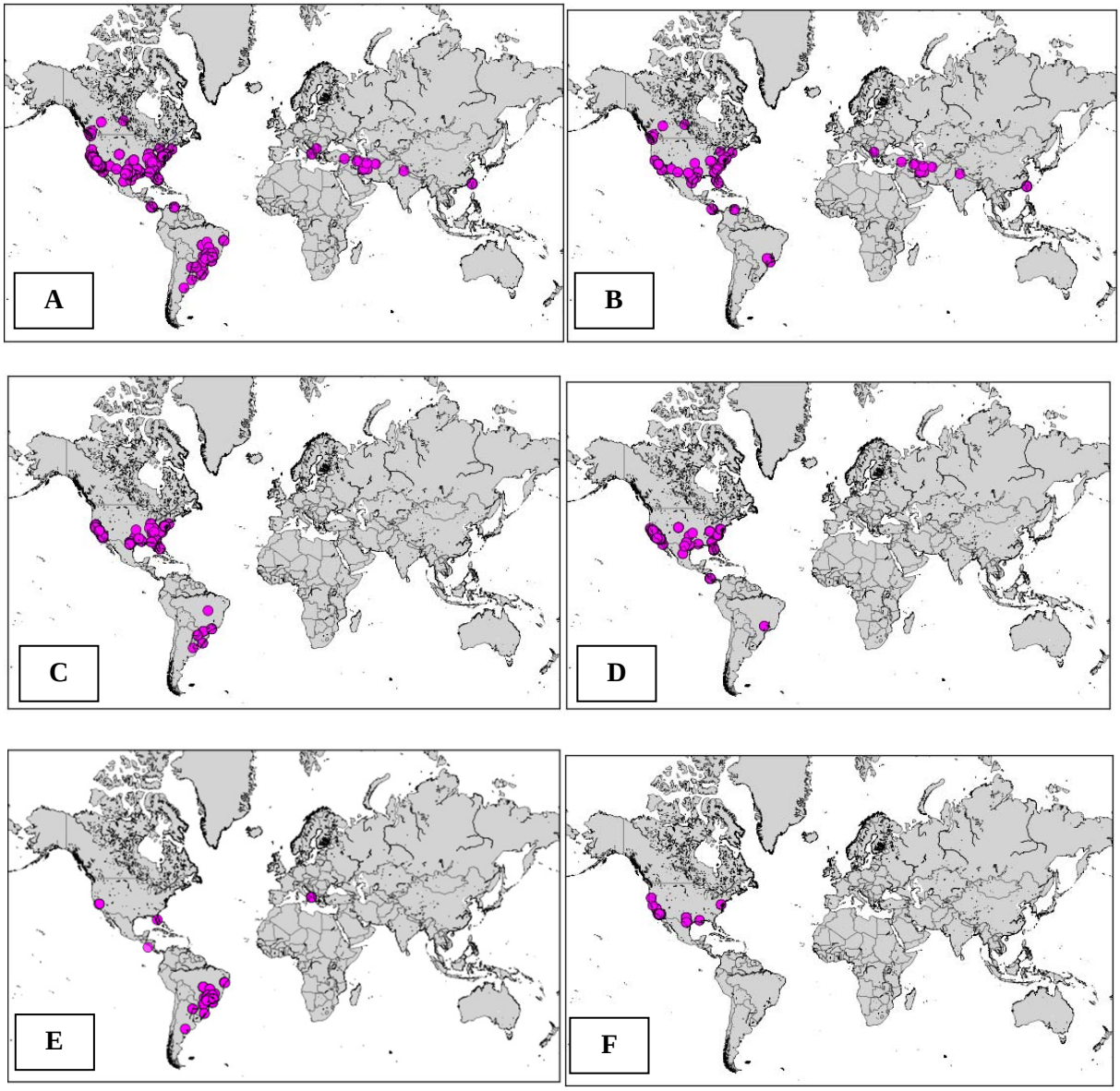


Figure 1: Worldwide distribution of *Xylella fastidiosa*. (A) all *Xylella fastidiosa* subspecies and unidentified subspecies. (B) Unidentified subspecies. (C) *Xylella fastidiosa* subsp. *multiplex*. (D) *Xylella fastidiosa* subsp. *fastidiosa*. (E) *Xylella fastidiosa* subsp. *pauca*. (F) *Xylella fastidiosa* subsp. *sandyi*. Data from the literature search; mapping: Joint Research Centre of the European Commission (JRC)

3.1.1.2. Symptoms, detection and identification

The symptoms associated with the presence of *Xylella fastidiosa* in plants vary from asymptomatic associations to plant death, due to the large number of different host affected by the bacteria, pathogen diversity, and partly because of the wide range of climatic conditions in areas where the pathogen is found.

Most host plants infected with *X. fastidiosa* do not express any symptom. Symptoms often consist of a rapid drying of leaf margins, with scorched leaves. The different names given to the disease illustrate this heterogeneity of symptoms: "Pierce's disease" on grapevine, "alfalfa dwarf", "almond leaf scorch", "phony peach disease", "plum leaf scald", "citrus variegated chlorosis" or "leaf scorch" of elm, coffee, oak, sycamore and oleander (Figure 2). In Taiwan, pear leaf scorch was also reported on *Pyrus pyrifolia* (Japanese pear) and *P. serotina* (Asian pear) (Chen et al., 2006).

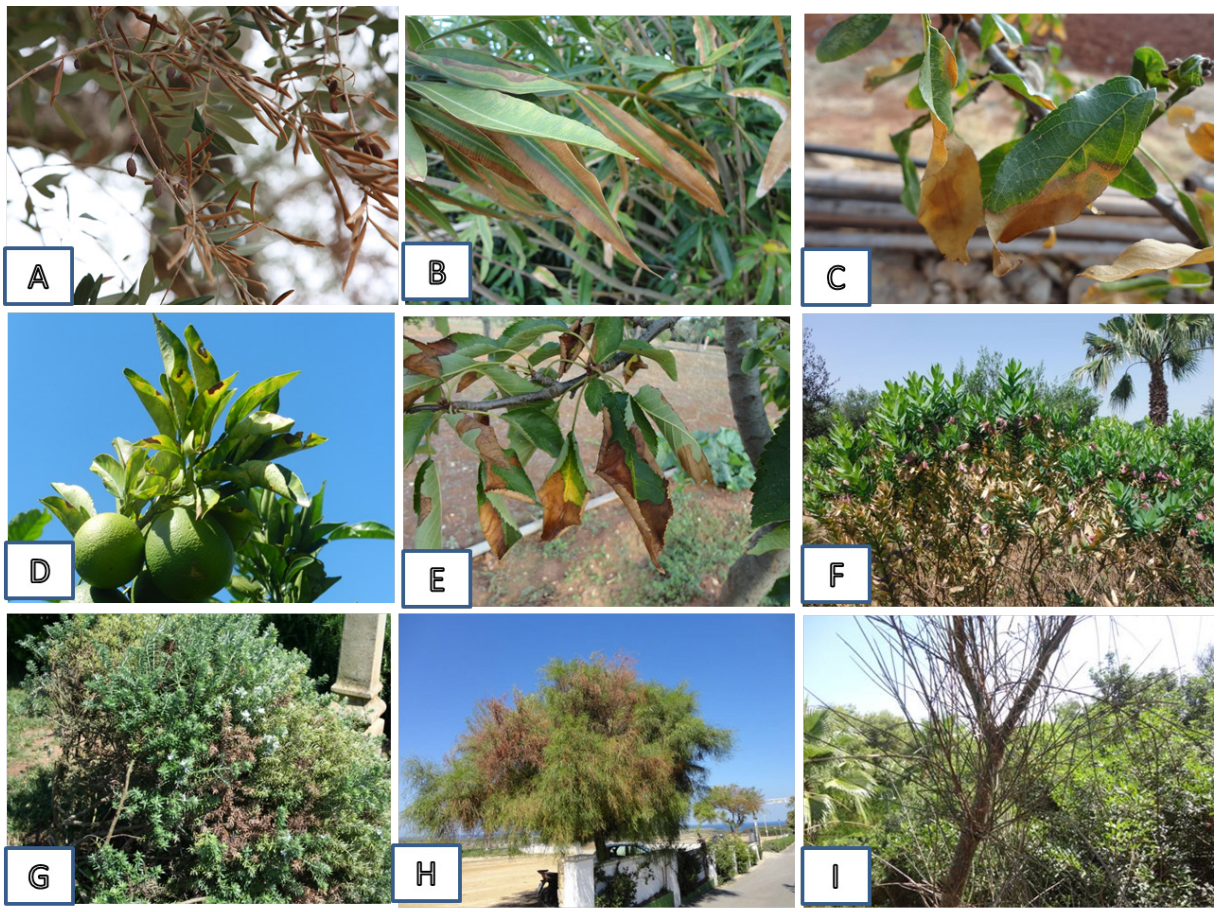


Figure 2: *Xylella fastidiosa* symptoms on various host plant species. (A) Olive trees (B) Oleander (C) Almond leaf scorch disease (D) Citrus variegated chlorosis symptoms on leaf (never found infected in Apulia) (E) Cherry (F) *Polygala myrtifolia* (G) *Westringia fructicosa* (H) *Acacia saligna* I: *Spartium junceum.* Photographs courtesy of Donato Boscia, CNR—Institute for Sustainable Plant Protection (A, B, C, E, F, G, H and I) and Helvecio Della Coletta Filho, Centro de Citricultura Sylvio Moreia – IAC Cordeiropolis, SP, Brazil (D).

The reliable detection and identification of *X. fastidiosa* is very important not only because of its quarantine status, but also because the different subspecies are markedly different in host range and, therefore, in terms of plant disease significance. Another reason is the fact that *X. fastidiosa* infects a wide range of host plant species asymptomatically. Symptom development depends on host plant species–*X. fastidiosa* genotype (Almeida and Purcell, 2003) and is usually correlated with high bacterial populations within plants (Hill and Purcell, 1995; Newman et al., 2003). Because bacterial populations within plants are correlated with pathogen acquisition efficiency by vectors (Hill and Purcell, 1997), plant species infected with low populations of *X. fastidiosa* may serve as an inefficient reservoir for vectors to acquire the bacterium (Almeida et al., 2005).

Many analyses are culture dependent and rely on isolation using non-selective media (Raju et al., 1982; Davis et al., 1983; Wells et al., 1983; Chang and Walker, 1988; Hill and Purcell, 1995; Almeida et al., 2004, Lopes and Torres, 2006). Detection must be performed under good laboratory conditions as isolates may take one to four weeks to develop colonies on solid media owing to their slow growth. Potential difficulties during *in vitro* cultivation include low bacterial densities in plant tissue, heterogeneity of bacterial distribution within the plant and potential growth inhibitors extracted during tissue grinding for culturing. Moreover, other pathogenic agents may be present at the same time in samples and may hinder the detection of *X. fastidiosa.*

Several methods have been used to identify *X. fastidiosa* directly in petiole or stem cross-sections, including electron microscopy (French et al., 1977) and immunofluorescence (Carabjal et al., 2004; Buzkan et al., 2005). Serologically based methods such as enzyme-linked immunoassay (ELISA) or immunofluorescence have been used extensively, but are sometimes considered less sensitive than the isolation approach (French et al., 1978; Sherald and Lei, 1991). Those methods could also lead to false-negative or -positive detections. The EPPO protocol (EPPO, 2004) states that, for official purposes, a strain should be isolated and pathogenicity tests should give positive responses.

Numerous polymerase chain reaction (PCR)-based methods have been proposed for *X. fastidiosa* detection, with different objectives, including general detection, quarantine purposes (Chen et al., 2000; Minsavage et al., 1994; Harper et al., 2010), subspecific detection targeting an *X. fastidiosa* subspecies or a given plant species for high-throughput methods (Pooler and Hartung, 1995; Oliveira et al., 2002; Huang, 2009; Guan et al., 2013; Li et al., 2013; Ouyang et al., 2013), *in situ* detection methods (Ouyang et al., 2013; Schaad et al., 2002) or loop-mediated isothermal amplification (LAMP) and Ex Razor procedures (Harper et al., 2010; Ouyang et al., 2013).

Identification of putative *X. fastidiosa* colonies is best achieved by molecular methods. These include sequence-based analyses targeting housekeeping genes. Such analyses target either single gene portions or, better, multiple genes by a method known as MLST or multilocus sequence analysis (MLSA) (Almeida et al., 2014; Nunney et al. 2010; Parker et al., 2012), which better addresses identification at the subspecies level due to the presence of homologous recombination among genotypes. Other techniques, such as quantitative real time PCR (Bextine and Child, 2007, Brady et al., 2012) and variable tandem repeat analysis (Coletta-Filho et al., 2001), have also been used for typing purposes, although they provide varying levels of genetic resolution.

3.1.1.3. Biology of the pathogen

Host plant colonisation

X. fastidiosa colonises the xylem network of plants, where it can move up- and downstream (Almeida et al., 2001; Meng et al., 2005). Populations of *X. fastidiosa* restrict water movement in the xylem, and high frequencies of blocked vessels are associated with disease symptom development (Newman et al., 2003). *X. fastidiosa* colonises many host plants that remain symptomless, and serve as a source of inoculum for vectors (Hopkins and Purcell, 2002). The colonisation of different host species (by different *X. fastidiosa* genotypes) ranges from successful infections resulting in plant death within months to persistent yet non-symptomatic infection (Purcell and Saunders, 1999). Therefore, colonisation patterns are complex and depend upon host plant species and genotype of the pathogen.

Despite the large variability of symptoms, there is a consistent association of symptoms with plant physiological responses to water stress. An important aspect of plant susceptibility is the ability of *X. fastidiosa* to move within the xylem network and reach high bacterial populations. Movement and the size of bacterial populations are correlated with the severity of disease symptoms. Importantly, they are also correlated with the efficiency with which *X. fastidiosa* is acquired by insect vectors. In other words, hosts that harbour larger bacterial populations distributed throughout the plant are more likely to result in infection of insects than hosts with low bacterial populations, which usually do not become systemic. Therefore, the importance of alternative hosts (i.e. not focal crop; plants such as weeds) in disease epidemiology is highly variable and dependent on their capacity to harbour large populations of the pathogen, in addition to being feeding hosts of the vector.

Vector transmission

Xylella fastidiosa is a xylem-limited bacterium that is exclusively transmitted by xylem sap-feeding insects belonging to the order Hemiptera, sub-order Auchenorrhyncha (Redak et al., 2004).

The transmission of *X. fastidiosa* by insects is peculiar in that it does not require a latent period, yet the bacteria are persistently transmitted (Almeida et al., 2005). Vectors (both nymphs and adults)

acquire the bacteria by feeding in the xylem of an infected plant and can inoculate the pathogen to healthy plants immediately after acquisition. Bacteria are restricted to the alimentary canal and do not systemically infect the insect body. They adhere to and multiply in the pre-cibarium and cibarium (parts of the foregut). This implies that vectors lose infectivity with moulting, as the foregut is of ectodermal origin and is renewed with moulting. Therefore, newly emerged adults must feed on an infected plant to become infectious and spread *X. fastidiosa.* Once infected, adult vectors can transmit during their whole lifetime, as the bacterium multiplies and persists in the vector foregut (Almeida et al., 2005). The bacterium is not transovarially transmitted to the progeny of the vector (Freitag, 1951). Winged adults, because of their high mobility, are mostly responsible for *X. fastidiosa* spread. It is important to remember that, since the bacterium is restricted to the foregut (Purcell and Finlay, 1979), the number of bacterial cells per insect is low (very few live bacterial cells in the vector's foregut are required for transmission: Hill and Purcell, 1995) and therefore a sensitive diagnostic tool, such as PCR, is needed to detect the presence of *X. fastidiosa* in the vector insects. ELISA is not sensitive enough for detection of *X. fastidiosa* in the vector insects. Importantly, even PCR (or qPCR and other related methods) have so far not been shown to provide robust results in insects.

On one hand, *X. fastidiosa* transmission is restricted to xylem sap-feeding insects; on the other hand, insect transmission of *X. fastidiosa* is known to be poorly specific and therefore all xylem sap-feeding insects are considered vectors, which has not been disproven so far (Frazier, 1944; Purcell, 1989; Almeida et al., 2005). However, transmission efficiency varies substantially depending on insect species, host plant and *X. fastidiosa* genotype (Redak et al., 2004; Lopes et al., 2010).

Ecology

The ecology of *X. fastidiosa* diseases is the outcome of complex biotic and abiotic interactions. Although general insights from one disease system are useful for another, ecological parameters are not necessarily transferable. A discussion of specific cases is provided to highlight this important aspect of *X. fastidiosa* ecology.

Despite the fact that *X. fastidiosa* has a notoriously large alternative host plant range, the epidemiological importance of such hosts varies. The spring spread of *X. fastidiosa* from host plants in riparian habitats (i.e. along creeks/rivers) into vineyards in coastal areas of northern California is well established (Purcell, 1974). Although there is vector spread of *X. fastidiosa* from grapevine to grapevine in late summer and autumn, only the spring spread from alternative hosts to grapevine is of epidemiological importance (reviewed in Hopkins and Purcell, 2002). A similar scenario occurs in the Central Valley of California, where insect vectors move to vineyards for brief flights from alfalfa fields, but there is no spread from grapevine to grapevine (Purcell and Frazier, 1985). The opposite scenario occurs with citrus variegated chlorosis in Brazil. In that case, *X. fastidiosa* is also known to colonise a wide range of weeds associated with citrus orchards (Lopes et al., 2005), but disease spread occurs primarily from citrus to citrus tree (Laranjeira et al., 1998). Alternative hosts, in this case, may be important for maintenance of the pathogen in the environment, and provide a habitat for insect vectors, but their epidemiological impact is deemed to be low.

Similarly, epidemics of Pierce's disease of grapevines in California, USA, may also have distinct characteristics if vector species are different. In coastal northern California, spread is driven by adult *Graphocephala atropunctata* leafhoppers that overwinter in riparian areas adjacent to vineyards. In spring they migrate to vineyards and infect vines, leading to a disease distribution limited to the overwintering habitat of vectors. After the introduction of the invasive species *Homalodisca vitripennis* to southern California, Pierce's disease epidemics had devastating consequences for vineyards in Temecula Valley, where entire vineyards were found to be symptomatic (i.e. no edge effect). In this case, insect vectors overwintered on adjacent citrus plants, reaching extremely large populations (one to two million per hectare) (Coviella et al., 2006). Vectors were found distributed throughout vineyards in very large numbers (Perring et al., 2001), leading to higher rates of disease spread.

In the Americas, in most diseases caused by *X. fastidiosa* that have been studied, the vectors are leafhoppers. In Europe, spittlebugs are much more abundant and diverse than sharpshooter leafhoppers, and not as much is known about their biology, ecology and role as vectors. In addition, agricultural practices and environmental conditions, including the landscape and climate, are extremely variable in the EU. Research will certainly be necessary to establish the basics of *X. fastidiosa* ecology in the EU.

3.1.2. Current distribution

3.1.2.1. Global distribution

Diseases caused by *X. fastidiosa* occur in tropical, subtropical and temperate areas, mainly in the Americas. The geographical distribution based on the coordinates of the the host plants (from the table shown in Appendix B) is as follows (see Figure 3):

- **North America**: *X. fastidiosa* has been reported in Canada (on elm in southern Ontario (Goodwin and Zhang, 1997), British Columbia (FIDS, 1992) and Saskatchewan (Northover and Dokken-Bouchard, 2012); on maple in Alberta (Holley, 1993)). Mexico and the USA (Alabama, Arizona, Arkansas, California, Delaware, District of Columbia, Florida, Georgia, Indiana, Kentucky, Louisiana, Maryland, Mississippi, Missouri, Montana, Nebraska, New Jersey, New Mexico, New York, North Carolina, Oklahoma, Oregon, Pennsylvania, South Carolina, Tennessee, Texas, Virginia, Washington, West Virginia: EPPO PQR, 2014).

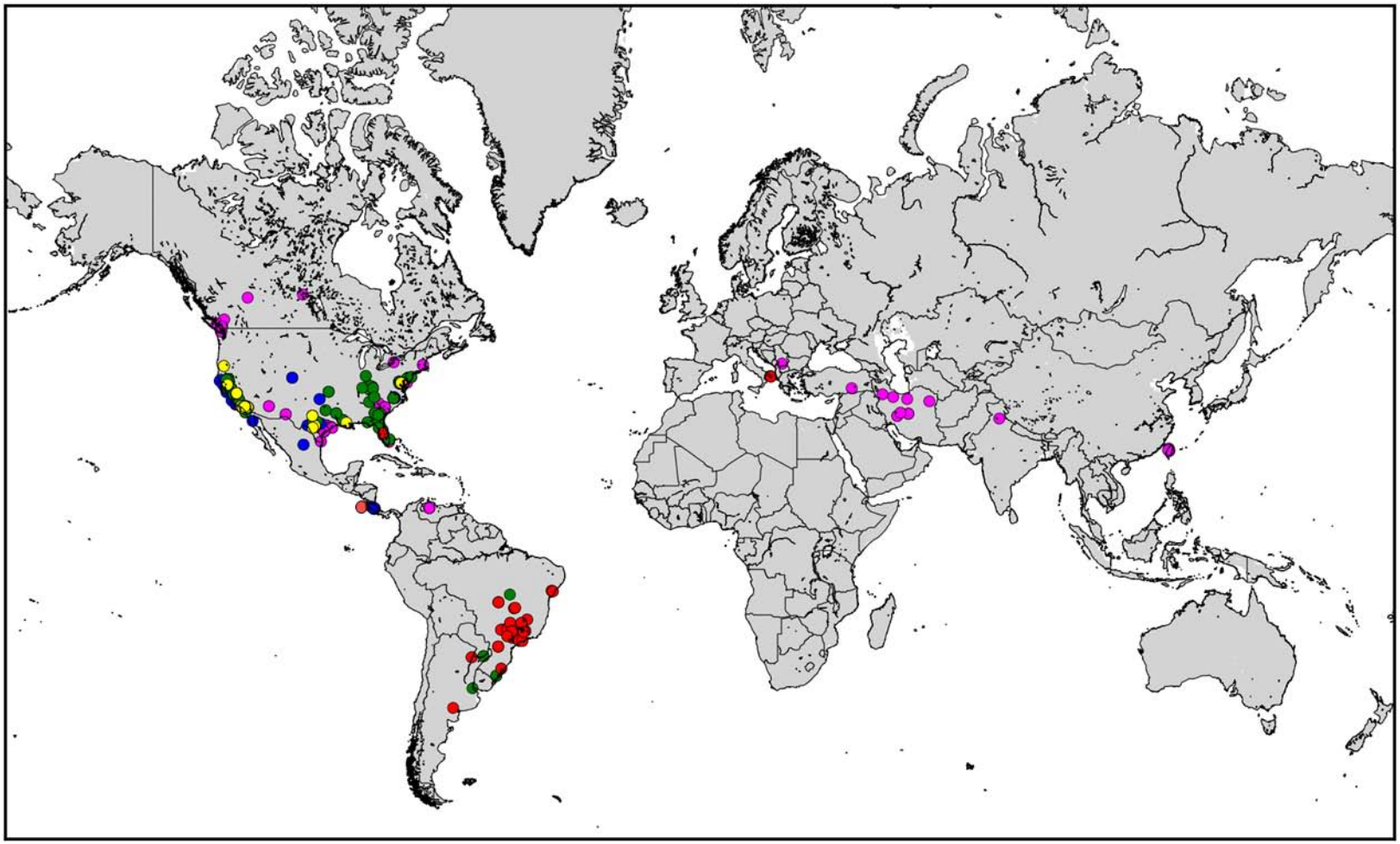
- **Central America and Caribbean**: *X. fastidiosa* has been reported in Costa Rica (Nunney et al., 2014) and Mexico (Legendre et al., 2014). In addition it has been intercepted in consignments imported into Europe from Honduras (EUROPHYT, online).

- **South America**: *X. fastidiosa* has been reported in Argentina (Leite et al., 1997; de Coll et al., 2000), Brazil (Bahia, Espirito Santo, Goias, Minas Gerais, Parana, Rio Grande do Sul, Rio de Janeiro, Santa Catarina, São Paulo, Sergipe), Ecuador (Legendre et al., 2014), Paraguay and Venezuela.

- **Asia**: *X. fastidiosa* has been reported in Iran (Amanifar et al., 2014), India (Jindal and Sharma, 1987: this report remains uncertain, detection based mostly on symptom observation and coloration of xylem), Lebanon (Temsah et al., 2015: this report remains uncertain, further analysis is needed to confirm the report based only on ELISA detection and scanning electron microscopy observations), Taiwan (Leu and Su, 1993), and Turkey (Güldür et al., 2005: this report remains uncertain, detection based on ELISA and electron microscopy observations; no further reports or studies published).

- **Africa**: *X. fastidiosa* has not been reported.

- **Europe**: An outbreak of *X. fastidiosa* in Kosovo was reported by Berisha et al. (1998), but this report was not confirmed by further studies. France reported the eradication of a confirmed case on coffee plantlets kept in contained glasshouse facilities (ANSES, 2012). These coffee plants were received from Ecuador (*Coffea arabica*) and Mexico (*Coffea canephora*) (Legendre et al., 2014). Recently, a field outbreak of *X. fastidiosa* has been recorded in the Apulia region of Italy (EPPO, 2013).



Colour code: blue = *X. fastidiosa* subsp. *fastidiosa*; green = *X. fastidiosa* subsp. *multiplex*; red = *X. fastidiosa* subsp. *pauca*; yellow = *X. fastidiosa* subsp. *sandyi*; fuchsia = *X. fastidiosa* subsp. unidentified)

Figure 3: World distribution of *Xylella fastidiosa* subspecies.

There are uncertainties associated with reports that incompletely describe the detection methods that were used. The tedious isolation process of *X. fastdidosa*, the difficulty in fulfilling Koch's postulates and the need also to understand the vector's role are certainly part of the explanation why the identification process has sometimes been stopped or performed inadequately. Furthermore, it should be stressed that, since infected plants might be missed because they are asymptomatic or show symptoms that could be due to drought, the known distribution can be linked only to areas where the disease has provoked clearly visible symptoms, and usually epidemics.

There are uncertainties concerning the presence of the pest in China, as it is described in literature as widespread in grapes in two provinces (Chu 2001, 2002). However, the papers by Chu (2001, 2002) do not provide details of detection methods apart from microscopy. In addition, the Panel has been unable, so far, to find any confirmation of these reports.

There are uncertainties regarding the prevalence and impact of elm leaf scorch disease caused by *X. fastidiosa* on elm (*Ulmus americana*) in Canada, because other pests and diseases, such as Dutch elm disease (DED), can contribute to elms' decline. Numerous sources suggest that *X. fastidiosa*-infected trees are very susceptible to DED (Sinclair et al., 1987; Goodwin and Zhang, 1997; Gould and Lashomb, 2007). Sinclair et al. (1987) suggest that over 40 % of cases of DED occurred in trees already affected by bacterial scorch (in the USA). DED is widespread in Canada and, therefore, it is difficult to determine the prevalence and impact of *X. fastidiosa* on elm populations in Canada, as trees may have succumbed to DED prior to being diagnosed with elm leaf scorch.

3.1.2.2. Occurrence in the risk assessment area

No field outbreak related to *X. fastidiosa* has been reported in the risk assessment area (EU-28) up until 2013.

France reported a suspected case of *X. fastidiosa* on apricot in 2011, based on a serological assay, but it has not been confirmed even though many tests have been performed (ANSES, 2012).

In 2012, the bacterium had been isolated in France from coffee plants (*Coffea arabica* and *C. canephora*) originating from Ecuador and Mexico (Legendre et al., 2014), but those plants were grown in a confined glasshouse, near Tours. The outbreak was eradicated (ANSES, 2012; EPPO 2012a).

In 2013, the occurrence of *X. fastidiosa* was reported in southern Italy (near Lecce, in the Salento peninsula, Apulia region), associated with quick decline symptoms on olive trees (*Olea europea*), oleander (*Nerium oleander*) and almond (*Prunus dulcis*) (Saponari et al., 2013). Investigations showed that symptomatic olive trees were generally affected by a complex of pests, including *X. fastidiosa*, several fungal species belonging to the genera *Phaeoacremonium* and *Phaemoniella* and *Zeuzera pyrina* (leopard moth) (Nigro et al., 2013). Investigations are still ongoing to delimit the outbreak area and the biological characterisation of the Apulian *X. fastidiosa* strain.

An interception of *X. fastidiosa* on coffee plants was reported by the Netherlands in October 2014 (EUROPHYT, online). The infected plants originated from Costa Rica.

No interception of regulated exotic vectors is recorded in the EUROPHYT database (EUROPHYT, online).

3.1.2.3. Occurrence in neighbouring countries

In addition, one outbreak of *X. fastidiosa* has been described on grapevine in Kosovo (Berisha et al., 1998). This report remains dubious because of the lack of further study and because of doubts about the nature of the original material (EPPO, 1998).

A report of *X. fastidiosa* colonising almond trees in southern Turkey also remains unconfirmed. Güldür et al. (2005) reported the presence of almond trees with leaf scorch symptoms that were

ELISA positive for *X. fastidiosa;* in addition, they used microscopy to demonstrate the presence of bacterial bodies in the xylem of symptomatic plants.

3.1.3. Host plants of *X. fastidiosa*

The extraction table presented in Appendix B summarises the host range of *X. fastidiosa* based on the available peer-reviewed literature. Some institutional websites provide valuable information on host plant species, but not always originating from peer-reviewed papers.

Although the list provided with this EFSA opinion was obtained from peer-reviewed articles, there are important considerations relevant to the interpretation of its contents. Most data have been generated in the USA and Brazil, even though *X. fastidiosa* is known to occur from Argentina to Canada. In addition, many of the plant species tested were hosts of economic importance or selected for experimentation based on their association with epidemics. Therefore, the list is necessarily limited to the research that has been performed, and should not be considered a definitive list of host plant species. Nevertheless, most, if not all, host plants of economic importance (i.e. crops and certain ornamentals) known to be susceptible to disease caused by this bacterium are listed. Additionally, it is important to stress that Koch's postulates have not necessarily been fully fulfilled for each of the host–*X. fastidiosa* subspecies combination. The list is simply based on hosts reported in the current literature to be associated with *X. fastidiosa.*

Data used to determine if a species is a host plant of *X. fastidiosa* are largely derived from two different approaches. The first is experimental research carried in greenhouses or in the field and involving mechanical inoculations of the pathogen. The second approach is based on field surveys: samples collected from plants suspected of harbouring *X. fastidiosa* infections are tested using various detection methods. In some cases, data are available through both approaches. Because a large proportion of host plants never express symptoms due to *X. fastidiosa* infection, the list did not include symptomatic species only. In addition, for a large proportion of plants, necessarily including all of those that do not express symptoms, experiments to fulfil Koch's postulates have not been performed. This is especially important for non-crop hosts, such as shade and ornamental trees, in addition to weeds. In many of these cases, the only reports available are based on pathogen detection of suspicious field samples, while others are asymptomatic hosts - and therefore Koch's postulates cannot be fulfilled. Because *X. fastidiosa* is taxonomically divided into subspecies, it was attempted to assign subspecies infecting each host plant species, by utilising available knowledge on the geographical distribution of isolates or where/when the research was conducted. Finally, in most cases the specific geographic location of isolates was not presented, so larger geographical regions were used. These were unavoidable technical limitations of the available data. The data are summarised in Tables 1 and 2 and presented in Appendix B.

Table 1: Host plants (families/genera/species) of *Xylella fastidiosa* divided by subspecies

Subspecies of *X. fastidiosa*	Plant family	Plant genera	Plant species
fastidiosa	42	138	164
multiplex	28	69	84
pauca	16	30	36
sandyi	5	6	5
Total	**63**	**193**	**309**

The host plant range of *X. fastidiosa* is very large. Based on currently available data, the host range comprises plants in 63 families, 193 genera and 309 species. Six of the families are monocotyledons, while 54 are dicotyledons and one is a gymnosperm (Ginkgoaceae). Despite this reported wide host range, it is important to highlight that (i) not all of these plants are susceptible to disease and (ii) not all plant species are associated with all *X. fastidiosa* subspecies. Table 2 summarises the host range by subspecies; the number of host plants is based on the available literature and not the real range of these

genetic groups. For example, subspecies *fastidiosa* is the most studied genotype and, therefore, it is expected that it would have a larger proven host range as a consequence of a larger number of studies addressing its ecology. Lastly, for most host plants species with few exceptions other than crops of agricultural importance, proof of pathogenicity (Koch's postulates) is not available.

Despite the importance of subspecies to *X. fastidiosa* biology and ecology, including host range, this taxonomic subdivision has been available for only a few years. Therefore, much of the literature does not include such terminology. Because of its importance, an effort was made to identify subspecies for isolates used in research and surveys prior to the use of this terminology.

In Appendix B, the putative *X. fastidiosa* subspecies were selected on the basis of following criteria: host plant species associated with the research, location where the isolate was obtained and phylogenetic placement of the isolate. The host is often closely associated with the location; for example, infections of citrus or coffee in Brazil are always associated with subspecies *pauca*, with no known exceptions.

Table 2: The list of host plants genera known from literature to be hosts of *Xylella fastidiosa* ssp. *fastidiosa*, *multiplex*, *pauca*, *sandyi* and unattributed subspecies

Subspecies	Plant family	Plant genus
fastidiosa	*Adoxaceae*	*Sambucus*
	Amaranthaceae	*Alternanthera*, *Chenopodium*
	Anacardiaceae	*Rhus*, *Toxicodendron*
	Apiaceae	*Conium*, *Datura*, *Daucus*, *Oenanthe*
	Apocynaceae	*Nerium*, *Vinca*
	Araliaceae	*Hedera*
	Asteraceae	*Ambrosia*, *Artemisia*, *Baccharis*, *Callistephus*, *Conyza*, *Franseria*, *Helianthus*, *Lactuca*, *Solidago*, *Sonchus*, *Xanthium*
	Betulaceae	*Alnus*
	Boraginaceae	*Amsinckia*
	Brassicaceae	*Brassica*
	Cannaceae	*Canna*
	Caprifoliaceae	*Lonicera*
		Symphoricarpos
	Convolvulaceae	*Convolvulus*, *Ipomoea*
	Cyperaceae	*Cyperus*
	Fabaceae	*Acacia*, *Chamaecrista*, *Cytisus*, *Genista*, *Lathyrus*, *Lupinus*, *Medicago*, *Melilotus*, *Spartium*, *Trifolium*, *Vicia*
	Fagaceae	*Quercus*
	Juglandaceae	*Juglans*
	Lamiaceae	*Callicarpa*, *Majorana*, *Melissa*, *Mentha*, *Rosmarinus*, *Salvia*,
	Lauraceae	*Persea*, *Umbellularia*
	Magnoliaceae	*Magnolia*
	Malvaceae	*Malva*
	Myrtaceae	*Eucalyptus*, *Eugenia*, *Metrosideros*
	Oleaceae	*Fraxinus*, *Syringa*
	Onagraceae	*Epilobium*, *Fuchsia*, *Godetia*, *Oenothera*
	Pittosporuceae	*Pittosporum*
	Platanaceae	*Platanus*

Subspecies	Plant family	Plant genus
	Poaceae	*Avena, Bromus, Cynodon, Digitaria, Echinochloa, Eragrostis, Eriochola, Festuca, Holous, Hordeum, Lolium, Paspalum, Pennisetum, Phalaris, Phleum, Poa, Setaria, Sorghum, Erodium, Pelargonium*
	Polygonaceae	*Persicaria, Polygonum, Rheum, Rumex*
	Portulaceae	*Montia, Portulaca*
	Resedaceae	*Reseda*
	Rhamnaceae	*Rhamnus*
	Rosaceae	*Cotoneaster, Fragaria, Photinia, Prunus, Rosa, Rubus*
	Rubiaceae	*Coffea, Coprosma*
	Rutaceae	*Citrus*
	Salicaceae	*Populus, Salix*
	Sapindaceae	*Acer, Aesculus*
	Scrophulariaceae	*Veronica*
	Simmondsiadaceae	*Simmondsia*
	Solanaceae	*Datura, Lycopersicon, Nicotiana, Solanum*
	Urticaceae	*Urtica*
	Verbenaceae	*Duranta*
	Vitaceae	*Ampelopsis, Parthenocissus, Vitis*
multiplex	*Altingiaceae*	*Liquidambar*
	Apocynaceae	*Catharanthus, Vinca*
	Araliaceae	*Hedera*
	Asteraceae	*Ambrosia, Encelia, Helianthus, Iva, Pluchea, Ratibida, Senecio, Solidago, Sonchus, Xanthium*
	Betulaceae	*Alnus*
	Brassicaceae	*Capsella, Sisymbrium*
	Caryophyllaceae	*Stellaria*
	Celastraceae	*Celastrus*
	Cornaceae	*Cornus*
	Ericaceae	*Vaccinium*
	Fabaceae	*Cassia, Cercis, Gleditsia, Lupinus, Medicago*
	Fagaceae	*Fagus, Quercus*
	Ginkgoaceae	*Ginkgo*
	Juglandaceae	*Carya*
	Lamiaceae	*Salvia*
	Lythraceae	*Lagerstroemia*
	Magnoliaceae	*Liriodendron*
	Malvaceae	*Malva*
	Moraceae	*Morus*
	Oleaceae	*Chionanthus, Fraxinus, Ligustrum, Olea*
	Plantaginaceae	*Veronica*
	Platanaceae	*Platanus*
	Poaceae	*Poa, Erodium, Sorghum*
	Rosaceae	*Prunus, Rubus*
	Rutaceae	*Citrus*
	Sapindaceae	*Acer, Aesculus, Koelreuteria, Sapindus*
	Ulmaceae	*Celtis, Ulmus*

Subspecies	Plant family	Plant genus
	Urticaceae	*Urtica*
	Vitaceae	*Ampelopsis*, *Vitis*
pauca	*Amaranthaceae*	*Alternanthera*
	Apocynaceae	*Catharanthus*, *Nerium*
	Asteraceae	*Acanthospermum*, *Bidens*
	Commelinaceae	*Commelina*
	Convolvulaceae	*Ipomoea*
	Euphorbiaceae	*Euphorbia*, *Phyllanthus*
	Fabaceae	*Acacia*, *Medicago*, *Senna*
	Lamiaceae	*Westringia*
	Malvaceae	*Hibiscus*, *Sida*
	Oleaceae	*Olea*
	Poaceae	*Brachiaria*, *Cenchrus*, *Cynodon*, *Digitaria*, *Echinochloa*, *Panicum*
	Polygalaceae	*Polygala*
	Portulaceae	*Portulaca*
	Rosaceae	*Prunus*
	Rubiaceae	*Coffea*, *Richardia*, *Spermacoce*
	Rutaceae	*Citrus*
	Solanaceae	*Nicotiana*, *Solanum*
	Verbenaceae	*Lantana*
	Vitaceae	*Vitis*
sandyi	*Apocynaceae*	*Catharanthus*, *Nerium*
	Bignoniaceae	*Jacaranda*
	Magnoliaceae	*Magnolia*
	Moraceae	*Morus*
	Xanthorrhoeaceae	*Hemerocallis*
NA	*Adoxaceae*	*Sambucus*
	Altingiaceae	*Liquidambar*
	Amaranthaceae	*Salsola*
	Anacardiaceae	*Pistachia*, *Schinus*
	Apocynaceae	*Catharanthus*, *Nerium*
	Aquifoliaceae	*Ilex*
	Araliaceae	*Hedera*
	Arecaceae	*Phoenix*
	Asteraceae	*Ambrosia*, *Baccharis*, *Conyza*, *Lactuca*, *Ratibida*, *Senecio*, *Silybum*, *Sonchus*, *Xanthium*
	Bignoniaceae	*Chitalpa*
	Brassicaceae	*Brassica*, *Capsella*, *Coronopus*
	Caprifoliaceae	*Lonicera*
	Caryophyllaceae	*Stellaria*
	Convolvulaceae	*Convolvulus*
	Cyperaceae	*Carex*, *Cyperus*
	Cypressaceae	*Juniperus*
	Fabaceae	*Albizia*, *Chamaecrista*, *Medicago*, *Spartium*
	Fagaceae	*Quercus*
	Geraniaceae	*Erodium*, *Geranium*

Subspecies	Plant family	Plant genus
	Ginkgoaceae	*Ginkgo*
	Juglandaceae	*Carya, Juglans*
	Lamiaceae	*Lavandula, Marrubium, Rosmarinus*
	Magnoliaceae	*Magnolia*
	Malvaceae	*Hibiscus, Malva*
	Moraceae	*Ficus, Morus*
	Oleaceae	*Chionanthus, Fraxinus, Olea*
	Onagraceae	*Ludwigia*
	Pinaceae	*Pinus*
	Plantaginaceae	*Plantago*
	Platanaceae	*Platanus*
	Poaceae	*Agrostis, Avena, Bromus, Cynodon, Echinochloa, Eriochloa, Hordeum, Lolium, Poa, Setaria*
	Polygonaceae	*Polygonum, Rumex*
	Portulaceae	*Portulaca*
	Ranunculaceae	*Ranunculus*
	Rosaceae	*Heteromeles, Prunus, Pyrus, Rubus*
	Rubiaceae	*Coffea*
	Rutaceae	*Citrus*
	Salicaceae	*Salix*
	Sapindaceae	*Acer*
	Solanaceae	*Datura, Solanum*
	Ulmaceae	*Ulmus*
	Verbenaceae	*Callicarpa, Lippia, Verbena*
	Vitaceae	*Ampelopsis, Vitis*

NA: Data not available regarding subspecies.

3.1.4. Vectors

X. fastidiosa is exclusively transmitted by xylem sap-feeding insects (order Hemiptera, sub-order Auchenorrhyncha: Redak et al., 2004). They have sucking mouthparts (mandibular and maxillary stylets) that allow them to reach the xylem of their host plants, from which they ingest sap. Owing to the very poor nutritional value of xylem fluid, xylem fluid feeders ingest large amounts of sap and produce large amounts of honeydew. They are generally not direct pests unless present at very high population levels. Within the Cicadomorpha, the three superfamilies, Cercopoidea, Cicadoidea and Membracoidea, include xylem fluid-feeding groups but, whereas all Cercopoidea (known as spittlebugs or froghoppers) and Cicadoidea (cicadas) are regarded as xylem fluid feeders, the superfamily Membracoidea includes a single xylem fluid-feeding subfamily, the Cicadellinae (known as sharpshooters). Only these three groups of 'specialists' in xylem fluid feeding have been shown to be vectors of *X. fastidiosa*. Some phloem sap feeders also feed marginally to the xylem, however tests for *X. fastidiosa* transmission capacity on one of these species were negative (Purcell, 1980). Spittlebugs, cicadas and sharpshooters are heterometabolous insects that develop through egg, five nymphal stages and adult (winged) stage. Nymphs of cicadas and of spittlebugs of the family Cercopidae are subterranean root feeders, whereas nymphs of spittlebugs of the family Aphrophoridae and of sharpshooters develop on the parts of host plants above the ground. All adults feed and live on the aerial parts of host plants (Ossiannilsson, 1981; Tremblay, 1995; Redak et al., 2004).

3.1.4.1. Identifying vectors

Although it is expected that all sharpshooter and spittlebug species are vectors of *X. fastidiosa* (Frazier, 1944; Purcell, 1989; Almeida et al., 2005), it is important to demonstrate that species not

formally identified as vectors can transmit the bacterium from plant to plant. In addition to identifying new vector species, studies should go further and provide information on the efficiency of the transmission process, so that the epidemiological relevance of newly identified species can be better put in context. This is important because, as previously demonstrated (Lopes et al., 2010; Daugherty et al. 2011), vector species may have very different transmission efficiencies depending on host plant species, or even by feeding on different tissues of the same host plant. Lastly, it is imperative to understand that detection of a pathogen within a putative vector is by no means evidence that a species is a vector; plant-to-plant transmission experiments are the only way to prove that a species is a vector.

Furthermore, a positive transmission to a given test plant does not necessarily imply that the vector can transmit the pathogen to other plants known to be host.

The procedures described below should be considered as general guidelines for the identification of new *X. fastidiosa* vectors in Europe.

Vector status of field-collected insects

At minimum, the identification of new vector species involves the confinement of field-collected insects on uninfected plants for an inoculation access period of 96 hours. After the inoculation access period (IAP), plants should be sprayed with appropriate pesticides and maintained in an insect-free greenhouse for later detection of the bacterium. This test determines only whether or not an insect is already contaminated by the bacteria and is able to transmit to a given plant species. Negative results do not imply that the species is not a vector.

Systematic testing to determine vector status

Insects from a healthy colony should be confined to *X. fastidiosa* -infected plants (or plant tissue) for an acquisition access period (AAP) of 96 hours and subsequently transferred to uninfected plants for a 96-hour IAP. In this way, source plants suitable for *X. fastidiosa* acquisition by a given potential vector are identified. Vector status may be investigated with any host plant species. However, bacterial isolates present in each region should be used for this work, i.e. genetic resolution to at least the subspecies level.

After the identification of a new insect species as a vector of *X. fastidiosa*, it is highly desirable to obtain additional information about its efficiency as a vector. This would include studies aimed at determining transmission efficiency, which must take into consideration the number of insects per plant and the amount of time insects spent on plants; multiple time points are necessarily to allow regression analysis. Importantly, transmission efficiency is a parameter that is highly dependent on insect–plant–pathogen interactions. Therefore, for example, a species very efficient in transmitting a genotype of *X. fastidiosa* from grapevine to grapevine may be very inefficient in transmitting the same genotype from alfalfa to alfalfa, or vice versa (Daugherty et al., 2011).

3.1.4.2. Non-European vectors of *X. fastidiosa*

Because *X. fastidiosa* has been found and studied primarily in the Americas, and causes disease in different crops in the Nearctic and Neotropic regions, its vectors have been identified and studied in these biogeographical areas only. Almost all known vectors of *X. fastidiosa*, all of them sharpshooters (Cicadellinae) or spittlebugs (Cercopoidea), are listed by Redak et al. (2004).

Besides the above-mentioned insects, cicadas are also xylem fluid feeders, but their role in transmitting *X. fastidiosa* is still largely hypothetical. There are only two reports of the possible role of cicadas (e.g. *Diceroprocta apache* Davis) in *X. fastidiosa* transmission (Paiaõ et al., 2002; Krell et al., 2007), providing very limited data, which makes the uncertainty very high.

Table 3 list the known vectors in the Americas. The geographical distribution, host plants and feeding preference of the American vector species, and their relative role in *X. fastidiosa* transmission, are well

documented (Redak et al., 2004). Most of the vector species spread in subtropical and tropical ecosystems and therefore develop and breed throughout the year. However, some North American sharpshooter species, e.g. *Draeculacephala minerva*, *Graphocephala atropunctata*, *Xyphon fulgida* and *Homalodisca vitripennis*, are known to overwinter as adult (http://www.cnr.berkeley.edu/xylella/insectVector/insectVector.html) and therefore *X. fastidiosa* can survive the winter in the vector, as well as in the infected plants.

The only *X. fastidiosa* vector species with a record of invasive potential is *H. vitripennis*. Originally from the south-west of the USA, *H. vitripennis* was first detected in southern California in the late 1980s, leading to an epidemic of Pierce's disease in the late 1990s and early 2000s (Hopkins and Purcell, 2002). Very large populations of *H. vitripennis* have been reported, up to two millions per hectare (Coviella et al., 2006). After its introduction into California, *H. vitripennis* also moved to the archipelagos of French Polynesia and Hawaii where it was reported to reach high populations (Grandgirard et al., 2006). In these two latter cases, it was suggested that the insect was introduced together with plant shipments. Biological control proved to be successful in controlling *H. vitripennis* in both French Polynesia and Hawaii (Grandgirard et al., 2008, 2009). It is not known why only *H. vitripennis*, among all the other vector species endemic to the Americas, is invasive. The widespread distribution of *H. vitripennis* in tropical regions as well as the US Gulf and south-west regions suggests that European regions with mild temperate climates, such as those in the Mediterranean, are at risk of colonisation by this insect, as previously suggested (Hoddle, 2004).

Table 3: Vectors of *X. fastidiosa* in the Americas: main insect groups and most important vector species

Insect group	Most important species	Distribution	Role as vector	Role as vector: criteria
Sharpshooters (Cicadellidae, Cicadellinae): 38 spp.	*Bucephalogonia xanthophis* (Berg)	Neotropical: Argentina, Bolivia, Brazil, Paraguay	High in citrus	Common, abundant on ornamental plants, citrus and nursery stocks
	Dilobopterus costalimai Young	Neotropical: Brazil	High in citrus	Common, abundant on ornamental plants and citrus
	Graphocephala atropunctata (Signoret)	USA and Central America	High in grapevine	Common in diverse ecosystems, on grapevine and ornamental plants
	Homalodisca vitripennis (Germar)	USA (southern states), Mexico (northern part), French Polynesia, Easter Island	High in grapevine	Common and abundant in diverse ecosystems, on grape, ornamentals, citrus and nursery stock
Spittlebugs (Cercopoidea): six species	*Philaenus spumarius* L.	USA Including Hawaii, Mexico, Tahiti	Low	Not associated with disease epidemics
Cicadas (Cicadoidea): two species	*Diceroprocta apache* Davis *Dorisiana viridis* (Olivier)	Mexico, Arizona, Utah, Nevada, California	Doubtful	Missing information on transmission capacity

3.1.4.3. Potential European vectors of *X. fastidiosa*

Following Frazier (1944) and Purcell (1989), all the xylem fluid feeders should be considered to be potential vectors. With the exception of *Philaenus spumarius* (Aphrophoridae), an Old World species introduced in North America and identified as a vector of *X. fastidiosa* in California (Purcell, 1980), all the American vector species are absent from Europe according to the Fauna Europaea database (de Jong, 2013). *X. fastidiosa* has never previously established in Europe and, in the case of the current

Apulian outbreak of *X. fastidiosa*, only one species, *P. spumarius*, has so far been proved to be able to transmit the strain of *X. fastidiosa* involved (Saponari et al., 2014). This species is the only vector identified so far in Europe.

Sharpshooters (Cicadellidae, subfamily Cicadellinae) are by far the most important vectors of *X. fastidiosa* in the Americas, but only a few species are present in Europe (Wilson et al., 2009). One species, *Cicadella viridis*, is widespread in Europe, but is common only in humid areas.

In contrast, a relatively high number of spittlebug species (Cercopoidea: Aphrophoridae and Cercopidae), which are less important vectors in America, occur in Europe and some, such as *Philaenus spumarius*, are very common, but are generally associated with herbaceous plants. Since, apart from *P. spumarius*, potential European native vectors have been very poorly studied so far (Lopes et al., 2014), their role in spreading *X. fastidiosa* is difficult to assess.

A list of potential vectors of *X. fastidiosa* in Europe, gathering all the sharpshooters and spittlebugs (Appendix C), was drawn from the Fauna Europaea database (de Jong, 2013). From this list, we selected the species with the highest potential for *X. fastidiosa* spread, based on three criteria: polyphagy, abundance and frequency in different environments (Figure 4).

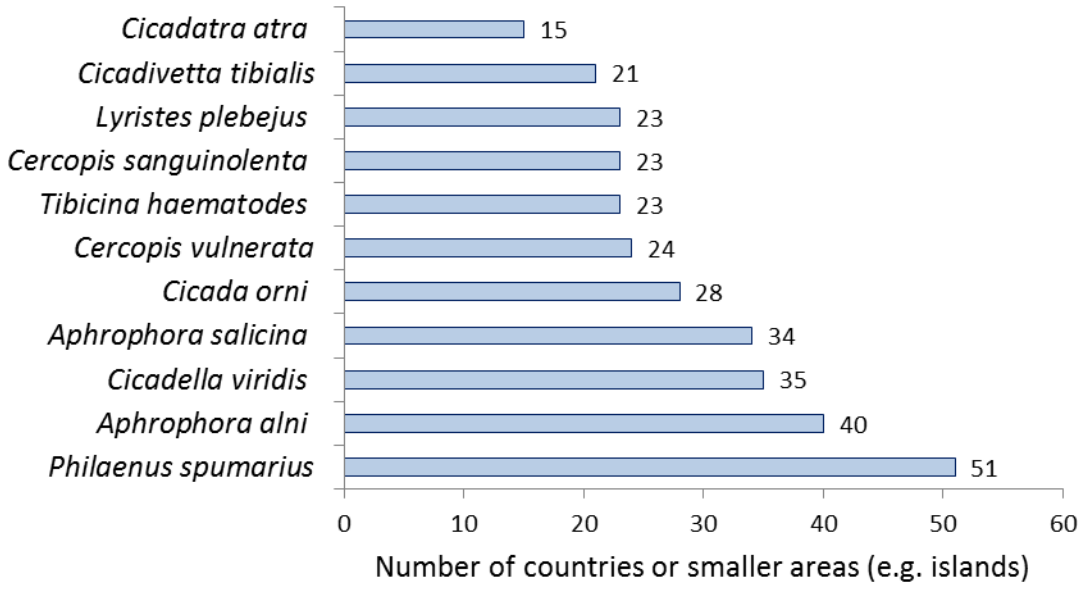


Figure 4: Reported presence of the most widespread species of xylem fluid feeders in Europe (from Fauna Europaea; de Jong, 2013)

As stated earlier, cicadas are xylem- fluid feeders and are also expected to be potential vectors, although their role in *X. fastidiosa* transmission is still unclear. In Italy, 18 species of cicadas are known, in the families Cicadidae and Tibicinidae, while 53 species are reported in Europe, most having a very restricted area of distribution (de Jong, 2013). Based on the two reports of cicadas as vectors of *X. fastidiosa* (Paiaõ et al., 2002; Krell et al., 2007), the Panel considers the potential role of cicadas as vectors of *X. fastidiosa* in Europe to be of high relevance (although the uncertainty is high), owing to the large populations of cicadas, particularly in southern EU regions, in addition to the wide host range of plant species utilised by these insects. An assessment of their potential ecological role as *X. fastidiosa* vectors, however, requires additional information.

Appendix C provides a list of cicadas potentially vectoring *X. fastidiosa* based on the Fauna Europaea database (de Jong, 2013). Table 4 and Figure 4 show the most important potential insect vector species in the EU and their distribution. It should be noted that, whereas the sharpshooters in America

overwinter as adult and when infected can maintain *X. fastidiosa* during winter, the European sharpshooters (Cicadellidae, Cicadellinae) and most of the European spittlebugs (Aphrophoridae, with the exception of a few Cercopidae) overwinter as egg (Nickel and Remane, 2002) and, therefore, if infected, cannot sustain overwintering of *X. fastidiosa*, since transovarial transmission of *X. fastidiosa* does not occur (Freitag, 1951).

Table 4: Current and potential vector species of *X. fastidiosa* in Europe: main insect groups and most important potential vector species.

Insect group	Most common species	Distribution	Potential role as vector	Potential role as vector: criteria
Sharpshooters (Cicadellidae, Cicadellinae): seven species	*Cicadella viridis* (Linnaeus 1758)	All Europe	Moderate to high	Very common, wide host range but hygrophilous
Spittlebugs (Cercopoidea): 34 species	*Aphrophora alni* (Fallen 1805)	All Europe	Moderate to high	Common, wide host range
	Aphrophora salicina (Goeze 1778)	All Europe	Moderate	Common, oligophagous
	Philaenus spumarius (L.)	All Europe	High	Very common and abundant in diverse ecosystems Identified as a vector in Apulia (Saponari et al., 2014)
	Cercopis vulnerata Rossi 1807	Not present in northern Europe	Moderate	Many host plants but mainly associated with herbaceous plants
Cicadas (Cicadoidea): 54 species	*Cicada orni* Linnaeus	Not present in northern Europe	Doubtful	Missing information on transmission capacity
	Cicadatra atra (Olivier)	Balkans, Italy and France	Doubtful	Missing information on transmission capacity
	Lyristes plebejus (Scopoli)	Not present in northern Europe	Doubtful	Missing information on transmission capacity
	Cicadivetta tibialis (Panzer)	Not present in northern Europe	Doubtful	Missing information on transmission capacity
	Tibicina haematodes (Scopoli)	Not present in northern Europe	Doubtful	Missing information on transmission capacity

3.1.4.4. Conclusions on vectors

All xylem fluid-feeding insects in Europe should be regarded as potential vectors, but some species are more likely candidate vectors, owing to their wide geographical distribution, abundance and host plant range. Members of the families Cicadellidae, Aphrophoridae and Cercopidaeare are vectors in the Americas and, hence, all members of these three families should be considered as potential vectors in Europe. With regards to the reports previously mentioned (Paiaõ et al., 2002; Krell et al., 2007), the Cicadidae and Tibicinidae should also be considered potential vectors. *P. spumarius* has been shown to transmit the local strain of *X. fastidiosa* to an indicator plant, *Catharanthus roseus* (Saponari et al., 2014). A preliminary report indicates that *P. spumarius* also transmits the local strain of *X. fastidiosa* to olive (Cornara and Porcelli, 2014; Martelli, 2014).

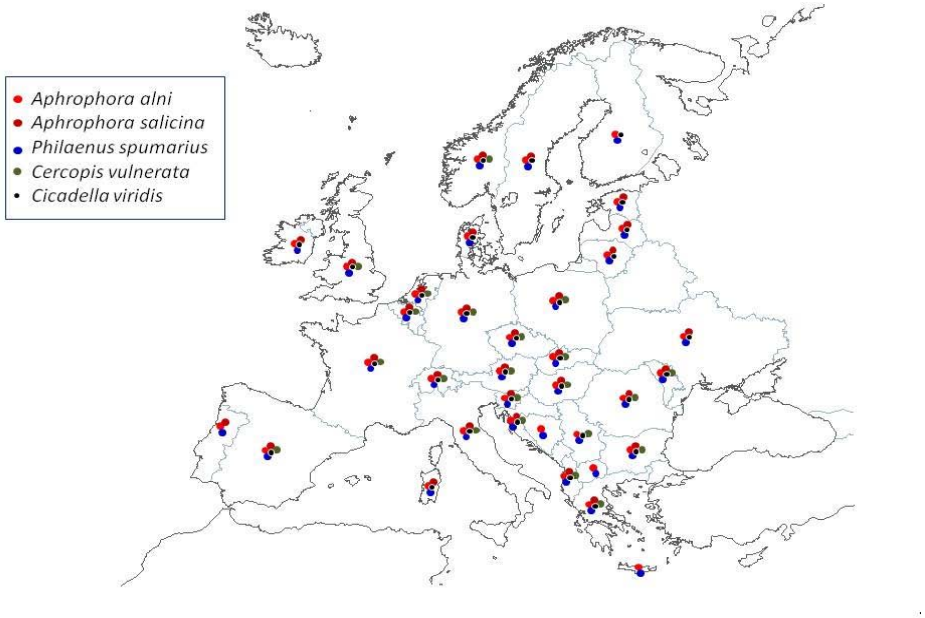


Figure 5: Reported presence in Europe of the most important potential vector species of *X. fastidiosa* (data from http://www.faunaeur.org; de Jong, 2013)

3.1.5. EPPO recommendations on regulation of *X. fastidiosa* and its vectors

Xylella fastidiosa is included in the EPPO A1 list (pests not present in the area) of pests recommended for regulation as quarantine pests. Among potential insect vectors, only *Homalodisca vitripennis*, *Xyphon fulgida* (syn = *Carneocephala fulgida*), *Draeculacephala Minerva* and *Graphocephala atropunctata* are also listed in that A1 list.

3.1.6. Regulatory status in the EU

3.1.6.1. Prevention of introduction of *Xylella fastidiosa* into the EU

X. fastidiosa is included in Annex I, Part A, Section I, of the Council Directive 2000/29/EC as a "harmful organism not known to occur in any part of the community and relevant for the entire community, whose introduction into, and spread within, all Member States shall be banned".

As other diseases thought to be caused by other pathogenic agents at the time Directive 2000/29/EC was written are now attributed to *X. fastidiosa*, *X. fastidiosa* is implied though not explicitly mentioned at several places throughout the Directive:

- causative agent of peach phony rickettsia, in Annex I, Part A, Section 1;
- causative agent of Citrus variegated chlorosis, in Annex II, Part A, section I, of Council Directive 2000/29/EC, "harmful organism whose introduction into, and spread within, all Member States shall be banned if it is present on plants of *Citrus* L., *Fortunella* Swingle, *Poncirus* Raf., and their hybrids, other than fruit and seeds".

Apart from measures targeting directly *X. fastidiosa*, some other measures already in place may mitigate the risks of its introduction:

- Members of the family Cicadellidae (non-European) known to be insect vectors of *X. fastidiosa* are included in Annex I, Part A, Section I, of EU directive 2000/29/CE.

Therefore, insects such as *Xyphonfulgida* (named in the Council Directive as *Carneocephala fulgida*, *Draeculacephala minerva* and *Graphocephala atropunctata* are banned. A full list of non-European insect vectors of *X. fastidiosa* is available in Appendix D of this opinion.

All known vector insects may act as a pathway for the introduction of the bacterium as well as invasive species that may help disseminating the disease.

The introduction into the EU of some known host plants is prohibited (*Citrus*, *Fortunella*, *Poncirus*, and their hybrids, other than fruit and seeds, *Vitis* other than plants originating in third countries (see Annex III, Part A, of Directive 2000/29/CE) and *Prunus*, originating from non-European countries), with the exception of dormant *Prunus* plants (free from leaves, flowers and fruit) from Mediterranean countries, Australia, New Zealand, Canada and the continental states of the USA (see Annex III, part A, of Directive 2000/29/CE).

3.1.6.2. Prevention of spread within and between Member States

As *X. fastidiosa* and its non-European vectors are listed as "not known to occur in the EU", there are no specific requirement in Directive 2000/29/EC for the internal movement of plants and plant products to prevent spread of this pest and its vectors. Nevertheless, for other phytosanitary reasons, some plants and plant products are listed in Annex V, Part A, section I, of Council Directive 2000/29/EC and therefore should be accompanied by a plant passport. A plant passport testifies that the plants or plant material to which it relates is in conformity with the EU regulation.

Council Directive 2000/29/EC makes possible the exemption from official registration for small producers whose entire production and sale of relevant plants are intended for final use by persons on the local market and who are not professionally involved in plant production. Such producers may therefore be exempted from official inspections and plant passport requirements.

As laid down in Article 16 of Commission Directive 2000/29/EC, Member States shall immediately notify the Commission and the other Member States of the presence, actual or suspected, in their territory of any of the harmful organisms listed in Annex I. Member States shall take all necessary measures to eradicate or, if that is impossible, to inhibit the spread of the harmful organisms concerned. Member States shall inform the Commission and the other Member States of the measures taken.

The recent discovery of outbreaks of *X. fastidiosa* in southern Italy does not immediately imply that the organism should be considered as present in the EU and that Council Directive 2000/29/EC should be modified accordingly. However, measures should be taken by Member States to avoid the spread within the EU of the pathogenic agent.

3.1.6.3. Emergency measures taken by the European Union

On 21 October 2013, Italy informed the other EU Member States and the Commission of the presence of *X. fastidiosa* in its territory, in two separate areas of the province of Lecce, in the Apulia region. Subsequently, two further separate outbreaks have been identified in the same province. The presence of the bacterium was confirmed as infecting several plant species, including *Olea europaea* (showing leaf scorching and rapid decline symptoms), *Prunus amygdalus*, *Nerium oleander* and other ornamentals (for details see section 3.1.9). This was the first time the presence of *X. fastidiosa* in the territory of the EU was confirmed in the field. The susceptibility of several other plant species to the bacterial strain present in south Italy is still under evaluation. It should be noted that Koch's postulates have not yet been fulfilled for any of these host plant species, but olive to olive transmission of *X. fastidiosa* by the vector *P. spumarius* seems to be demonstrated (Cornara and Porcelli, 2014; Martelli, 2014).

Following the information on this outbreak, the European Commission took a first emergency measure, Commission Implementing Decision 2014/87/EU[7], on 13 February 2014, which was replaced by Decision 2014 497/EU on 23 July 2014 on additional and emergency measures to be implemented within the EU in order to prevent the introduction into and the spread within the EU of *X. fastidiosa.* Here only the Commission implementing decision of 23 July 2014 is presented.

These emergency measures consist basically in:

- the establishment of special requirements for the introduction into the EU of plants for planting, other than seeds, of certain plant species;
- the establishment of special requirements for movement within the EU of plants for planting, other than seeds, of certain plant species grown in a demarcated area/infected zone;
- the conduct of surveys for the presence of *X. fastidiosa* in all Member States on plants for planting, other than seeds, of certain plant species and on other possible host plants;
- the need for immediate report of suspect cases of *X. fastidiosa* to the competent authority;
- a procedure for confirmation and notification of presence of *X. fastidiosa* ;
- the establishment of demarcated areas and buffer zones;
- reporting on measures.

These risk reduction options will be analysed later in this opinion (see section 4).

3.1.7. Potential for establishment and spread in the risk assessment area

As host plants and suitable habitats exist in the risk assessment area, and as vectors are known to occur, there is a potential for establishment and spread of *Xylella fastidiosa.* The outbreak occurring in southern Italy shows that the pathogen, once entered, can establish and spread.

Many host plant species do occur spontaneously or are cultivated all over the risk assessment area, with many hosts of economic importance, such as grapevine, citrus, almond, plum and peach and trees such as elm, oak, or sycamore. There is uncertainty with regard to the potential host range of *X. fastidiosa* in the European flora as a range of European wild plant species have never met the bacterium and it is not known whether they would be hosts, symptomatic or asymptomatic (EFSA, 2013a). For example, native wild plums (*Prunus angustifolia*) are considered as important reservoirs for the spread of the phony peach disease (French, 1976). It is not known if wild European species like *P. spinosa* could play such a similar role.

The environmental conditions found in the risk assessment area are suitable for survival, multiplication and spread of both *X. fastidiosa* and its vectors. Tropical, subtropical and Mediterranean climates appear to be particularly favourable for *X. fastidiosa* persistence and disease outbreaks (Purcell, 1997), although *X. fastidiosa* is also encountered in cooler climates, as shown by reports in Canada and New Jersey. Using the CLIMEX program, Hoddle (2004) proposed a map showing the potential worldwide range of *X. fastidiosa* subsp. *fastidiosa* and one of its vectors, *Homalodisca vitripennis*. Minimal winter temperature has been used to delineate areas where the Pierce's disease of grapevine or phony peach disease occurred in the USA. A cold temperature exclusion model using the thresholds –12 °C and –9.4 °C for two and four days respectively was proposed by Engle and Margarey (2008).

[7] Commission Implementing Decision of 13 February 2014 as regards measures to prevent the spread within the Union of *Xylella fastidiosa* (Well and Raju).

The only route for natural spread of *X. fastidiosa* is by insect vectors that generally fly short distances, but can be transported by wind over longer distances. All xylem sap feeder insects should be regarded as potential vectors, including insects from the families Cicadellidae, Aphrophoridae, Cercopidae, Cicadidae and Tibicinidae. Several of these insect species are present and widely distributed within the risk assessment area (Table 5 and Figure 5), although their ecological relevance for an effective contribution to *X. fastidiosa* spread is difficult to assess. The movement of infected plants for planting is a very effective way for long-distance dispersal of *X. fastidiosa* and would also contribute to the spread of *X. fastidiosa*.

Besides natural spread routes, human-assisted movement (vectors on infested plants or on their own in vehicles) is a major potential contributor to the movement of the disease despite limited information reported on the topic. The introduction of the efficient vector *Homalodisca vitripennis* in California, French Polynesia, Hawaii and Easter Island is thought to have occurred through such means (Petit et al., 2008).

3.1.8. Potential for consequences in the risk assessment area

In countries where it occurs, *X. fastidiosa* is known to cause severe direct damage to important crops such as grapevine, citrus and stone fruits and also to forest trees and landscape and ornamental trees. It also causes indirect economic damage in areas producing plants for planting material, as exports from areas where the disease is known to occur may be forbidden.

A thorough review of the literature yielded no indication that eradication is a successful option once the disease is established in an area. Past attempts, in California, Taiwan and Brazil, proved unsuccessful (Lopes et al., 2000; Purcell, 2013; Su et al., 2013), probably because of the broad host range of the pathogen and its vectors. It is difficult to estimate the potential consequences for the risk assessment area because the agro-ecological conditions in the risk assessment area are different from those in areas where *X. fastidiosa* epidemics have been reported, and those differences, which affect the vectors involved in transmission, clearly impact disease spread. Nevertheless, there is a clear record of the impact of *X. fastidiosa* in countries where the pest is reported. Concerning potential consequences, the only report close to the risk assessment area is the identification of *X. fastidiosa* from a grapevine area in Kosovo, where about 30 % losses were reported, although it is difficult to establish clearly a role for *X. fastidiosa* (Berisha et al., 1998).

Historically, in California, Pierce's disease caused by *X. fastidiosa* was responsible for an outbreak in the 1880s with the destruction of more than 16 000 ha of grapes (Goodwin and Purcell, 1997). Major outbreaks were also reported in the 1930s and 1940s. In 1999, the disease re-emerged owing to the introduction of the glassy winged sharpshooter, *H. vitripennis*, and affected 25 % of the 1 200 ha of vineyards in Riverside County (Temecula Valley, California).

In Georgia, phony peach disease is the major factor limiting peach production. Known to occur since 1890, possibly introduced in southern USA, it spread from Georgia in 1928 to 10 different states in 1933 (Hutchins, 1933; Purcell, 2014).

Initially, citrus variegated chlorosis was found on a few orange trees in Brazil. Five years later, more than 2 million trees were affected. Today, citrus variegated chlorosis is endemic throughout the citrus regions of São Paulo state, as well as all other Brazilian states where sweet orange is planted over large areas. According to recent surveys of disease incidence, approximately 40 % of the 200 million sweet orange plants in São Paulo show symptoms of citrus variegated chlorosis (Almeida et al., 2014). Within affected fields, the incidence of citrus variegated chlorosis can increase from a single infected tree to 90 % within eight years (Gottwald et al., 1993).

Ornamental plants are also affected. Oleander is planted along the sides of roads and in private gardens: losses on Californian highways alone have been estimated to amount to US$125 million (Henry et al., 1997). In New Jersey, bacterial leaf scorch was estimated to affect 35 % of the street and

landscape oaks, with both aesthetic and economic consequences (Gould et al., 2004). Although reported more frequently since 1980, the impact of *X. fastidiosa* in forest is more difficult to assess owing to a general lack of data (Sinclair and Lyon, 2005).

These different examples highlight the impact of *X. fastidiosa* and its potential economical consequences.

3.1.9. Current situation in Italy (Apulian situation)

In 2013, the occurrence of *X. fastidiosa* was reported in southern Italy (near Lecce, in the Salento peninsula, Apulia region), associated with quick decline symptoms on olive trees (*Olea europea*), oleander and almond (Saponari et al., 2013). *X. fastidiosa* was found initially in the area of Gallipoli (around 8 000 ha of olive trees, with a significant part severely affected) and it was subsequently found in many other sites, first to the north and later also to the east of the initially reported outbreak areas. Recently, the Italian Ministry of Agriculture Policies declared infected almost the whole province of Lecce, considering it as a unique, very large, outbreak (Italian Ministerial Decree, 2014). A map showing the locations of the samples found positive for *X. fastidiosa* for the monitoring periods October 2013-March 2014 and June-October 2014 is presented in Figure 6.

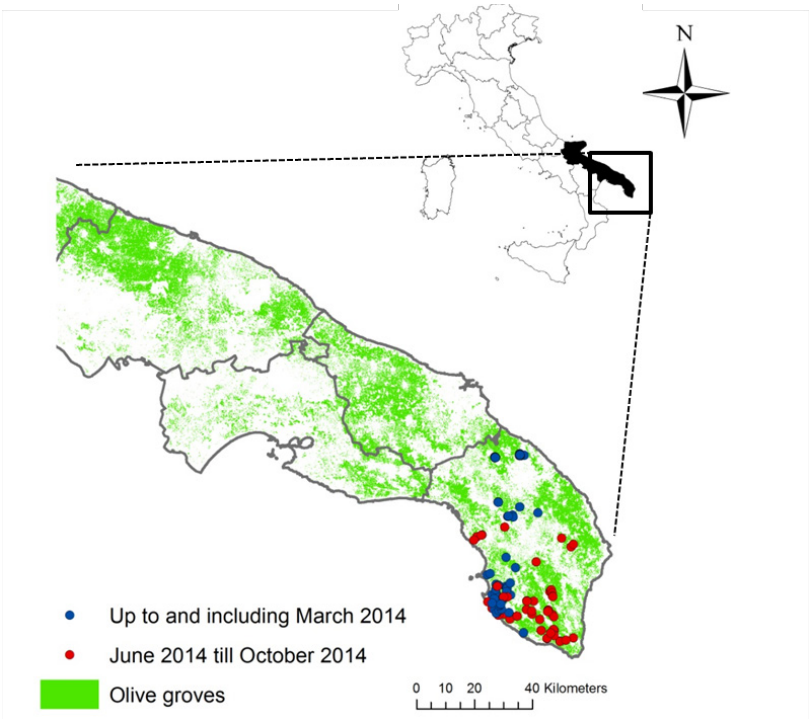


Figure 6: Locations of samples positive for *X. fastidiosa* in Apulia, Italy. Green dots indicate olive groves based on Regione Puglia land use map; blue dots indicate samples positive for *X. fastidiosa* taken from October 2013 to March 2014; red dots indicate samples positive for *X. fastidiosa* taken from June 2014 to October 2014. No positive samples were recorded in April-May 2014. Data provided by T. Caroppo, Innova Puglia, 10/12/2014. Map prepared by S. White and D. Hooftman, Center for Ecology and Hydrology, UK

X. fastidiosa has been associated with the quick decline syndrome of olive (Martelli, 2014). Investigations showed that symptomatic olive trees were generally affected by a complex of pests and pathogens including *X. fastidiosa*, several fungal species belonging to the genera *Phaeoacremonium* and *Phaemoniella*, and *Zeuzera pyrina* (leopard moth) (Nigro et al., 2013; Saponari et al., 2013). Although the specific role of *X. fastidiosa* in the syndrome remains to be understood, and Koch's postulates are yet to be completely fulfilled, preliminary observations show that *X. fastidiosa* is also found in younger olive plants in the absence of the other organisms (Martelli, 2014). Reports on the

association of *X. fastidiosa* with similar olive disease have been also recently published from Argentina (http://www.agromeat.com, online reference, 2014).

X. fastidiosa has been identified from olive plants based on PCR detection, ELISA, indirect immunofluorescence, electron microscopy and immunogold labelling (Cariddi et al., 2014), as well as by laboratory culture. The genotype of the strain of *X. fastidiosa* present in Italy is considered to be a new genetic variant within the subspecies *pauca* (Maria Saponari and Donato Boscia, CNR, Institute for Sustainable Plant Protection, personal communication, September 2014; Cariddi et al., 2014). It has been shown that the strain present in Italy is very homogeneous, and identical to a variant infecting oleander in Costa Rica. This also represents the first report of subspecies *pauca* in Costa Rica (Nunney et al., 2014). It was assigned a new sequence type (ST) profile, ST 53, and named CoDiRO for "Complesso del Disseccamento Rapido dell' Olivo". Concatenated sequences of the seven MLST genes (Figure 7) showed that the CoDiRO strain is a "divergent" variant within the subspecies *pauca*. Because this specific genotype has not been biologically fully characterised, it is not yet possible to infer its host range.

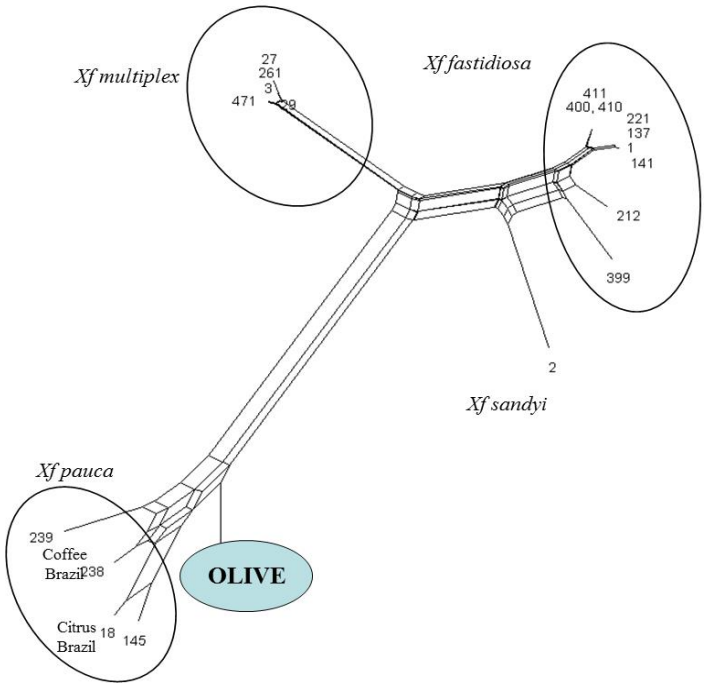


Figure 7: Phylogenetic tree of the Apulian isolate of *X. fastidiosa* derived from multilocus sequence typing (MLST) based on the concatenated sequences of seven genes. The Italian CoDiRO strain is indicated by the green circle (olive) (Courtesy of Maria Saponari, CNR, Bari, Italy)

3.1.9.1. Current distribution in Apulia

During the spring–summer period of 2014, further major spread was registered, with several tens of new outbreaks detected, mainly on the Ionian Sea coast of the central/southern part of the province (counties of Gagliano, Morciano, Salve, Presicce, Ugento, Alliste, Taurisano, Ruffano, Specchia, Casarano), but also, to some extent, on the Adriatic Sea coast (Bagnolo, Cursi, Palmariggi) and on the central-northern part of the province (Nardò, Lequile). Despite its rapid spread in the southern and central parts of the province, the disease seems not to be expanding quickly in the northern part of the province (Lecce-Surbo, Trepuzzi), and at the moment there is no evidence of foci beyond the provincial border. Official monitoring is now focusing on this border, with the aim of delineating a buffer zone.

3.1.9.2. Host plants

From the discovery of the bacterium in Apulia in October 2013 until June 2014, up to 17 440 samples have been analysed (12 605 olive samples, 174 grapevine (+ 1 758 nursery samples), 200 citrus samples, 458 samples in the Araceae, Pinales, Cactaceae and 2 245 additional samples taken from other botanical plant species) (Faraglia et al., 2014).

Figure 2 shows the symptoms of plants testing positive for the presence of *X. fastidiosa* by PCR, ELISA and culturing, such as olive, almond, cherry (*Prunus avium*) and oleander, as well as coastal rosemary (*Westringia fructicosa*), myrtle-leaf milkwort (*Polygala myrtifolia*), *Spartium junceum* and *Acacia saligna*, which also tested positive for the presence of *X. fastidiosa* by PCR and ELISA (Saponari et al., 2014). Initially, *Sorghum*, *Malva*, *Quercus* were also proposed as potential hosts but these findings could not yet be confirmed (Maria Saponari and Donato Boscia, CNR, Institute for Sustainable Plant Protection, personal communication, September 2014) and therefore the host status of these species is still uncertain. EFSA has requested further work on the host range in order to reduce uncertainties as plants may be infected without showing any symptoms. Symptomatic plants may also test negative when analysed.

The bacterium was isolated on periwinkle wilt gelrite and buffered cysteine–yeast extract media, from symptomatic natural infected oleander and periwinkle infected by *X. fastidiosa*-positive spittlebugs. Later on, it was isolated from olive, *Olea oleaster*, almond, cherry, *Polygala myrtifolia*, *Westringia fruticosa* (Maria Saponari and Donato Boscia, CNR, Institute for Sustainable Plant Protection, personal communication, October 2014).

In olive trees, symptoms are found on all known varieties. Old varieties, such as Ogliarola Salentina, Cellina di Nardò and the common varieties Frantoio and Coratina, appear quite susceptible while the variety Leccino seems less susceptible, although there is much uncertainty about such indications because such records are based on field observations and still have to be fully demonstrated. Such observations might also be the result of different disease vector pressures in the areas where the disease is present.

Although the disease was more frequently found in old trees, presumably because of the severity of symptoms, it has also been observed on young plants (Cariddi et al., 2013). This became more evident during the spring and summer of 2014 (Donato Boscia, CNR, Institute for Sustainable Plant Protection, personal communication, September 2014). First leaf scorch or, more often, desiccation symptoms generally appear on one or two branches, and then appear randomly on the rest of the canopy. It is thought that the dieback symptoms take several years to extend to the whole plant. Experiments by grafting demonstrate that it takes at least seven months for leaf scorch symptoms to appear on the grafted plant part On cherry, it has been observed that early symptoms (May–June) are not typical leaf scorch, but these non-specific symptoms are later followed by clear leaf scorch symptoms (August) (for symptoms see Figure 2).

To date, the bacterium has not been detected in *Vitis* spp., *Citrus* spp., *Pistacia lentiscus*, *Pittosporum* spp., *Calendula arvensis*, *Papaver rhoens*, *Senecio vulgaris*, *Cynodon dactylon*, *Merculliaris annua*, *Clematis vitalba*, *Sonchus oleraceus*, *Stellaria media*, *Daucus carota*, *Capsella bursa pastoris*, *Urtica dioica*, *Oxalis pes-caprea*, *Fumaria officinalis*, *Trifolium* spp., *Geranium pusillum*, *Smilax aspera* and *Myrtus communis*. Moreover, a monthly survey of weeds (over 100 species) growing in highly contaminated areas from December 2013 to September 2014 did not identify positive samples.

A project funded by EFSA is currently being conducted by the CNR, National Research Council, in Apulia to perform a preliminary assessment of the susceptibility of some European crops to the Apulian isolate of *X. fastidiosa*. This project is expected to deliver its final report by end 2015.

3.1.9.3. *X. fastidiosa* Italian situation—vectors

Since the discovery of the *X. fastidiosa* -associated epidemics in olive groves in 2013, field surveys and transmission experiments have been carried out by the scientists of the IPSP-CNR and of the University of Bari to identify the vector(s) and to describe the epidemiology of CoDiRO disease.

Field surveys have been carried out throughout the year, mainly by sweep nets, in the infested areas, both on olive trees and on grasses. Collected insects were further identified and tested in the laboratory for the presence of *X. fastidiosa* by PCR. These investigations failed to find sharpshooters, which are by far the most important vectors in the Americas. In contrast, spittlebugs, a group of xylem sap feeders known to transmit *X. fastidiosa* but of negligible importance in the Americas, were very common and locally abundant. In particular, the species *Philaenus spumarius* (Hemiptera, Aphrophoridae) was the dominant species and, contradicting data from the literature, adults were present throughout the year, including during winter months, when the species is thought to overwinter in the egg stage. It is not possible yet to conclude if the insect in the area is bivoltine rather than univoltine (as reported in the literature) or if adults are very long-lived because of the mild winter conditions of the Salento area.

P. spumarius nymphs were found on herbaceous hosts in spring (normally nymphs are not observed on olive trees, with very rare exceptions). Feeding preferences of *P. spumarius* adults and different levels of contamination by *X. fastidiosa* varied according to the season of collection. In wintertime and early spring adults were collected on grasses only. From May onwards adults were collected more and more frequently on olive trees (as the grasses started to undergo water stress and drying), and in the summer months *P. spumarius* was common and abundant on olive trees. By the autumn more adults were found again on the grass cover. *P. spumarius* samples collected in wintertime and early spring (March and April) never tested positive for *X. fastidiosa* in PCR assays, whereas in May very few insects tested positive, while in June and July many more samples tested positive. Data from August 2014 collections are currently under analysis. As for the transmission experiments, adults of *P. spumarius* collected in heavily infected olive orchards in 2013 and caged on periwinkle plants proved to be able to transmit *X. fastidiosa* (Saponari et al., 2014).

In 2014, the transmission ability (to periwinkle) of this spittlebug was confirmed with insects collected in the field in the summer months (Saponari et al., 2014a). Spittlebugs were also captured from young, potted olive, grapevine, citrus and oleander plants. These plants are currently under observation for symptom development and molecular analysis and data are not yet available. Survival of the insects was good on all the test plants except oleander. In controlled acquisition experiments on field-infected olive trees (insects were captured on symptomatic branches) *P. spumarius* adults proved to be able to acquire *X. fastidiosa* from olive, but the subsequent experiments regarding transmission to olive are still ongoing (IPSP-CNR and University of Bari, unpublished). *Neophilaenus campestris* (Hemiptera, Aphrophoridae) seems to be less common but, in a recent survey carried out in the olive orchards of Salento (Elbeaino et al., 2014), a high proportion of adults of this species were infected. In contrast, *Cercopis sanguinolenta* (Hemiptera, Cercopidae) was relatively common on weeds but was not found on olives and did not test positive for *X. fastidiosa* in PCR assays. As for the cicadas, the species *Cicada orni* (Hemiptera, Cicadidae) was found on olive trees, but the analysed samples tested negative for *X. fastidiosa.* Adults of this species were also caged on olive for a controlled acquisition/transmission experiment but they all died while caged on olive. Samples from this experiment were then analysed by PCR for *X. fastidiosa*, and a few of them tested positive. Among phloem feeding leafhoppers, adults of the species *Euscelis lineolatus,* captured from October to December 2013 in heavily infected olive orchards, tested positive for *X. fastidiosa* (Elbeaino et al., 2014).

3.1.10. Conclusion on the pest categorisation

X. fastidiosa presents a risk to the EU territory because it has the potential to cause diseases in the risk assessment area once it establishes, as hosts are present and the environmental conditions are

favourable. *X. fastidiosa* may affect several crops in Europe, such as citrus, grapevine and stone fruits (almond, peach, plum), but also several tree species and ornamental plants, such as oak, sycamore and oleander. *X. fastidiosa* has a very broad host range, including many cultivated and spontaneous plants common in Europe. There is some host differentiation among the generally accepted four subspecies of *X. fastidiosa* with regard to symptomatic hosts, but many plants could be infected and remain asymptomatic. There is, however, high uncertainty with regard to the potential host range of *X. fastidiosa* in the European flora as a range of European wild plant species have never met the bacterium and it is not known if they would be hosts, and symptomatic or asymptomatic. In addition, there is limited published information on the biology of *X. fastidiosa* subspecies that have been recently described. The biology of these subspecies is not yet fully understood. The impact of *X. fastidiosa* in forest is more difficult to assess owing to a general lack of data.

All xylem fluid-feeding insects in Europe are considered to be potential vectors. Members of the families Cicadellidae, Aphrophoridae and Cercopidae are vectors in the Americas and, hence, should also be considered as potential vectors in Europe. The Cicadidae and Tibicinidae should also be considered to be potential vectors. However, there are uncertainties with regards to their potential contribution to an epidemic in Europe.

The environmental conditions required for establishment are met in many places, as demonstrated by the detection of *X. fastidiosa* in Apulia, Italy. There is a potential for consequences in the EU territory, as shown by the impact on olive in Apulia and as illustrated by the impact of Pierce's disease in California and citrus variegated chlorosis in Brazil.

X. fastidiosa is present in Europe with a distribution restricted to part of the Lecce province in the Italian region of Apulia and is under official control.

3.2. Probability of entry

In this section, the identification of entry pathways and the assessment of the probability of entry of *X. fastidiosa* are provided. The overall probability of entry has been assessed by the Panel, combining for each pathway the ratings of the various steps, with the rule that, within each pathway, the overall assessment rating should not be higher than the lowest probability.

3.2.1. Identification of pathways

Recent interceptions of plants for planting and outbreaks of *X. fastidiosa* (see sections 3.1.2 and 3.1.9) show that this pathogen can enter the EU. Several trade pathways can be identified for the entry, as well as for the spread, of *X. fastidiosa.*

3.2.1.1. List of pathways

The Panel identified the following pathways for entry of *X. fastidiosa* into the EU.

1. Plants for planting infected with *X. fastidiosa*

Entry of the pathogen into EU territory by the movement of plants for planting is considered to be the most important pathway, since *X. fastidiosa* has approximately 300 reported host plant species (see Table 2 and Appendix B) and many of them are imported into Europe as planting material. For example, partial records from NPPO inspection points in seven EU Member States between 2000 and 2007 include more than 150 million individual plants belonging to genera listed as host plants for *X. fastidiosa* and imported from countries where *X. fastidiosa* is known to occur (ISEFOR, 2014). Therefore, with planting material, there is often a high risk of introduction of the pathogen, especially with asymptomatic plants, which should not be underestimated. Exotic insect vectors can also be associated with the plants for planting pathway. According to Grandgirard et al. (2006), *Homalodisca vitripennis* probably arrived in French Polynesia with imported ornamental plants bearing egg masses, which are relatively resistant to insecticides.

2. Plants or plant material imported for research or breeding purposes

Plants or plant materials that are intended to be imported for research or breeding purposes should comply with EU Directive 2000/29/EC. Nevertheless, and providing that special measures are applied, it is also possible to import plants or plant material for such purposes under derogation, when conditions laid down in EU Directive 2000/29/EC are not fulfilled. These special conditions are given in EU Directive 2008/61/EC and are intended to avoid any phytosanitary risks.

Owing to the variety of plant species, plant material or related items that can be introduced for such purposes, the diversity of geographic origins, the limited amounts of plant material that are generally introduced (that not always make sampling possible) and the means of import commonly used, it is difficult to systematically control this pathway.

Although the volume of exchanges is limited and linked to a derogation system, the diversity of plant material from a geographically large area imported increases the risk of introductions. When dealing with host plants currently regulated, such as citrus and grapevine, the probability of entry, establishment and dissemination from such a pathway is considered very unlikely, as imported quantities of plant are limited, breeding and research material is usually used under confined conditions with detection and control measures, and the plant material is often destroyed after experimentation.

The recent introduction of *X. fastidiosa* in France on coffee plants imported for breeding purposes illustrates the possibility of introduction through such a pathway, when currently plants for planting (e.g. coffee plants) are imported that are not subjected to testing. The pathway is then considered as similar to the plants for planting pathway. The uncertainty is considered to be high as the rate of unofficial introduction is largely unknown and is difficult to monitor.

3. Seeds

Li et al. (2003) demonstrated the presence of *X. fastidiosa* in seeds of sweet orange (*Citrus sinensis*) and suggested that seedlings from those seeds are symptomatic after germination. However, the experiment was not replicated. More recently, Coletta-Filho et al. (2014) performed a larger multi-year experiment that concluded that sweet orange seeds from infected plants do not lead to *X. fastidiosa* transmission to seedlings. Other recent papers have confirmed the lack of seed transmission (Cordeiro et al., 2014; Hartung et al., 2014).

The uncertainty related to seed transmission is considered high as the four published studies concerned only one host species out of the wide host range of the bacterium. The level of infection is expected to be variable and dependent on disease incidence in plants and the probability of the pathogen colonising seeds (Coletta-Filho et al., 2014). The pathway is therefore considered as unlikely, with high uncertainty linked to the lack of extensive studies.

4. Fruits

Citrus fruit was considered by ANSES (2012) as an entry pathway but no details were provided. Li et al. (2003) detected *X. fastidiosa* by PCR in fruit, as well as in germinated seedlings, derived from seeds from sweet orange (*Citrus sinensis*) plants infected with citrus variegated chlorosis disease. Infected seedlings from citrus waste of imported infected fruit could theoretically transfer the pathogen to the environment. However, no further analysis was conducted, and transmission by vectors from infected fruit was not tested in that study. In addition, the same group was not able to reproduce that work (Hartung et al., 2014) and seed transmission in citrus was not found by Coletta-Filho et al. (2014) and Cordeiro et al. (2014).

The risk of table grapes as a source of inoculum of *X. fastidiosa* has been reviewed by the Australian Quarantine and Inspection Service and was considered not epidemiologically significant (AQIS, 2010), because eggs of vectors (sharpshooters) are not laid on grape clusters; sharpshooter vectors are

easily disturbed and unlikely to occur on harvested grape clusters as hitch-hikers and the concentration of *X. fastidiosa* in grape clusters is very low. In addition, grape clusters showing symptoms of Pierce's disease are not likely to be harvested and traded; survival of *X. fastidiosa* is low under normal in-transit cold storage regimes, and the likelihood of inoculum bearing fruit being fed upon by potential Australian insect vectors is extremely low. Similar conclusions were also reached for stone fruit (Biosecurity Australia, 2010). In fact, with regard to transfer to a suitable host, for grapes, Purcell and Saunders (1995) demonstrated that, when the blue-green sharpshooter *Graphocephala atropunctata* and the green sharpshooter *Draeculacephala minerva* were allowed to feed on grape clusters from vines infected with Pierce's disease, the vectors were not able to transmit *X. fastidiosa* to healthy grapevines. In addition, cold storage at 4 °C, which is common practice for transport and storage of citrus and grapes, was shown to strongly affect *X. fastidiosa* viability in grape clusters (Purcell and Saunders, 1995).

Because fresh fruit has to be transported, stored, and sold soon after harvest, the likelihood of bacterial survival in fruit is moderate with high uncertainty, as it has not been studied extensively. Pest management procedures applied to fruits prior to export or at destination are unlikely to impact bacterial survival in the fruit.

Given that there is no confirmation of seed transmission in citrus and that experiments showed lack of transmission by vectors from infected grape clusters, this pathway is deemed unlikely, with high uncertainty owing to the lack of extensive studies.

5. Cut flowers and ornamental foliage infected with *X. fastidiosa*

Transport and storage of cut flowers and ornamental foliage are carried out at low temperatures, but not for long periods. Therefore, these conditions are not expected to affect the viability of *X. fastidiosa.* Bextine and Miller (2005) have shown that *H. vitripennis* is able to acquire and transmit *X. fastidiosa* from stems of *Chrysanthemum grandiflora* artificially infiltrated with a bacterial suspension. Their experiment was conducted under artificial conditions as it was conducted with a "non-host" plant (Costa et al., 2004) and a highly concentrated suspension of bacteria. Therefore, this evidence for transmission is not considered strong evidence for entry of *X. fastidiosa* with chrysanthemum cut flowers. In addition, cut flowers or cut ornamental foliage are not expected to be attractive to xylem fluid feeders, and their domestic decorative use is not expected to favour transfer by vectors to natural environments or crops. The same applies for citrus fruit with leaves. Therefore, this pathway is considered as unlikely. Uncertainty is high also because of lack of further studies.

6. Detached wood

The probability that a xylem fluid-feeding insect would transfer the bacterium from detached wood to a host plant is considered very unlikely. There is no record of acquisition of *X. fastidiosa* from detached wood and, therefore, this pathway is not considered further. Uncertainty is high because of lack of studies.

7. Infectious insect vectors

Infectious insect vectors can travel on plant material (see also point 1 in this section), but they are also capable of travelling on their own as stowaways. Such a pathway is considered as a major one, and infectious vectors travelling associated with plants or plant parts and infectious vectors travelling on their own as stowaways are discussed separately for clarity. Once infected, adult vectors can transmit *X. fastidiosa* throughout their lifetime, because the bacterium multiplies and persists in the vector foregut (Almeida et al., 2005). During inspections made in French Polynesia at an international airport, live individuals of the insect vector *Homalodisca vitripennis* were found in cargo bins, hangars and planes. Furthermore, live *H. vitripennis* individual were found in Japan in planes coming from Tahiti (Grandgirard et al., 2006). In Italy, the insect vector *Philaenus spumarius* has also been found in vehicles visiting olive groves (FVO report, 2014; see Figure 12).

3.2.1.2. Major pathways

The major pathways to be further assessed in details are as follows:

- Plants for planting
- Infectious insect vectors

3.2.2. Entry pathway I: Plants for planting (including plants imported for breeding or research, but excluding seeds)

Entry of the pathogen into EU territory by the movement of plants for planting is considered to be the most important pathway. Since *X. fastidiosa* has approximately more than 300 host plant species (see section 3.1.2, Table 2 and Appendix B) and many of them are imported (often as planting material) into the EU, the risk of introduction of the pathogen (especially with asymptomatic plants) is considerable. For some of these crops, the pathway is currently regulated.

3.2.2.1. Probability of association with the pathway at origin

X. fastidiosa is already a well-established pest in the Americas (see section 3.1.2), where it has been associated with well-known diseases, such as Pierce's disease of grapevine, phony peach disease, plum leaf scald, almond, elm, oak, sycamore, mulberry and maple leaf scorch, and citrus variegated chlorosis disease. *X. fastidiosa* has been shown to have up to 300 host species among both monocotyledonous and dicotyledonous plants (see Table 2 and Appendix B). It occurs often in asymptomatic association with host plants.

X. fastidiosa is also thought to be associated with the pathway at origin on a year-long basis. Experimental cold therapy suggests that freezing temperatures can eliminate the bacterium from affected grapevines (Purcell, 1977) and plums (Ledbetter et al., 2009), but this has not yet been demonstrated for other host plants. Nevertheless, the occurrence of *X. fastidiosa* in areas with cold winter conditions such as Ontario, Canada (Goodwin and Zhang, 1997), and New Jersey, USA (Gould et al., 2004), indicates that the impact of winter conditions on *X. fastidiosa* survival might also be dependent upon factors such as the host, vector or the *X. fastidiosa* subspecies considered.

The detection of *X. fastidiosa* in countries outside the Americas, such as Taiwan (Leu et al., 1993), and more recently in Italy (Saponari et al., 2013) and Iran (Amanifar et al., 2014), suggests that the current distribution of *X. fastidiosa*, on a worldwide basis, is probably underestimated.

Furthermore, *X. fastidiosa* has been intercepted twice in France in infected coffee plants from South and Central America, demonstrating that entry can occur via plant propagation material, even on plants that are not cultivated in the field in the EU. A recent interception in the Netherlands in asymptomatic ornamental coffee plants testing positive for *X. fastidiosa* (EUROPHYT, online), yet to be confirmed by isolation of the pathogen, has also been reported recently (Figure 8).

In areas where *X. fastidiosa* is causing major diseases, management procedures are generally in place, in the form of insect vector control programmes, in association with targeted pruning and plant removal strategies. Nevertheless, except when very early detection occurred (as when *X. fastidiosa* was intercepted in France in infected coffee plants, see section 3.1.2.2), eradication attempts have always proved unsuccessful, in California, Taiwan and Brazil (Lopes et al., 2000; Purcell, 2013; Su et al., 2013).

Although importation into the EU of citrus and grapevine plants and, to a lesser extent, stone fruit plants is currently prohibited, import of other hosts such as ornamental plants is allowed, with large volumes of plant species being traded and rapid transport allowing survival of pest and their vector insects (EPPO, 2012b).

EUROSTAT data do not provide indications of the imported volume of plant for planting material by plant species. Nevertheless, different categories for plant for planting material are distinguished in EUROSTAT, including categories containing hosts of *X. fastidiosa* such as the following: dormant bulbs, tubers, tuberous roots, corms, crowns and rhizomes; unrooted cuttings (including vines); vine slips (grafted or rooted); trees, shrubs and bushes; roses; vegetable and strawberry plants; live forest trees; outdoor rooted cuttings and young plants of trees, shrubs and bushes; outdoor trees, shrubs and bushes; live outdoor plant including their roots, indoor rooted cuttings and young plants; indoor flowering plants with buds or flowers; live indoor plants and cacti.

Importations from the different countries where *Xylella fastidiosa* has been reported so far (Argentina, Brazil, Costa Rica, Mexico, Taiwan and the USA) are presented in Table 5 and Figure 5. The data show that Costa Rica is the major contributor to EU importations of live plants, accounting for imports of 25 811 tons (average/year) over the years 2008 to 2013. Approximately 5 279 tons (average/year) of dormant bulbs, tubers, tuberous roots, corms, crowns and rhizomes was imported from Brazil. A total of 3 100 tons of unrooted cuttings was imported over the period, of which 1 789 tons was from Costa Rica and 1 025 tons from Taiwan. It should be stressed that countries where *X. fastidiosa* was discovered only recently, such as Iran, and countries where the presence of the bacteria is uncertain, such as China, India and Turkey, have not so far been included in the analysis.

Without more detailed information on the plant species imported, it is difficult to accurately estimate the volume of host plants potentially contaminated with *X. fastidiosa* that have been imported. The importation data presented here should also be further nuanced based on the fact that *X. fastidiosa* is unevenly distributed in the affected countries, but they highlight the importance of potential host plants importation within the EU.

Table 5: EUROSTAT data for importation from countries where *X. fastidiosa* has been reported. Figures are given in 100 kg (average per year from 2008 to 2013)

	Argentina	**Brazil**	**Canada**	**Costa Rica**	**Mexico**	**Turkey**	**Taiwan**	**USA**
Bulbs, tubers, tuberous roots, corms and rhizomes (dormant)	0	52 797	207	1 280	28	2 654	1 520	4 226
Bulbs, tubers, tuberous roots, corms, crowns and rhizomes (in growth)	1	102	1	339	4	1	7 307	30
Unrooted cuttings and slips	4	1 809	9	17 898	207	563	10 250	260
Edible fruit tree, shrubs and bushes	329	2	57	191	593	1 896	46	1 340
Roses	0	0	9	26	0	41	0	29
Live plants	5 797	3 366	84	258 114	4 542	10 227	13 208	28 140

More details on trade of plants for planting can be obtained from the ISEFOR database[8]. The ISEFOR

[8] The FP7 project ISEFOR, Increasing Sustainability of European Forests: Modelling for Security against Invasive Pests and Pathogens under Climate Change (2010–2014), has addressed the threat to forests represented by alien invasive pests and pathogens, with a particular focus on pathways of invasion, concentrating on the global trade in plants for planting. For this purpose, a large database of 379 580 entries, representing 49 940 077 286 units (individual plants, cuttings, etc.), belonging to 1 965 plant genera and covering the period 2000 to 2012 has been constituted, gathering data from the NPPOs of 12 EU Member States.

database covers all plants for planting according to the definitions of IPPC ("Plants: living plants and parts thereof, including seeds and germplasm [ISPM 5, 2012]; Plants for planting: plants intended to remain planted, to be planted or replanted" according to ISPM 5, i.e. bare rooted plants; bonsai; budstick; bulbs, rhizomes, etc.; cuttings (rooted or not); potted plants; scions; seeds; tissue cultures. The database is far from complete: many countries had no such data, or did not send their data, or sent only some of their data (e.g. Belgium: from one inspection point only). There are also large differences between countries regarding the period covered by their data. And, finally, there are certainly errors remaining in the database (misspelled names, synonyms, etc.). Thus, the figures collected from the database are indicative only but, partial as they are, they still confirm the immense flow of potential host plants of *X. fastidiosa* from third countries that belong to the distribution range of *X. fastidiosa*. For example, the database shows that many plants from susceptible genera have been imported recently in Europe, such as *Acacia*, *Acer*, *Citrus*, *Coffea*, *Nerium*, *Quercus*, *Prunus*, *Ulmus*, *Vinca* and *Vitis*. Whereas, in the case of plants currently regulated, the number of importations is often limited to about 10, for unregulated ones the imported quantities sometimes exceed the million of pieces imported within the EU. Importation in seven EU Member States between 2000 and 2007 comprised 157 769 736 individual plants belonging to genera listed as host plants for *X. fastidiosa* and imported from countries where *X. fastidiosa* is known to occur (ISEFOR, 2014).

Figure 8: Coffee plants imported in the Netherlands from Costa Rica and tested positive for *X. fastidiosa* in 2014 (by courtesy of M.B. De Hoop, Plant Protection Organisation, The Netherlands)

Taking into account the very large host range of *X. fastidiosa*, the high importation rate of EU of plants for planting and the recent interceptions of contaminated plants for planting in the Netherlands and other European countries (Figure 8; EUROPHYT, online), the probability of association with the plants for planting pathway is rated as very likely, with low uncertainty, considering, however, possible variations owing to origin, crop and type of material (certified vs. non-certified).

3.2.2.2. Probability of survival during transport or storage

The pathogen is transported readily in infected living plant material and is very likely to survive both transport and storage, particularly in potted plants that are transported at mild temperatures which are not expected to influence significantly the viability of the pathogen.

Dormant plants of *Vitis* are conserved and transported at lower temperatures. However, *X. fastidiosa* can survive in dormant grapevine plant material in the vineyard, and if grape plant material is cut and stored over the winter at 4°C, after rooting, it can still be infected (Feil, 2001).

Some procedures, e.g. hot-water treatment (50 °C for 20 minutes, 45 °C for 180 minutes, have been shown to eliminate the bacteria from dormant cuttings (Goheen et al., 1973), but such treatments are not systematically applied to materials in transport. It should also be considered that potted plants can not be treated this way.

If insect vectors are associated with the pathway, application of insecticides (effective on all development stages) before shipment may reduce this likelihood, although live *H. vitripennis* individuals were still found in aeroplanes after fumigation of the plant cargo with methyl bromide (Grandgirard et al., 2006) (see section 4.2.1.5).

Overall, the probability of the pathogen surviving transport and storage is rated as very likely, with low uncertainty.

3.2.2.3. Probability of surviving existing pest management procedures

X. fastidiosa infections often remain symptomless (Purcell and Saunders, 1999). Leaf scorch symptoms might also be confused with water stress or early senescence. Thus, it is considered that visual inspection cannot reliably detect infected plants. Asymptomatic or poorly symptomatic plants can escape inspection, and therefore *X. fastidiosa* infection may be overlooked in a wide range of situations. Visual inspection of dormant materials is also inappropriate for detection of the disease. Emergency measures laid down in Decision 2014 497/EU do not target the entire list of host plants that may host *X. fastidiosa.* Apart from thermotherapy (see section 4.1.3.7), as far as it is known *X. fastidiosa* is not adversely affected by temperature during transport or by pesticide treatment.

The probability of infected plants surviving existing management procedures (here: bypassing phytosanitary inspection) is thus rated as very likely, with low uncertainty.

3.2.2.4. Probability of transfer to a suitable host

Upon entering the risk assessment area on infected plant material, the pathogen is already in a suitable host to be planted and grown; therefore, transfer to a suitable host is ascertained. Further dispersal by vectors of *X. fastidiosa* from the imported infected plants to local neighbouring plants susceptible to *X. fastidiosa* is expected to occur with high efficiency because of the wide host range of the pathogen and the large number of European xylem fluid-feeding insects, all of which can be considered to be vectors. Many of the hosts of *X. fastidiosa* are grown in Europe in commercial plantations, natural and ruderal vegetation, alleys, parks or gardens (e.g. peach, plum, almond, apricot, olive, citrus, grapes, oak, magnolia, ginkgo, oleander, sunflower, alfalfa, ragweed, Bermuda grass, etc.). Overall, the probability of transfer of *X. fastidiosa* to a suitable host considering the plants for planting pathway is rated as very likely with low uncertainty.

Finally, for this pathway the probability of entry through the plants for plantings is rated as very likely with low uncertainty.

3.2.3. Entry pathway II: Infectious vectors of *X. fastidiosa*

In this section, the probability of entry of *X. fastidiosa* with infectious vectors travelling on their own is considered. For clarity, the case of insect vectors travelling on plant consignments is also discussed

here. Owing to the lifelong persistence of the bacterium in adult vectors, *X. fastidiosa* can be easily transported as long as the vector survives. Nymphs can carry the bacteria, but will lose them when they moult. Most of the information available so far refers to *H. vitripennis*, which is considered as the most invasive *X. fastidiosa* vector species (Redak et al., 2004; Grandgirard et al., 2006). The difficulty of determining how much of this information can be extended to other species increases the uncertainty of the conclusions.

3.2.3.1. Probability of association with the pathway at origin

Vectors associated with plants or plant parts

There are no data in the EUROPHYT database (EUROPHYT, online) on interceptions of *X. fastidiosa* vectors, even though these insects are rather large and conspicuous (*H. vitripennis* is approximately 12 mm long). The vectors listed in section 6.1 may be carried with the plants as eggs, nymphs or adults. According to Grandgirard et al. (2006) and Petit et al. (2008), egg masses are the most likely form in which *H. vitripennis* was transported on ornamental or agricultural plants between the islands of French Polynesia. As eggs themselves are not infected, because no transovarial transmission occurs (Freitag, 1951), they need to be transported on infected plants to generate infective nymphs and adults, as only vectors in these stages can acquire and transmit the pathogen. The high number of vector species or potential vector species, the high number of host plant species, the high prevalence of the pathogen and of some vector species in areas of their current distribution makes the association of an infectious vector with the consignment at the origin likely. However, this risk can be decreased in the case of certified production in a screen house. The application of insecticides (effective on all development stages) before shipment may also reduce this likelihood, although live *H. vitripennis* individuals were still found in aeroplanes after fumigation of the plant cargo with methyl bromide (Grandgirard et al., 2006) (see section 9.2.3.6). Uncertainty of the assessment is high owing to the lack of data on frequency of xylem fluid-feeding insects in traded consignments.

Vectors travelling on their own as stowaway

The possibility that sharpshooters or spittlebugs could travel on containers, ships, aeroplane holds or aeroplane cabins on their own has so far not been explored, but Grandgirard et al. (2006) and Petit et al. (2008) mention that *H. vitripennis* has been found in aeroplanes in French Polynesia. They report that *H. vitripennis* exhibits a strong response to light, which could explain the movements of this species towards aeroplanes. Furthermore, in some recently invaded areas, very high population densities were observed (> 100 nymphs per minute of sweep netting: Petit et al., 2008). In Italy, the insect vector *P. spumarius* has been also found in vehicles visiting olive groves (FVO report 2014; see Figure 12).

Other insect species have also been suspected or observed to travel on their own as stowaways in aeroplanes (e.g. *Diabrotica virgifera virgifera* (Nentwig, 2007)), terrestrial vehicles (e.g. the chestnut gall wasp, *Dryocosmus kuriphilus* (EFSA PLH Panel, 2010b), or the horse chestnut leaf miner *Cameraria ohridella* (Gilbert et al., 2004, 2005)) or in various consignments (e.g. *Harmonia axyridis*) (CABI datasheet; Smith and Fisher, 2008; Brown et al., 2008). For all these reasons, it is considered likely that vectors could enter a ship or an aeroplane. The uncertainty is considered to be medium because of the lack of direct, quantitative studies.

3.2.3.2. Probability of survival during transport or storage

Vectors associated with plants or plant parts

The capacity of the vectors to move successfully on plants has been fully illustrated by the invasion dynamics of *H. vitripennis* in California, French Polynesia, Hawaii and Easter Island (Petit et al., 2008). We could not find specific studies determining survival of *X. fastidiosa* vectors or, more generally, xylem fluid-feeding insects during transport and storage of plant consignments. However, the survival of *H. vitripennis* was studied under constant temperatures and feeding conditions for up to

three weeks. This study showed that continuous exposure to either low (< 5 °C) or high (> 30 °C) temperatures is detrimental to adult survival and that low temperatures (threshold lies between 7.8 and 13.2 °C) caused early mortality because of inhibition of feeding activity (Son et al., 2009). When provided with a citrus plant on which to feed, approximately 75 % of the adults survived three weeks at temperatures between 13 °C and 24 °C. Assuming that these data can be extrapolated to other species, the probability of survival of nymphs or adults during transport and storage is assessed as unlikely at low temperatures and for long periods, e.g. with consignments of dormant plants, whereas it is likely with consignments of potted plants with leaves that are transported and stored at milder temperatures, provided that these plants are not sprayed with insecticides. Uncertainty is considered as medium owing to a lack of data for the various vector species.

Vectors travelling on their own as stowaway

Without food, with only water, adults *H. vitripennis* could survive 16 days at 13 °C (Son et al., 2009). Grandgirard et al. (2006) report that living adults of *H. vitripennis* have been discovered in aeroplanes from Tahiti, after their landing in Japan. However, during careful surveys of *H. vitripennis* populations in French Polynesia, Petit et al. (2008) found only low populations around the airports, whilst higher populations were found in highly urbanised areas. As a result, they suggested that the insects were not likely to have been introduced as adults on aeroplanes because they would not tolerate transit stress in the planes. However, the provisions described in the previous section (impact of low or high temperature) also apply to vectors travelling on their own. The probability of survival during transport or storage is thus considered from unlikely to likely, with high uncertainty (owing to the lack of field evidence).

3.2.3.3. Probability of surviving existing pest management procedures

Xylem fluid-feeding vectors, sharpshooters and spittlebugs, can be detected by visual inspection; thus, culling and visual selection measures during preparation of consignments of plants for planting or phytosanitary inspection at the point of entrymay allow an infestation to be detected. However, the large number of vector species and of host plants, many of them without symptoms, makes systematic inspection much more difficult, as the constraints already described in section 3.2.2.3 (list of *X. fastidiosa* hosts not directly addressed in the legislation; no specific requirement indicated for plant propagation material for *X. fastidiosa*) also apply to visual inspection of consignments for vectors. The same caveats apply to fumigation or insecticide treatments, which are very likely to kill *X. fastidiosa* vectors but will not be applied systematically on a vast range of plant species, many of which are asymptomatic. Cold treatments are not useful as several days of exposure to low temperature (0.1 °C and 3.2 °C) are needed to kill *H. vitripennis* (Son et al., 2009). The probability of surviving/escaping existing management procedures is therefore assessed as moderately likely. As little information is available regarding the implementation rate of management procedures previous to or during shipment, and as most of the available data relate to only one species, uncertainty is high.

3.2.3.4. Probability of transfer to a suitable host

Vectors associated with plants or plant parts

The vector species are mobile xylem fluid feeders with a wide host range. According to Petit et al. (2008), the adult stage is probably not the most high-risk invasive propagule of *H. vitripennis*. On the other hand, infectious adults are persistently infected, winged and very mobile and they can fly actively in the range of about 100 metres (Blackmer et al., 2004; Coviella et al., 2006), thus facilitating host finding. Infected nymphs are much less mobile as they are wingless, and, moreover, they lose infectivity as soon as they moult, so their possible role in transferring *X. fastidiosa* to a suitable host plant is negligible. The polyphagy of most of the vectors, including *H. vitripennis*, and the wide range of *X. fastidiosa*-susceptible plants increase the probability of an encounter between an infectious adult insect and a susceptible host plant. Therefore, the probability of transfer to a suitable host is rated as moderately likely with low uncertainty.

Vectors transported on their own as stowaway

Owing to the large distance between the areas already colonised by infectious vectors of *X. fastidiosa* and the risk assessment area, only adult infectious vectors travelling on their own by aeroplane and boats can be introduced. Petit et al (2008) found that adults of *H. vitripennis* are not a very effective means for long-distance spread and, if the adult stage was the main source of propagule pressure, the airport zones of invaded areas would exhibit the largest pest populations, whereas, in fact, very low populations were recorded around the airports. Long-distance human-mediated dispersion of *H. vitripennis* has most likely occurred via egg masses introduced to new locations on ornamental or agricultural plants, and eggs cannot carry and transmit *X. fastidiosa* (Petit et al., 2008). Moreover, airports and harbours are relatively distant from crops and natural vegetation, and the probability of infectious vectors transferring *X. fastidiosa* to a suitable host plant is low for adult insects and negligible for nymphs with low uncertainty.

Overall the entry through the pathway of infectious vectors of *X. fastidiosa* is rated as moderately likely, depending on type and treatment of the consignment, with high uncertainty owing to the lack of specific data.

3.2.4. Conclusions on the probability of entry

The main entry pathway for *X. fastidiosa* is the trade and movement of plants for planting (seeds excluded). The pathway of infectious vectors of *X. fastidiosa* transported on plant consignments or travelling on their own is also of concern. The pathway of plants imported for breeding or research purposes is considered either minor, in the case of plants that are currently regulated, or similar to the plants for planting pathway. Fruit, seeds, cut flowers and ornamental foliage are minor pathways with low likelihood of entry. Uncertainty is medium for the plants for planting pathway and high or very high for the others, because of the lack of data or published information.

3.2.4.1. Plants for planting

Very likely	The entry is rated very likely for plants for planting because: • The association with the pathway at origin is considered to be very likely for plants for planting because: (1) plants for planting have been found to be a source of the bacterium for outbreaks; (2) host plants can be asymptomatic and often remain undetected; (3) a very large number of plant species are recorded as hosts; (4) very high quantities of plants for planting are imported from countries where *X. fastidiosa* is reported. • The ability of the bacteria to survive during transport is very high. • The probability of the pest surviving any existing management procedure is very likely since *Xylella* is often found in asymptomatic association with host plants. • The probability of transfer to a suitable host is rated as very likely, based on the intended use the plant material for planting (rootstocks) or grafting (scions, budwood) as well as on the fact that host plants are extensively present in the risk assessment area. Insect vectors are also widely distributed throughout the risk assessment area.

3.2.4.2. Infectious vectors

Vectors associated with plants or plant parts	
Moderately likely	The entry is rated moderately likely because the pest: • is often associated with the pathway at the origin, • the ability of infectious insect vectors to survive transport or storage is low to high depending on the conditions of transportation, • is affected by the current pest management procedures existing in the risk assessment area, • has some limitations for transfer to a suitable host in the risk assessment area.
Vectors travelling on their own as stowaway	
Moderately likely	The entry is rated moderately likely because: • The pest is often associated with the pathway at the origin. • The ability of infectious insect vectors to survive transport or storage is low to high depending on the conditions of transportation. • The pest is affected by the current pest management procedures existing in the risk assessment area. • The pest has some limitations for transfer to a suitable host in the risk assessment area.

3.2.5. Uncertainties on the probability of entry

3.2.5.1. Plants for planting

Medium	• The distribution and prevalence of X. *fastidiosa* in the countries of origin are not fully known. • There are only a few records of interceptions of infected plants. • It is difficult to assess the level of susceptible plants for planting imported within the whole of the EU because EUROSTAT data are not collected on a host by host basis. • The host range is very large (possibly around 300 species) and may be even larger and the knowledge of host plant susceptibility is incomplete. • Many plants may host *X. fastidiosa* asymptomatically.

3.2.5.2. Infectious vectors

High	Both for vectors associated with plants or plant parts and for vectors travelling on their own, the uncertainties on the probability of entry are considered as high because: • The distribution and prevalence of *X. fastidiosa* in the countries of origin are not fully known. • There are no data on the interception of vectors in the EUROPHYT database. • Data on the prevalence of xylem fluid-feeding insects in traded consignments are lacking • There is a lack of data on the various vector species. • Little information is available regarding the implementation rate of management procedures previous to or during shipment. • Few data (only on *H. vitripennis*) are available on the vectors' autonomous dispersal capacity as stowaways. • There is a lack of direct, quantitative studies. Few data (only on *H. vitripennis*) are available on the vectors' capacity to survive long-distance transportation on their own in vehicles.

3.3. Probability of establishment

3.3.1. Availability of suitable hosts, alternative hosts and vectors in the risk assessment area

More than 300 species, belonging to 63 different families, have been found to be susceptible to the pathogen (see Table 2 and Appendix B). Therefore, the probability of finding suitable host plants in the risk assessment areas is very likely with a low uncertainty. Although the majority of these species are restricted to the Americas, at least 80 species, belonging to 26 families, cultivated and wild, are also present in the European territory. The wide host range of the pathogen clearly indicates that many European plant species are likely to be susceptible to *X. fastidiosa.* Known host plants of *X. fastidiosa* and/or exotic vectors (and related plant species that are likely to be susceptible) are widespread in the risk assessment area in many different habitats all over the geographical range of the EU. They are represented by grasses, trees and shrubs, both wild and cultivated.

Potential vectors (spittlebugs, sharpshooters and cicadas) are present and widespread in the risk assessment area (see Tables 4 and 5), including the known vector *Philaenus spumarius* (Purcell, 1980; Saponari et al., 2014a).

Because of their very wide geographical distribution, it is likely that, once the pest is introduced in the risk assessment area, it will be transmitted to other plants by endemic xylem sap-sucking insects. However, only a few potential European vector species are common and abundant in nature (*P. spumarius* and very few other species; see Table 4 and Figure 4). Therefore the likelihood of one or a few infected plants being visited by the vector can be rated as high. Most of the European xylem sap-sucking vectors are associated with herbaceous plants. Herbaceous plants are therefore potentially more likely than trees to be first infected following introduction, and then serve as sources of further spread. On the other hand, trees are long-lived and often more apparent than herbaceous plants, and this increases the likelihood of the vector coming in contact with them.

3.3.2. Suitability of the environment

X. fastidiosa spreads mainly in the tropics, subtropics and in areas where climatic conditions are similar to those in the Mediterranean zones (e.g. Pierce's disease of grapevine in California), with some spots in temperate or colder areas. It is also present in New Jersey and the Washington DC area in the USA and has been detected as far north as in Canada, in the Niagara peninsula in southern Ontario (Goodwin and Zhang, 1997; Gould and Lashomb, 2007), in British Columbia (FIDS, 1992), in Saskatchewan (Northover and Dokken-Bouchard, 2012) and in Alberta (Holley, 1993).

Crops or ornamental plants or forest trees affected by *X. fastidiosa* are widely grown in the risk assessment area. It is very likely that the areas where citrus, grapevine or olive trees are grown in Europe are also suitable for the development of *X. fastidiosa* (Hoddle, 2004), based on summer temperatures favourable for *X. fastidiosa* development in conjunction with relatively low winter temperatures. Potential insect vectors have been detected almost everywhere in Europe although there is a lack of data about their abundance (Figure 4).

No known abiotic factors are likely to be substantially different in the risk assessment area and in the current area of distribution. Therefore, no abiotic conditions may affect pest establishment. No competing species are known so far to displace *X. fastidiosa* from plants. Owing to the wide range of host plants, it is very unlikely that the pathogen will be outcompeted by other microbes in the susceptible plants. No natural enemies of *X. fastidiosa* are known with the exception of phages specific to *X. fastidiosa* (Summer et al., 2010) or with broad host range (Ahern et al., 2014) that have been isolated in North America. No information is available about the presence of phages attacking *X. fastidiosa* in the assessment area. Egg, nymph and adult parasitoids (Hymenoptera, Aphelinidae and Mymaridae, and Diptera, Pipunculidae) and predators (mainly spiders) of sharpshooters and spittlebugs are known in the risk assessment area (Waloff, 1980; Weinberg, 1987; Ceresa-Gastaldo and Chiappini, 1994), and some of these species are likely to adapt to newly introduced species of the

same families. Natural enemies may suppress vector populations with variable efficiency, reducing spread of the pathogen, but natural control of vectors is unlikely to eliminate vector populations and stop spread of pathogens entirely (Eilenberg et al., 2001).

3.3.2.1. Climatic conditions

X. fastidiosa is known to occur over large areas in different climatic zones, in tropical countries and subtropical areas such as Brazil, Costa Rica and southern California and in more temperate or even continental climate regions such as British Columbia, southern Ontario and Saskatchewan in Canada, the north-eastern regions of the USA and Argentina (see Figures 1, 3. 9, 10 and 11 and Appendix G).

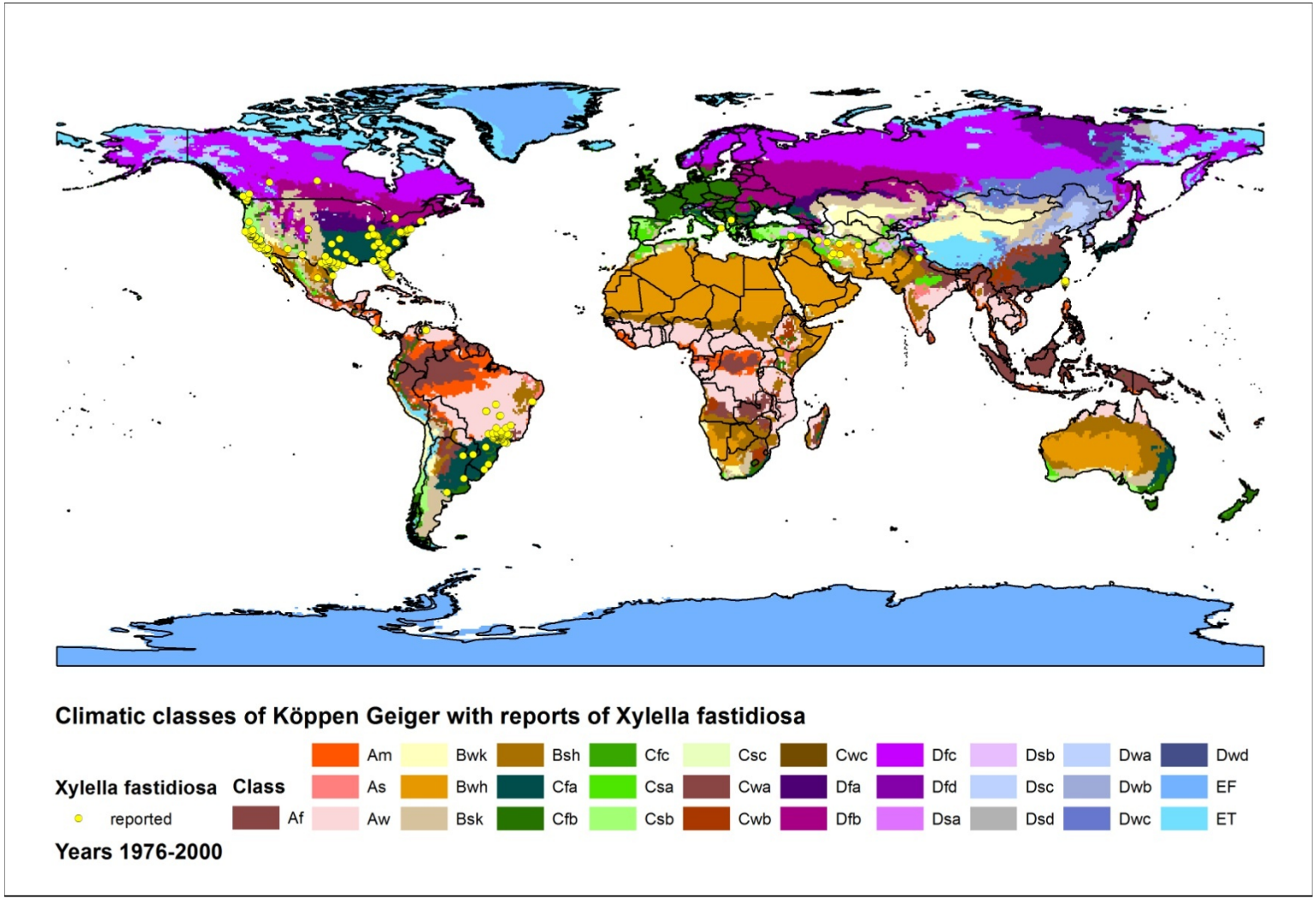
It is very likely that the pathogen will find suitable climatic conditions allowing its establishment and spread in the southern part of the risk assessment area, including the Mediterranean coast, as the Mediterranean climate (Köppen–Geiger climate group Csa and Csb) (Figure 9) also occurs in California, where three *X. fastidiosa* subspecies (*X. fastidiosa* subsp. *multiplex*, *X. fastidiosa* subsp. *fastidiosa* and *X. fastidiosa* subsp. *sandyi*) have been detected so far (Figure 1). The recent establishment of *X. fastidiosa* in Apulia, Italy, confirms this statement. Several approaches have been used to infer the suitability of climatic zones for *X. fastidiosa*, mostly in the USA and based on the subspecies *fastidiosa*. Purcell and Feil (2001) proposed using isotherms of January winter temperature for zones where Pierce's disease has a severe (4.5 °C), occasional (1.7 °C) or rare (–1.1 °C) impact on grapes. Hoddle (2004) used CLIMEX to produce maps of potential distribution for *X. fastidiosa* and *H. vitripennis*, based on data from Feil and Purcell (2001) and Feil (2001). The optimum *in vitro* growth temperature for the bacteria is 28 °C, and no growth of *X. fastidiosa* subsp. *fastidiosa* was observed *in vitro* at 12 °C (Feil and Purcell, 2001). Anas et al. (2008) have shown the effect of warming temperature on disease severity, and mapped areas at risk of Pierce's disease by using the number of winter days with temperatures below –12.2 °C or –9.4 °C. These parameters have also been used for creating a NAPPFAST map for *X. fastidiosa* in the USA (Engle and Magarey, 2008).

In grapevines, plants may recover from infections during winter. Plants systemically infected, with or without symptoms, may not be infected by *X. fastidiosa* in the following years. This is a very well reported phenomenon in grapevines; on the west coast of the USA, it limits the northern spread of Pierce's disease (Hopkins and Purcell, 2002). Although the recovery mechanism remains unknown, low winter temperatures increase the rate of recovery (Purcell, 1980). In the field, recovery happens more often when infections occur in the summer or autumn than during the spring (Feil and Purcell, 2001). It should be noted that winter recovery has been demonstrated for grapevines infected with *X. fastidiosa* subsp. *fastidiosa*, and that all research on the topic has been conducted in California. For example, the presence in the Washington DC area of trees chronically infected with isolates of *X. fastidiosa* subsp. *multiplex* highlights the fact that this bacterium can survive at higher latitudes. Henneberger et al. (2004) pointed out also that the bacteria was able to overwinter in sycamore trees at relatively low air temperatures (–5 °C), probably being protected in the roots.

Xylella fastidiosa occurs in dry environments, such as southern California, and in reasonably wet areas, such as north-eastern USA. Daily variations in temperature, including minima and maxima, also vary widely within the distribution range of *X. fastidiosa*. However, it is important to note that the climatic conditions limiting particular subspecies and/or phylogenetic clades of *X. fastidiosa* are poorly understood. In other words, current knowledge about the putative climatic conditions necessary for *X. fastidiosa* are based on the distribution of the species as a whole, and this may not be an appropriate extrapolation to specific genotypes. For example, it is not yet fully known if there is a difference in the cold resistance between *X. fastidiosa* subspecies that could explain the spread further north in USA and Canada of the subspecies *multiplex* or if this extension is linked to the tree hosts of the disease. Nor is the response of the bacteria to temperature fully known. Plant-pathogenic bacteria are usually able to follow their host plant distribution. A comparison of the hardiness zones where *X. fastidiosa* has been reported previously (Figure 10) with European zones indicates that *X. fastidiosa* could occur over large areas in Europe. The same conclusions may be drawn if the annual minimum temperatures of the pest current distribution are compared with the European climate data (Figure 11).

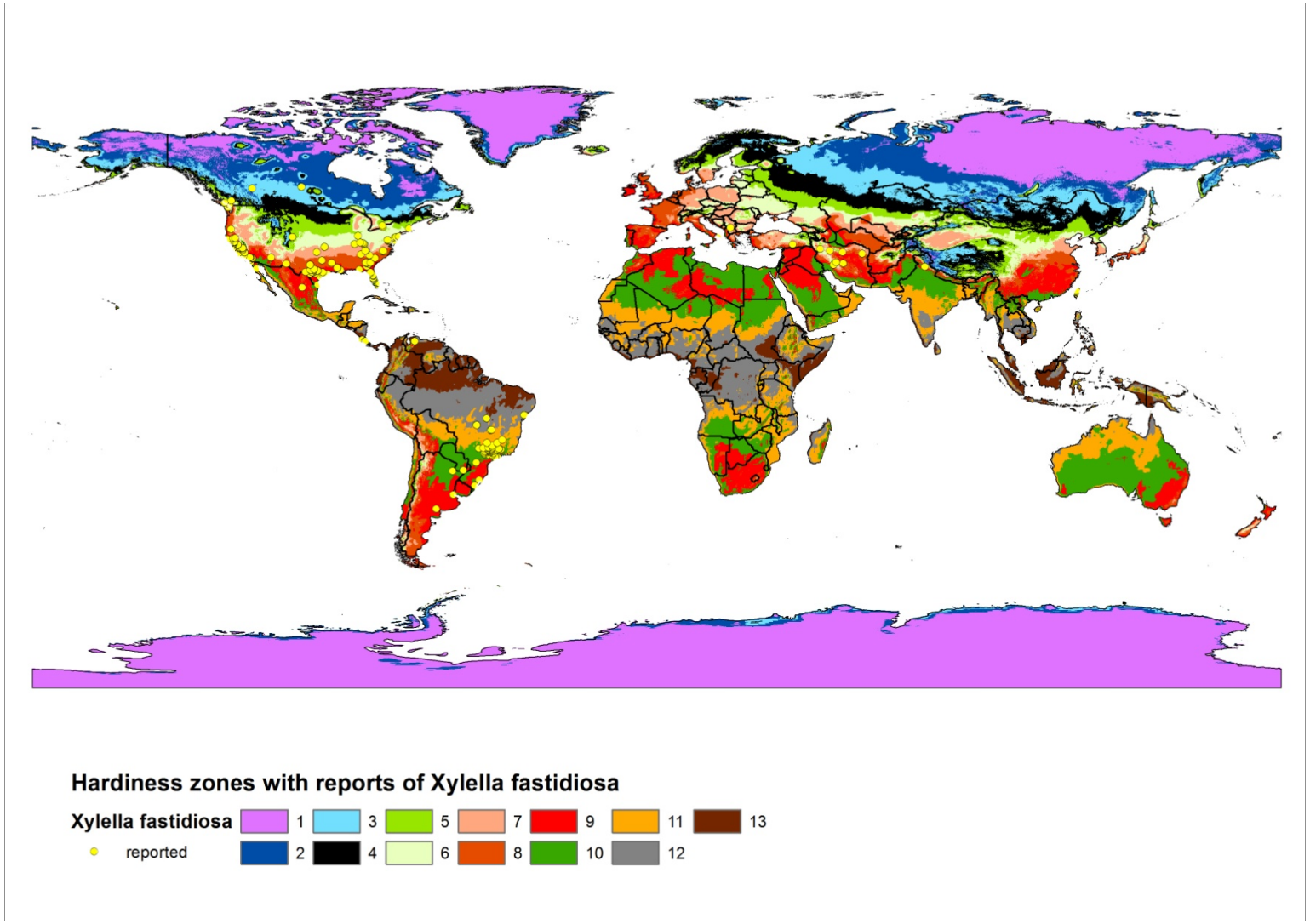
The probability of *X. fastidiosa* establishing in other European areas is therefore considered to be very likely, particularly for those areas characterised by mild winter conditions (Purcell, 2001; Anas et al., 2008) and for hosts such as citrus, grapevine, olive, stone fruits and other ornamental plants, e.g. oleander. The uncertainty associated with the probability of establishment in more northern European areas and on ornamental and forest trees such as American sycamore, elm and oak is higher owing to a lack of knowledge on possible differences between different subspecies of *X. fastidiosa* and on susceptibility of European plant species. It should also be noted that, whereas the sharpshooters in America overwinter as adults and, when infected, can maintain *X. fastidiosa* during winter, the European sharpshooters (Cicadellidae, Cicadellinae) and most of the European spittlebugs (Aphrophoridae, with the exception of a few Cercopidae) overwinter as eggs (Nickel and Remane, 2002) and, therefore, cannot sustain the overwintering of *X. fastidiosa*.

It is expected that the climatic environment in which crops are grown under protected conditions could be suitable for the development of *X. fastidiosa.* Although no outbreak of this pathogen has been reported in protected crops in the Americas, there are scientific reports (Appendix B) and border interceptions (in the Netherlands on ornamental coffee) of *X. fastidiosa* in ornamentals. There may be several reasons for the absence of reported outbreaks under protected conditions: the time needed to develop infection is longer than crop cycle in some protected crops; the presence of symptomless infections and the very low frequency of sharpshooter and spittlebug vectors under greenhouse conditions.



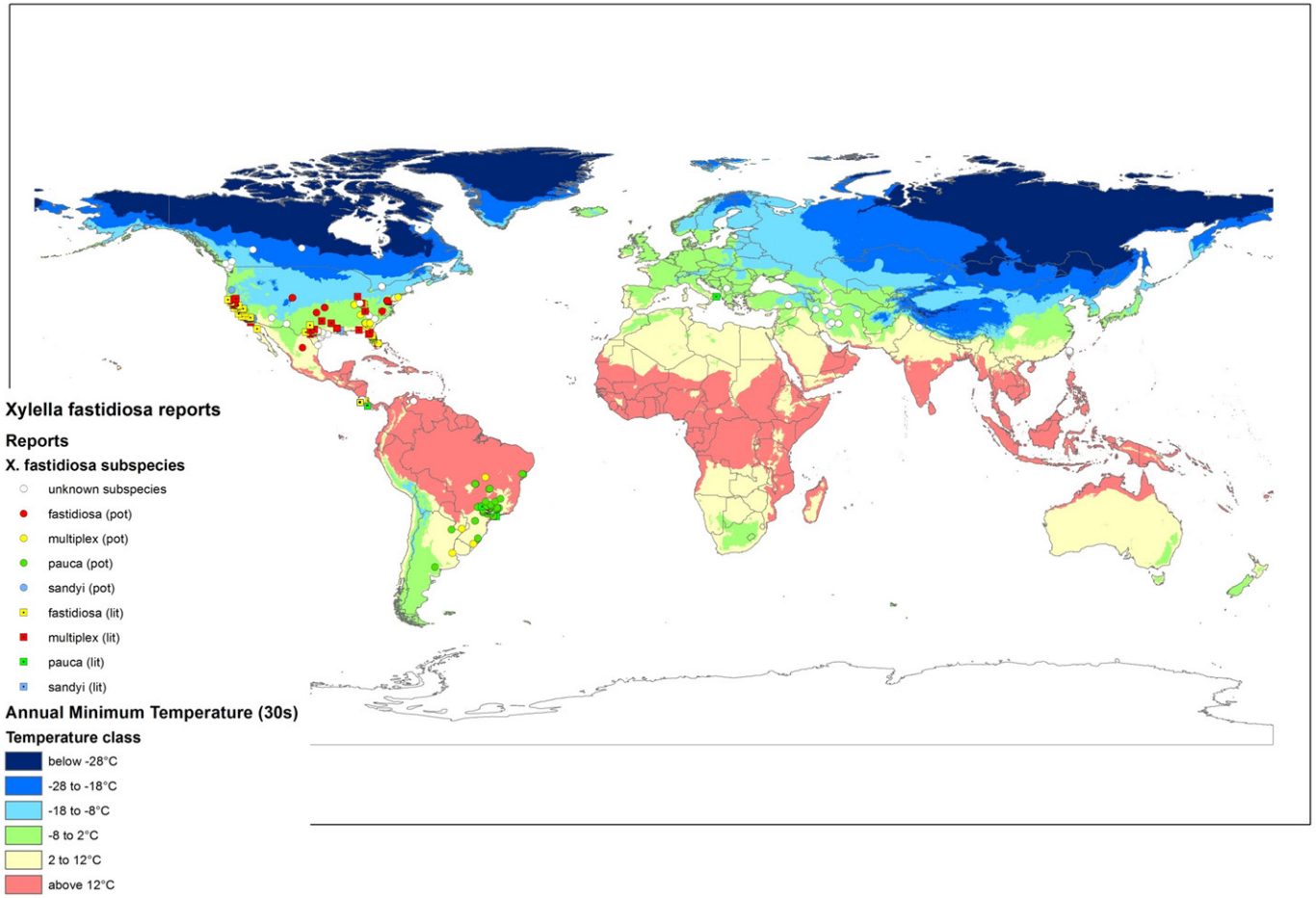
Yellow points represent places where *Xylella fastidiosa* was reported, according to the extensive literature search and the database in Appendix B

Figure 9: Köppen–Geiger climatic classification map (1976–2000) and *Xylella fastidiosa* distribution.



Yellow points represent places where *Xylella fastidiosa* was reported (see Appendix B)

Figure 10: World map of 30 years global hardiness zones between 1978 and 2007, according to Magarey et al. (2008), and *Xylella fastidiosa* distribution.



Temperature classes (-28°C, from -28°C to -18°C, from -18°C to -8°C, from -8°C to 2°C, from 2°C to 12°C, above 12°C) were chosen based on annual minimum temperatures of northern records of *X. fastidiosa* in Canada. Reports of *X. fastidiosa* from the extensive literature search database: (lit) indicates reports where the subspecies was assigned in the original paper; (pot) indicates reports for which a potential subspecies was assigned by the Panel as described in Appendix B

Figure 11: World map of annual minimum temperatures from WorldClim database (http://www.worldclim.org) and *Xylella fastidiosa* subspecies distribution.

3.3.3. Cultural practices and control measures

Perennial crops and wild vegetation are likely to be the most favourable environments for the establishment of *X. fastidiosa.* The reported presence of this pathogen in olive trees in the Apulia region of Italy is in line with this hypothesis. Very severe pruning can cure infected trees (Weber et al., 2000; Hopkins and Purcell, 2002; Queiroz-Voltan et al., 2006), but the results depend at least on the host plant species and, therefore, pruning might be effective with a high uncertainty.

It is very likely, with very low uncertainty that current pest management practices in the risk assessment areas will fail to prevent establishment of *X. fastidiosa.* No antibacterial compounds are routinely applied to the perennial crops, except copper, which is unable to cure plants of *X. fastidiosa* or even to prevent transmission by insects.

No eradication attempts have proved successful, so far, in California, Taiwan or Brazil (Purcell, 2013; Lopes et al., 2000; Su et al., 2013), owing to the broad host range of the pathogen and of its vectors, which include a large number of wild plants. No effective eradication technique, e.g. the sterile insect technique, is currently available for any of the vector species.

3.3.4. Other characteristics of the pest affecting the probability of establishment

Current evidence indicates substantial genetic diversity and a wide host plant range of *X. fastidiosa. X. fastidiosa* has four currently accepted subspecies, with phylogenetic clades within those subspecies causing disease in specific hosts (equivalent to pathotypes). There are substantial genomic and phenotypic differences within the *X. fastidiosa* species. The mutation rate has not been estimated experimentally, but *X. fastidiosa* is naturally competent and undergoes homologous recombination at high rates in the laboratory and under field conditions, as evidenced by sampled populations in the Americas (Almeida et al., 2008; Kung and Almeida 2011, 2014). The bacterium occurs in a wide range of climate and habitats, from tropical regions in Costa Rica and Brazil to more temperate or continental areas such as north-eastern USA and Ontario, Canada. Although there is substantial diversity within X. fastidiosa, it is not known how much biological plasticity individual phylogenetic groups have, or are capable of having, under selective pressure. Therefore, the likelihood of future changes in host plant range cannot be assessed.

Specific genotypes of *X. fastidiosa* have already been introduced into new areas outside its original area of distribution. Evidence is provided by (i) phylogenetic placement of introduced isolates and (ii) lack of genetic diversity at the site of introduction. The first example is the introduction into southern Brazil, from North America, of a subspecies *multiplex* genotype causing disease in plum (Nunes et al., 2003). The second is the introduction into Taiwan, also from North America, of an isolate of subspecies *fastidiosa* causing Pierce's disease of grapevines (Su et al., 2012).

3.3.5. Conclusions on the probability of establishment

The probability of establishment of *X. fastidiosa* is considered to be very high, based on the very high probability that the pest will find a suitable host owing to the very large range of host plants and potential host plants and to the wide distribution and polyphagy of known and potential vectors. Even if the climate of only part of the risk assessment area closely matches the climate in other areas where *X. fastidiosa* is well established (e.g. Mediterranean climate), several elements combine to support the possibility that large areas of Europe will be prone to establishment of *X. fastidiosa*: the high capacity of *X. fastidiosa* to persist in contrasting climatic conditions and ability of the bacteria to overwinter in areas with low winter temperature (Anas et al., 2008). Nevertheless, at present it is difficult to anticipate precisely the possible distribution of *X. fastidiosa* in Europe owing to uncertainties linked to the optimal and minimal temperature requirement for growth of *X. fastidiosa* subsp. *multiplex* found in Canada and northern USA and it has yet to be verified that the bacteria is able to shelter in roots and larger plants such as forest and ornamental trees (Hennenberger et al., 2004).

Currently, except for the specific measures implemented in Southern Italy, there are no fully effective practices or control measures to avoid establishment, due to the large host range comprising asymptomatic ones and the wide presence of potential insect vectors.

Very likely	• There is a very high probability of finding a suitable host owing to very large range of host plants and potential host plants, and to wide distribution and polyphagy of known and potential vectors. • *X. fastidiosa* has an apparently high capacity to adjust to contrasting climatic conditions. There is a very high probability that the pest will find a climatically suitable environment, with no known adverse abiotic factors and no known natural enemies (but some natural enemies are known for the vectors). Information regarding winter recovery in infected plants is conflicting. • There are no fully effective cultural practices or control measures.

3.3.6. Uncertainties on the probability of establishment

Low	• *X. fastidiosa* is already established in Apulia. • There is no uncertainty regarding the availability of a wide range of host plants, but questions remain regarding the susceptibility of indigenous European flora. • There is one confirmed vector species, and it is widespread, abundant and polyphagous; a large range of additional potential vectors are yet to be studied. • A large range of suitable climatic environments are available in the risk assessment area. There is a lack of data regarding the overwintering capacity and the range of temperatures within which the different subspecies of the bacteria can thrive.

3.4. Probability of spread

3.4.1. Spread by natural means

The only route of natural spread of *X. fastidiosa* is by insect vectors, mainly sharpshooters and froghoppers or spittlebugs. Transmission is very rapid because there is no latency period. Depending on the host species, a large component of spread can occur asymptomatically. There is no trans-stadial or transovarial transmission of the bacterium. The pathogen persists and multiplies in the foregut of the adult vectors, which can remain infectious throughout their lifespan (Almeida et al., 2005). The potential vector species in the EU are listed in section 3.1.4.2.

Dispersal seems to be primarily limited by the short-range flight of leafhoppers, e.g. around 100 metres for *H. vitripennis* (Blackmer et al., 2004), with a similar range reported for *Scaphoideus titanus* (Lessio and Alma, 2004). Gottwald et al. (1993) conducted spatial analyses of the spread of citrus variegated chlorosis in citrus plantings in Brazil and found strong associations between trees immediately adjacent to each other, suggesting that tree-to-tree spread was dominant. In addition, leafhoppers can be transported by wind over long distances. For example, the aster leafhopper, *Macrosteles fascifrons* (Stal), is carried from the Gulf Coast states of Texas, Louisiana, Arkansas and Oklahoma to Ohio, Wisconsin and the Northern Great Plains (Hoy et al., 1992), and thus wind contributes to long-distance dissemination. Sharpshooters and spittlebugs are much larger than the aster leafhopper, and therefore wind transportation could be less effective.

The density and pattern of host plants in the landscape will have a significant influence on spread (Plantegenest et al., 2007), particularly on short- and medium-range vector dispersal from plant to plant. In general, host landscapes characterised by areas of contiguous hosts at high density will be more conducive to spread.

3.4.2. Spread by human assistance

Tranportation of infected plant material is an effective means of long-distance dispersal. Vegetative propagation through grafting is widely used for most long-lived perennial *X. fastidiosa* hosts;

transportation of live plant tissue is a common practice in the various agricultural industries affected by this pathogen, eventually increasing its geographic distribution (Almeida et al., 2014). As described by Almeida et al. (2014), transmission by infected plant material was probably the main mode of spread of citrus variegated chlorosis within Brazil to areas far from the initial foci in São Paulo state. Two factors are considered to have been important in this initial spread: (1) the long incubation period required for symptom expression and (2) the fact that the bacterium can be transmitted from plant material taken from infected but as yet asymptomatic plants used for grafting. Since the production of healthy nursery trees under vector-proof screen houses became mandatory, tree-to-tree transmission of *X. fastidiosa* by vectors is the major, if not the only, form of bacterial spread in São Paulo state (Almeida et al., 2014).

Inadvertent transportation of vectors in vehicles should also be considered, as it has been observed for other pests, such as the chestnut gall wasp, *Dryocosmus kuriphilus* (EFSA PLH Panel, 2010b), and the horse chestnut leaf miner, *Cameraria ohridella* (Gilbert et al., 2004, 2005). Spread by vehicles may occur via the general public by car or by the agricultural transport of vehicles with infected plant material and vectors.

In the currently affected zone of the risk assessment area, spread by human assistance could also be increased by commercial practices such as the direct retail selling of small potted cuttings and the important ferryboat traffic to Greece: Bari and Brindisi being important communication hubs in this respect.

Human-assisted spread would result in stratified dispersal, with one long-distance component allowing both the colonisation of new areas, sometimes very far from the area of origin, and the local colonisation of these newly reached spots by a diffusion process depending on autonomous local spread of the vectors.

3.4.3. Other means of spread

Two other potential means of *X. fastidiosa* spread are deemed potentially important. However, they are considered as having high uncertainty, primarily because of the small number of studies addressing these modes of transmission and the small sample sizes used in those studies. These are root–root transmission and transmission via contaminated pruning equipment (i.e. during plant pruning). Root-root transmission of pathogens between neighbouring plants can occur when the roots make intimate associations called root grafts (Epstein, 1978). A report shows transmission of *X. fastidiosa* via citrus root grafts in 31 % of experimental plants tested (He et al., 2000). Another study with grapevines did not observe root grafts between plants and, consequently, no transmission (Krell et al., 2007). Root-to-root transmission may be important for plants that readily produce root grafts. One study indicates that pruning of infected plants leads to the transmission of *X. fastidiosa* (Krell et al., 2007). However, pruning of symptomatic plant material is also used as a strategy for controlling citrus variegated chlorosis in Brazil (Almeida et al., 2014). It should be noted that plant pruning is a routine practice for many crops susceptible to *X. fastidiosa* diseases and for experimental research, and there are no other reports of transmission via contaminated pruning equipment.

3.4.4. Preliminary results of modelling the spread of *X. fastidiosa* on olive in Apulia

Given the lack of data and the fact that research is ongoing, the Panel considers that it is difficult to provide firm conclusions from models at the moment. The aim of the spread model produced by the Centre for Ecology and Hydrology (CEH) is to explore the potential spread of *Xylella fastidiosa* through Apulia and to contribute to the risk assessment for the disease (White et al., 2014). Following appropriate parameterisation, the model can be used to identify the spatial risk of disease spread and to assess the effectiveness of different risk reduction options. The model is also a useful tool to prioritise epidemiological information gaps regarding disease establishment and spread.

The project originates from an ongoing EFSA project by the CEH team to create an inventory and review of models for the spread of plant pests in the EU. The Decision Support Scheme from this project identified a spatially explicit epidemic simulation model produced by Sisterson and Stenger (2013) as the most appropriate model for *X. fastidiosa*, and the spread model is therefore based on this. A single run of the model produces a prediction of disease spread on a spatial grid representing the Apulia region. Multiple runs of the model can be performed to explore the consequences of the uncertainty in the epidemiological information available and to test the effectiveness of different risk reduction options. The model operates on two spatial scales, a within-patch scale and a between-patch scale (where a patch can be a field, orchard, or any amount of host in a grid cell). The original model by Sisterson and Stenger (2013) incorporated space explicitly at both spatial scales (i.e. individual plants within a patch as well as individual patches within the region). A simplified version of this model is produced in order to overcome the computational challenges associated with operating a simulation model on a landscape the size of the Apulia region. A single deterministic equation is used to represent disease progress at the within-patch scale. This is parameterised using data from a study of an observed citrus variegated chlorosis epidemic in a Brazilian citrus planting (Gottwald et al., 1993), but can also be fitted using available expert information on the likely values of primary and secondary infection in the Apulian region. A dispersal kernel is used to quantify the probability of dispersal between any two patches in the landscape. A negative exponential function is used, i.e. the probability of spread between any two locations decreases exponentially with distance.

The spread model is run on a landscape of olive hosts as current detections have primarily involved olive trees. The olive host map is generated from the Corine Land Cover Map at a grid cell scale of 1 km^2. Non-olive hosts can also be included, provided information on their spatial distribution and density is available. Where there is uncertainty in the host distribution, the model can be used to explore the consequences of different host distribution scenarios.

Preliminary results show that the spread model is highly sensitive to the dispersal scale used. Quantifying the dispersal scale through better understanding of vector movement is thus a priority (White et al., 2014). Some data are available from literature to suggest a scale of 100 metres is an appropriate mean dispersal distance. However, the role of longer-distance wind-mediated dispersal and human movement (both into and within Apulia) needs to be better understood as it will be key to establishing new foci and driving spread.

The model results are also sensitive to the amount of non-olive host in the landscape. Given that the host distribution of olive is relatively fragmented in Italy, compared with *X. fastidiosa* host distributions in the USA and Brazil, this may help to slow the spread of *X. fastidiosa.* However, non-olive hosts could act as stepping stones. Filling in these gaps, and understanding their epidemiological significance is key. Preliminary results also suggest that non-targeted roguing, on its own, may have limited effectiveness and that targeted roguing should be explored. However, this will also be highly sensitive to the dispersal scale and the amount of non-olive susceptible host in the landscape.

3.4.5. Containment of the pest within the risk assessment area

After taking into account the following points, the Panel considers that the pathogen is very unlikely to be contained in the risk assessment area:

- The number of confirmed or potential host plants is very large, which may lead to a continuum of available hosts over the landscape (for example, in Apulia, olive and oleander are grown throughout the whole region).
- Polyphagous, abundant and widespread known (*P. spumarius*) and potential vectors;
- It is impossible to interrupt all human movements (likely to help in transporting the bacteria with plants or their vectors) between the identified contaminated area and the rest of the risk assessment area.

- It is difficult to contain the vectors themselves within the identified contaminated area.

3.4.6. Conclusions on the probability of spread

The only route for natural spread of *X. fastidiosa* is by insect vectors that generally fly short distances, up to 100 metres, but it can probably be transported by wind over longer distances. Spread of infected plant material and vectors by the general public by car or boat, or by agricultural ground transportation, should also be considered. The movement of infected plants for planting is considered to be the most effective way of long-distance dispersal of *X. fastidiosa*. The spread is considered as very likely, with medium uncertainty. There is difficulty in delineating the limits of the contaminated area. However, this does not affect the low overall uncertainty regarding the probability of spread. It is difficult to characterize the extent to which the epidemiology and spread in the current contaminated area typifies potential spread in other areas.

Very likely	• There are a large number of confirmed or potential host plants. • A polyphagous, abundant and widespread vector is known (*P. spumarius*). • Spread may be by infected plants for planting, infectious insect vectors travelling as stowaways or infectious vectors flying or being transported over longer distances via wind. • It is impossible to contain the vectors within the identified contaminated area.

3.4.7. Uncertainties on the probability of spread

Medium	• The contributions of human- and wind-mediated spread are still poorly documented. • There is a lack of data on how far the insect vectors can fly. • There is a lack of precise data on how current practices possibly impact insect vectors. • There is a lack of data on the abundance of vectors within the risk area

3.5. Assessment of consequences

3.5.1. Pest effects

3.5.1.1. Negative effects on crop yield and/or quality to cultivated plants

The impact of *X. fastidiosa* on crops in the Americas is variable, depending on host plant, geographical region, epidemiological constraints and management options. The yield of most infected symptomatic plant species is negligible or not commercially acceptable; plants often die within years of infection.

Grapevine production in the south-eastern USA (e.g. Florida, Georgia) is considered to be economically unfeasible because *X. fastidiosa* is endemic and experimental vineyards are destroyed within years of planting (Anas et al., 2008). In California, on the other hand, grapevine production is differentially affected in different regions, depending on vector ecology. In central California (e.g. Napa and Sonoma valleys), where an endemic vector occurs at low densities, losses are low but regular, while in southern California, a decade ago, prior to the widespread use of pesticides to control the invasive vector *H. vitripennis*, *X. fastidiosa* caused the collapse of the local wine industry. A recent study has estimated the cost of *X. fastidiosa* disease to the grapevine industry in California (Alston et al., 2013; Tumber et al., 2014). Without the control of *H. vitripennis*, which is ongoing, loss estimates for the California grapevine industry would also increase.

In Brazil, approximately 40 % of 200 million citrus plants in Sao Paulo State show disease symptoms due to infection with *X. fastidiosa* (Almeida et al., 2014). There, small growers have been eliminated from the industry, orchards are replanted more frequently because of *X. fastidiosa* infections and the increased costs of controlling vector populations and surveying for vectors and symptomatic plants have substantially changed the Brazilian citrus industry. Economic losses due to tree removal alone

are estimated to be very severe (Bove and Ayres, 2007). However, in the case of the citrus industry in Brazil, it is difficult to discern the economic impact of citrus variegated chlorosis, caused by *X. fastidiosa*, from that of citrus greening, caused by *Liberibacter* spp. In Argentina, the disease killed 500 000 plum trees between 1935 and 1940 and was therefore considered to be a plague of national importance (http://www.agromeat.com/156985/inta-y-senasa-detectaron-la-bacteria-xylella-fastidiosa-en-olivos).

The emergence of oleander leaf scorch in California in the 1990s was associated with high mortality of plants used as decoration along highways. Oleander is a popular plant for landscaping along highways because it is hardy and easy to care for; it is common in California because it can tolerate the extreme high temperatures and dry climate found in the area. In 1997, CalTrans, the organisation responsible for the management of highways in California, estimated the economic impact of the loss of oleanders along highways in the state at US$125 million, with additional cost needed for plant replacement (Henry et al., 1997). In addition, motorways in southern California are now largely devoid of green plants in central reservations.

Most information available is based on crops of economic importance; little is known about the impact of *X. fastidiosa* on forest trees (e.g. oaks, elm), ornamental plants, or trees in urban and suburban environments. Most research on forest and shade trees is limited to the association of *X. fastidiosa* with symptomatic trees. Although it is evident that *X. fastidiosa* causes severe disease symptoms on some forest tree species, the relative importance, impact and incidence remain unknown or poorly understood. Oak leaf scorch disease is reported in the USA from southern New York to Georgia, with incidences up to 50 % in landscape planting (Sinclair and Lyon, 2005).

3.5.1.2. Magnitude of the negative effects on crop yield and/or quality of cultivated plants in the risk assessment area in the absence of control measures

It is difficult to infer the risks of *X. fastidiosa* to countries in the risk assessment area because of the ecological complexity of this pathogen and the fact that the fauna and flora, as well as climatic conditions, in the EU are different from those in the Americas. Without control measures, it is expected that the pathogen will eventually spread to all areas where ecological conditions are adequate. The relative impact of *X. fastidiosa* will depend on which host plant species are susceptible and which are not, and on the distribution and population abundance of vector species. If a genotype is pathogenic to citrus, for example, and conditions are adequate for establishment and spread, the expectation is that it would become a serious threat to citrus production in the risk assessment area. The same is true for other perennial fruit crops, such as those in the genus *Prunus* (almonds, peaches, plums, apricots, cherry). There is not enough information to provide a full assessment on the possible impact on forest/shade trees such as various oak species. In other words, if conditions are adequate for spread, the negative impact would be excessively high. If spread is limited there could be a very negative yet local impact. Unfortunately, the Panel cannot accurately assess the extent of negative impacts, other than to conclude that crops/regions with adequate conditions for pathogen spread would certainly see serious adverse impacts without the implementation of control strategies.

3.5.1.3. Magnitude of the negative effects on crop yield and/or quality of cultivated plants in the infected area of Salento (Lecce province) in the absence of control measures

Preliminary studies conducted in the infected area of Salento showed that the local strain of *X. fastidiosa* (CoDiRO strain, subspecies *pauca*) can infect, besides olive, stone fruits like almond and cherry, oleander and some other ornamentals (Saponari et al., 2013, 2014b). In contrast, *X. fastidiosa* has not been detected from citrus and grapevine, and until now preliminary transmission experiments have consistently failed to infect citrus and grapevine (Maria Saponari, CNR, Bari, Italy, and Donato Boscia, CNR—Institute for Sustainable Plant Protection, personal communication 2014). In the absence of control measures in the infected area of Salento, the negative effects on crop yield of olive are dramatic, as documented by the extended area with olive dieback. Although almond and cherry orchards are of of less importance than olive in Salento, these crops are more economically important

in other areas. Other known hosts of the local strain of *X. fastidiosa* are of landscape value, and therefore *X. fastidiosa* is also an important threat to these ornamentals. The populations of the known vector, *P. spumarius*, are locally very high, and therefore there is a much higher risk of continuous epidemic spread of the disease to the susceptible host plants with dramatic damages to olive orchards and to landscape ornamental species. Olive is a very important landscape tree in the area, in addition to being an economically important crop, and therefore a massive negative impact on the Salento landscape is expected.

3.5.1.4. Control of the pest in the risk assessment area in the absence of phytosanitary measures

To the Panel's knowledge, there are no examples of *X. fastidiosa* control without phytosanitary measures once it is established in agricultural crops. In the *X. fastidiosa*-infected area of Apulia, a number of insecticides are registered for use and routinely applied to control the main insect pests of crops (Regione Puglia, 2014). Several active ingredients used for the control of aphids, scale insects, mealy bugs, fruit flies and berry moths (e.g. neonicotinoids, flonicamid, organophosphates, pyrethroids) on crops that are known to be susceptible to the local strain of *X. fastidiosa* (olive, almond and cherry) or known to be important hosts of other *X. fastidiosa* strains/subspecies (citrus, grapevine) are also likely to have insecticide activity against the spittlebugs and sharpshooters that may act as vectors of *X. fastidiosa.* However, the time of the year for the insecticide application is intended to target the above-mentioned pests, and not *X. fastidiosa* vectors. This limitation, together with the lack of knowledge on the activity of most insecticides against xylem sap feeders, hampers prediction of the effectiveness of such insecticide applications against vectors. It is conceivable that the routine insecticide applications on the main crops reduce the risk of *X. fastidiosa* transmission by the spittlebug vectors but that the insecticides used are not able to protect plants from *X. fastidiosa* inoculation in the presence of the vector. Therefore, specific measures against the vectors are needed. Grass/weed cover is often present in perennial crops in the area, especially during the rainy season, and can host nymphal stages of the spittlebug vectors in the spring, as observed in the olive orchards (Cornara and Porcelli, 2014). In the risk assessment area, copper-based products are used to control plant-pathogenic bacteria, such as *Pseudomonas syringae* pv. *syringae* in citrus or a number of fungi on stone fruits and grapevine (Regione Puglia, 2014), but these products are not active against *X. fastidiosa.*

The CoDiRO strain of *X. fastidiosa* also infects ornamental plants of the genera *Acacia*, *Nerium*, *Polygala*, *Spartium* and *Westringia*, which are common in private gardens, along the roads and in the wild. No control of *X. fastidiosa* is achieved on these hosts in the absence of specific control measures. It is very likely, with low uncertainty, that the routine pest control strategies in the infected area are not effective enough to control the spread of *X. fastidiosa.*

3.5.1.5. Control measures currently applied in the risk assessment area

To date, as *X. fastidiosa* is not considered to be established in the risk assessment area (except in the Apulian area), no control measures specifically targeting the disease are in place. Nevertheless, the potential vectors of the bacterium may be, at least partly, controlled by the insecticides or the integrated pest management strategies already in place in orchards for other reasons. This may interfere with the spread of the disease.

3.5.1.6. Control measures currently applied in the infected area of Lecce province.

Recently, specific and compulsory measures to control *X. fastidiosa* epidemics have been designed by the Italian Ministry of Agriculture (Italian Ministerial Decree No 2777 issued on 26 September) and implemented in the area under the surveillance of the Phytosanitary Service of the Apulian Region (Resolution 1842 (Apulia Region), 5 September 2014). The measures are based on an integrated pest management strategy that includes insecticide applications against the vector, agronomic measures to suppress nymphal stages of the vector on the weeds and removal of infected plants. In more detail, olive orchards must be pruned at least every two years to identify early symptoms of infection, and shoots/branches with early symptoms must be eliminated while heavily symptomatic plants must be

uprooted. During January–April the soil in the olive orchards must be tilled or, alternatively, weeds must be mowed to destroy herbaceous hosts of the vector nymphs. Where the weed hosts of the vector nymphs are not easily accessible, herbicides can be used to eliminate these plants, or spot application of insecticides should be targeted to these host plants. From May to August, adult population of the vector must be targeted with insecticides in the olive canopy. From September to December, further insecticides can be applied to olive and with spot treatments on the weed hosts of the vector. From May onwards, weed removal is inadvisable because of the possible presence of vector adults, which would be forced to leave the weeds and eventually colonise olive or other susceptible plants. Any transportation of the cut/mown weeds is prohibited. Any production and marketing of propagation material of plants known to be susceptible to the locally identified strain of *X. fastidiosa* is prohibited in the infected area.

3.5.2. Environmental consequences

The Panel has identified two different categories of environmental consequences: the direct and indirect impact on the host plants themselves, and the indirect impact caused by the control methods implemented against the disease, in particular insecticide treatments.

Most of the *X. fastidiosa* diseases studied affect agricultural crops, but some forest trees are also affected (Sinclair and Lyon, 2005). In some areas, it is no longer possible to grow some host plants, e.g. grapevine in southern Florida, because of the intensity of the disease. The floristic composition of some cultivated, semi-natural or natural landscapes is thus likely to change, as well as the associated faunistic composition, leading to wide ecosystemic, agricultural and socio-economic consequences. A change of crop is likely to modify the historical and cultural image of the land, as well as the local economic activity in a very broad sense (agriculture, agro-industry, trade, tourism).

The intensive use of insecticide treatment to limit the disease transmission and control the insect vector may have direct and indirect consequences for the environment by modifying whole food webs with cascading consequences, and hence affecting various trophic levels. For example, the indirect impact of pesticides on pollination is currently a matter of serious concern (EFSA, 2013b). In addition, large-scale insecticide treatments also represent risks for human and animal health.

3.5.3. Conclusion on the assessment of consequences

Based on sections 3.6.1 (pest effect) and 3.6.2 (environmental consequences), the overall impact of the disease, even if control measures are used, is anticipated to be major. The disease would cause losses of yield and require economically and environmentally costly control measures. The presence of affected host plants in the vicinity of plant breeding companies or nurseries would reduce their access to some markets. The occurrence of the disease would also lead to increased insecticide use in groves and/or affected areas, which would give rise to environmental concerns.

Rating	**Justification**
Major	The consequences are rated as major: • Yield losses and damage would be high and imply costly control measures in commercial crops, smallholdings and family gardens, and when conditions are suitable for symptom expression and efficient insect vectors are present. Economic impacts are expected to affect agriculture itself, but also the whole economic chain downstream (agro-industry, trade, agro tourism). • The impact on the cultural, historical and recreational value of the landscape is expected to be high. • Insecticide treatments may have a direct impact on whole food webs and indirect impacts on various trophic levels (e.g. pollination).

3.5.3.1. Uncertainties on the assessment of consequences

Rating	
Low	Uncertainty is considered as low because: • The complexity of the disease depends on multiple factors, including agronomic and ecological conditions that might combine in different manner, leading to different degrees of impact. It is also difficult to predict the exact host range of a given strain and there is a lack of knowledge on the potential insect vectors in the risk assessment area • Based on a worst case scenario approach, considering the severe outbreak on olive in Apulia, the massive impacts reported on citrus in South America and on grapes in North America and the moderate to major consequences on forest trees in North America, there is low uncertainty on the assessment of major consequences of *X. fastidiosa* for the EU territory

3.6. Parts of the risk assessment area where the pest can establish and which are most at risk

Major crops affected by *X. fastidiosa* are cultivated in the risk assessment area. Besides olive, citrus and grapevine, as well as ornamental plants, such as *Nerium oleander*, other host plants, such as stone fruits, ornamental and forest trees (oak, elm, and American sycamore), are widely cultivated over the risk assessment area. The pest can establish easily in the southern part of Europe, which has a Mediterranean climate. There is little doubt that such host plants could be affected within Europe, even though the total area that might be affected remains an open question owing to a lack of data on the capacity of the bacteria to overwinter in locations with a cold winter.

Based on the areas where *X. fastidiosa* subsp. *multiplex* is currently found, it is believed that *X. fastidiosa* could also establish further north (see sections 3.3 and 3.4), at least in areas where winters are sufficiently mild or in plants such as forest trees (e.g. elm or oak). Nevertheless, because data are lacking, it is difficult to assess precisely how far north the pest could establish.

3.7. Conclusion of the pest risk assessment

Under current phytosanitary measures, the conclusions of the pest risk assessment conducted by the Panel are as follows:

The probability of entry on plants for planting is rated very likely because:

- The association with the pathway at origin is rated as very likely for plants for planting because (1) plants for planting are seen as a source of the bacterium for outbreaks, (2) host plants can be asymptomatic and often remain undetected, (3) a very large number of plant species are recorded as hosts and (4) very high quantities of plants for planting are imported from countries where *X. fastidiosa* is reported.

- The ability of the bacteria surviving during transport is very high.

- The probability of the pest surviving any existing management procedure is rated as very likely.

Additionally, the probability of transfer to a suitable host is rated as very likely, based on the intended use of the plant material for planting (rootstocks) or grafting (scions, budwood) as well as on the fact that host plants are extensively grown in the risk assessment area. Insect vectors are also largely distributed throughout the risk assessment area.

The likelihood of entry for the infectious insect vectors is moderately likely because the pest:

- is often associated with the pathway at the origin;
- is moderately able to survive during transport or storage;
- is affected by the current pest management procedures existing in the risk assessment area;
- has some limitations for transfer to a suitable host in the risk assessment area.

The probability of establishment is rated as very likely, based on the very high probability that the pathogen will find a suitable host because of the very large range of host plants and potential host plants and the wide distribution and polyphagy of known and potential vectors. Other elements taken into account are the high probability of finding a climatically suitable environment, with no known adverse abiotic factors and no known natural enemies of *X. fastidiosa*, as well as some conflicting information regarding winter recovery in infected plants with regards to the different subspecies of *X. fastidiosa*. The fact that there are no fully effective cultural practices or control measures should also be stressed.

The probability of spread is a rated as very likely, because of the large number of confirmed or potential host plants and the abundance and widespread distribution of known (*P. spumarius*) or potential vectors. It is also considered impossible to interrupt all human movements (likely to help in transporting the bacteria or their vectors) between the identified contaminated area and the rest of the risk assessment area, as well as to contain the vectors themselves within the identified contaminated area.

The overall consequences are rated as major because, in commercial groves, and when optimal agro-ecological conditions would meet efficient insect vectors, yield losses and damages would be high and imply costly control measures. The disease is also likely to have a negative social impact since it is not readily controllable in smallholdings and family gardens. Depending on the host range of the *X. fastidiosa* subspecies introduced, major crops, ornamental plants or forest trees could be affected, as in other areas of the world. In addition to these considerations, the use of insecticide would give rise to environmental concerns. Furthermore, breeding and nursery activities might be affected.

3.8. Degree of uncertainty

Uncertainty regarding entry via the plants for planting pathway is considered as medium, because the distribution of *X. fastidiosa* in the countries of origin is not fully known, knowledge of host plant susceptibility is only partial, only a few interceptions have been recorded, and it is difficult to detect asymptomatically contaminated plants. The difficulties in assessing precisely the quantities of plants for planting imported into the EU are also a matter of uncertainty. Additionally, for the pathway "infectious vectors", only limited data on *H. vitripennis* are available on the vectors' capacity to survive long-distance transportation on their own in vehicles. Similarly, only limited data on *H. vitripennis* are available on the vectors' autonomous dispersal capacity. There are no data on the interception of vectors in the EUROPHYT database.

The uncertainty level for establishment is a rated as low, based on the fact that *X. fastidiosa* is already established in Apulia. There is no uncertainty regarding the availability of a wide range of host plants, but questions remain regarding the susceptibility of the indigenous European flora. There is one confirmed vector species (*P. spumarius*), which is widespread, abundant and polyphagous; a large number of additional potential vectors are yet to be studied. A large range of suitably climatic environments is available in the risk assessment area. There is a lack of data regarding the overwintering capacity at low temperature and, more generally, regarding the range of temperature over which the bacteria can thrive.

Concerning the spread, the uncertainty is rated as medium. The role of human- and wind-mediated spread is still uncertain. There is a lack of data on how far the insect vector can fly. There is also a lack of precise information about how current farming practices could possibly impact potential insect vectors and limit the spread of the disease.

The uncertainty for the consequences is rated as low, based on a worst-case scenario approach. The exact host range of a given strain, the lack of knowledge on the potential vectors in the risk assessment area and the agro-ecological complexity of the diseases shall nevertheless be taken into account.

4. Identification and evaluation of risk reduction options

The identified risk reduction options are rated for their effectiveness, technical feasibility and uncertainty, as described in the tables in Appendix E. First, risk reduction options to reduce the probability of entry, establishment and spread of *X. fastidiosa* are systematically identified and evaluated for the two main pathways of plants for planting and of infectious vectors. Then, the current phytosanitary measures related to *X. fastidiosa*, its vectors and host plants in the EU are presented and discussed.

Risk reduction options to prevent entry and spread are dealt with together when they are common to both steps. When an option is relevant for only one of the two steps, entry or spread, this is specified in the text and in the tables. For each pathway, each risk reduction option is evaluated as a stand-alone measure, assuming that no other risk reduction options are in effect, either for that pathway or for the other pathways. Systems approaches integrating two or more risk reduction options are identified and evaluated for pathways where possible.

It should be noted that, owing to the very wide host range of *X. fastidiosa*, as well as to the variation of such host range depending on the strain considered, the proposed risk reduction options should be adapted, on a case by case basis. Similarly, the type of vector(s) might differ from one situation to another.

4.1. Identification and evaluation of risk reduction options to reduce the probability of entry and spread for the pathway plants for planting

In the following sections of this chapter, the identified risk reduction options are valid for both preventing the entry of *X. fastidiosa* into the EU from Third countries and preventing its spread from an outbreak area into other areas within the EU. Only plant species that are known to be hosts of *X. fastidiosa* (according to detection tests, with or without symptoms, susceptible, tolerant or asymptomatic carriers) are considered here although it is assumed that a larger number of plant species that have not been studied in this regard may also be associated with *X. fastidiosa.* A summary of the applicable risk reduction options identified and evaluated for this pathway is shown in Table 6.

4.1.1. Options ensuring that the area, place or site of production at the place of origin, remains free from *X. fastidiosa*

The International Standard for Phytosanitary Measures No 4 (FAO, 1995) describes the components to consider when establishing and delimiting pest-free areas (PFAs). A ‘pest-free area’ is ‘an area in which a specific pest does not occur as demonstrated by scientific evidence and in which, where appropriate, this condition is being officially maintained’. It can be an entire country, an uninfested part of a country in which a limited infested area is present or an uninfested part of a country within a largely infested area.

The International Standard for Phytosanitary Measures No 10 (FAO, 1999) makes provisions that:

- A pest-free place of production is a place of production in which a specific pest does not occur, as demonstrated by scientific evidence, and in which, where appropriate, this condition is being officially maintained for a defined period.

- A pest-free production site is a defined portion of a place of production in which a specific pest does not occur, as demonstrated by scientific evidence, and in which, where appropriate, this condition is being officially maintained for a defined period and which is managed as a separate unit in the same way as a pest-free place of production.

In order to comply with this phytosanitary measure, the pest should comply with certain characteristics:

- The natural spread of the pest (or its vectors, if appropriate) is slow and over short distances.
- The possibilities for artificial spread of the pest are limited.
- The pest has a limited host range.
- The pest has a relatively low probability of survival from previous seasons.
- The pest has a moderate or low rate of reproduction.
- Sufficiently sensitive methods for detection of the pest are available, either visual inspection or tests applied in the field or in the laboratory, at the appropriate season.
- As far as possible, factors in the biology of the pest (e.g. latency) and in the management of the place of production do not interfere with detection.

4.1.1.1. Limiting import to plants for planting originating in pest-free areas

When the import of plants for planting of hosts of *X. fastidiosa* is restricted to material originating in pest-free areas, the probability of introduction of *X. fastidiosa* into the risk assessment area is reduced. The effectiveness depends on the frequency and the confidence level of detection surveys to confirm absence of *X. fastidiosa* in the pest-free area and the buffer zone, and the intensity of phytosanitary measures to prevent entry of infected plant material as well as of infectious vectors into the pest-free area. The design and frequency of surveys to confirm absence of *X. fastidiosa* in the area and the buffer zone should take into account, beside crops, the presence of host weeds, unmanaged host plants in gardens, parks and uncultivated areas and the possible presence of latently infected plants, in order to accomplish the required confidence level of the surveys. Detailed information on surveillance and survey is provided in sections 4.3.1 (Surveillance) and Appendix F.

Effectiveness

The effectiveness of a PFA system is assessed as high when perfectly managed.

Technical feasibility

The establishment and maintenance of a pest-free area for *X. fastidiosa* is technically feasible, but surveys with adequate attention to the distribution of managed and unmanaged host plants in the pest-free area should be performed when designating the pest-free area and its buffer zone. Such an approach represents a huge amount of work.

The technical feasibility is assessed as high.

Uncertainty

The uncertainty of these ratings is moderate because of the difficulty of ensuring that all plants and vectors remain uninfected.

4.1.1.2. Limiting import to host plants for planting originating in pest-free production places or pest-free production sites

It is possible to limit the importation of host plants for planting to plants that have been produced either in pest-free production areas or in pest-free production sites. The application of insecticides that are active against *X. fastidiosa* vectors to plants grown inside screen houses increases the chance of obtaining healthy plants.

Effectiveness

The effectiveness of designation and maintenance of pest-free production places or pest-free production sites with respect to *X. fastidiosa* within an infested area is assessed as low except in the context of a system approach with plants grown under well-maintained exclusion systems.

Technical feasibility

The feasibility of producing healthy plants in an area where *X. fastidiosa* is present, relying on the concepts of pest-free production places or sites, is considered as low for export purposes, because of the very wide host range of the bacterium, the large numbers of known and putative xylem sap-feeding vector species that can spread naturally up to 100 metres and at longer distances by wind or as hitch-hikers in vehicles, and the possible presence of asymptomatic infections. Feasibility may nevertheless be increased when other risk reduction options, such as growing plants under exclusion (screen houses; see section 4.1.2.3 below), are applied.

Uncertainty

Uncertainty is low.

4.1.1.3. Limiting import of host plants for planting to plants originating in pest-free production places or pest-free production sites where insect vector populations are surveyed and kept under control

X. fastidiosa is disseminated by insect vectors. Early infections are difficult to detect. Moreover, planting material could be healthy but may harbour infected insect vectors that could transmit the disease to plants for planting material at destination, or transmit it to plants already grown in the surroundings at destination. Special efforts are then necessary to ensure that (1) insect vector populations are surveyed and kept at extremely low level in growing plots and (2) exported lots are free from living insect vectors.

Effectiveness

The effectiveness of designation and maintenance of pest-free production places or pest-free production sites with respect to *X. fastidiosa* within infested areas, for export purposes, when additional measures are taken to keep insect vector populations under strict control, is assessed as low because of the difficulty of preventing infectious vectors from entering from the outside.

Technical feasibility

The technical feasibility is considered as moderate.

Uncertainty

Uncertainty is medium as it is difficult to ensure that all measures are appropriately applied.

4.1.2. Options preventing or reducing *X. fastidiosa* infestation in the crop at the place of origin

4.1.2.1. Cultural practices at the level of the crop, field or place of production that may reduce pest prevalence

For diseases that are vector transmitted, the impact can be mitigated by actions on the plant itself, or on the disease or on its vectors, providing these actions are coordinated over large enough areas.

Helping the plant to react against the disease

In general, Hopkins and Purcell (2002) state that the cultural practices that maintain the grapevine in a healthy, actively growing condition can lead to reduction in the severity of symptoms of Pierce's disease. But this does not prevent the plant from acting as a reservoir of *X. fastidiosa* for insect vectors or from eventually becoming heavily symptomatic.

Effectiveness

The effectiveness of those practices is considered to be negligible for phytosanitary purposes as they only reduce the bacterium population in a plant and do not prevent entry to the territory.

Technical feasibility

Feasibility is rather high, at least for the species studied by the authors, under some very precise conditions.

Uncertainty

Uncertainty is considered to be very high.

Control of the disease *in planta*

Pruning of sweet orange trees in Brazil was reported to reduce the symptoms of citrus variegated chlorosis and eliminate infection, but only in very specific conditions at the very beginning of symptom development (Amaral et al., 1994). Pruning must be very aggressive to work well, extending to large portions of plants and should be accompanied by frequent surveys and effective vector population control. Other examples of successful control by pruning are not available in the literature. This approach is very much dependent on how fast and far the bacterium is moving along the xylem vessels and therefore the extent of its distribution in the plants. These strategies, which are applicable only to some groves, and only when very early symptoms are observed, must be implemented over a large area; otherwise infectious vectors from the surrounding vegetation/neighbouring agricultural fields can reinfect the area, making the strategy unsuccessful. Lastly, it should be noted that pruning has been shown to work for only one crop, sweet orange, despite the fact that it has been tested elsewhere (e.g. grapevines, a crop in which pruning does not work). Also, it should be kept in mind that pruned plants may still act as reservoirs for insect transmissions.

Apart from the case described above, there is no control method currently available to eradicate *X. fastidiosa* from infected plants. According to Almeida (Rodrigo Almeida, University of Berkeley, USA, personal communication, December 2014), who refers to tests by Purcell, pruning to control disease does not work with grapes.

Bacteriophages, viruses that infect bacteria, have been identified for *X. fastidiosa* (Summer et al., 2010; Ahern et al., 2014). The use of bacteriophages to control plant diseases has been explored for several Xanthomonadaceae. a group of bacteria that have an epiphytic phase (Civerolo and Keil, 1969; Filho and Kimati, 1981; Balogh, 2006) but not *X. fastidiosa.* Civerolo (1971) conjectured that, once into the plant, it was very difficult to achieve control through phages. Current work has been limited to the description of viruses, although it is expected that they will be tested in the future. The use of bacteriophages to control plant diseases is fraught with risks (Jones et al., 2007, 2012), such as resistance, and uneven killing of target cells within hosts.

Recently, it was reported that N-acetylcysteine, which is used to treat some human diseases, has *X. fastidiosa*-killing activity and resulted in a decrease in bacterial populations and significant symptom remission in citrus (Muranaka et al., 2013). An important aspect of this work was the

remission of symptoms upon application of this molecule during irrigation, but it should be noted that *X. fastidiosa* populations remained viable in the plant and symptoms reappeared several months after treatments stopped. More importantly, treated plants would remain as a source of *X. fastidiosa* for vectors, allowing spread to occur to areas treated with this product, as well as in areas that had not been treated.

Inoculation of *Vitis vinifera* in greenhouse and in vineyards with naturally occurring strains of *X. fastidiosa* subsp. *fastidiosa* that were weakly virulent or avirulent to grapevine resulted in some reduction in symptoms development (Hopkins, 2005); however, reports have shown that these results are so far not broadly applicable when tested in different grape-growing regions (Hopkins et al., 2011). In this specific case, however, the use of the strain of subspecies *fastidiosa* being tested in the USA in the EU would represent the introduction of novel *X. fastidiosa* genetic diversity into the risk assessment area. This could be an important problem because of the very high rates of *X. fastidiosa* recombination rates in the field (Nunney et al., 2013, 2014) and laboratory (Kung and Almeida 2011, 2014); in other words, recombination between the genotype present in Apulia, Italy, and any novel genotype could lead to recombination and eventually the emergence of new diseases. Furthermore, the strategy of using avirulent strains to fight *X. fastidiosa* infections may be counterproductive, as changes in virulence or reversions of avirulent strains may occur through lateral gene transfer, a phenomenon well known to occur in *X. fastidiosa* (e.g. de Mello Varani et al., 2008). Similarly, some plant endophytes might also help to control *X. fastidiosa*, but results are not conclusive and the work in this area is largely experimental at this stage (Lacava et al., 2004).

Although the use of antibiotics to control plant bacterial diseases is not normally recommended, to avoid increasing resistance to antibiotics in general, the efficacy of several antibiotics has been investigated, among which is tetracycline (Hopkins and Mortensen, 1971; Lacava et al., 2001).

The risk of developing multidrug resistance following either antibiotic or copper-based controlled measures should be considered (Muranaka et al., 2013).

Effectiveness

The effectiveness of the above mentioned methods for disease control *in planta* is considered to be negligible for phytosanitary purposes.

Technical feasibility

Feasibility is considered moderate for pruning owing to the difficulty of removing infective plant parts in due time. Feasibility is considered as low for bacteriophages and avirulent strains of *X. fastidiosa* as it is difficult to inject them into the plant. The feasibility is considered to be low for all compounds that are to be sprayed (antibiotics, N-acetylcysteine, etc.) as they are unlikely to reach the bacterium.

Uncertainty

Uncertainty is considered to be low.

Control of the vectors throughout the growing season

X. fastidiosa is transmitted by many different xylem sap-sucking insect species to different host plants, so the epidemiology of the different epidemics can vary, even for the same disease in different areas. For example, the spread of Pierce's disease in coastal northern California is due to primary infections, whereas in southern California secondary spread by the vector *H. vitripennis* is important (Hopkins and Purcell, 2002). Primary infections are defined as occurring from outside the plot (vineyard, olive grove) whilst secondary spread is the transmission of the disease within the plot (Almeida et al., 2005). In the case of the Italian outbreak in the Apulia region, the preliminary research results suggest that both primary infections and secondary spread occurred, with the latter predominating. This explains why some fields are infected at a distance from others and why the disease can attack up to 100 % of olive plants in certain groves.

Chemical treatments against insect vectors in the case of primary infections

When infections are predominantly or exclusively primary (incoming infected insect vector from outside the crop) (such as in northern California vineyards), insecticide applications on the crops are not very effective (Purcell, 1979). The vectors live outside the crop and visit it from time to time over a long period of the year, transmitting the pathogen even with very short feeding periods (Almeida et al., 2005). However, insecticide applications to the crop and on vegetation adjacent to vineyards can kill the vectors before they visit many different plants, thus reducing spread (Purcell, 1979), providing the treated zone is large enough.

Effectiveness

If primary infections predominate, insecticide applications on the crop are of low effectiveness. The application of insecticides in the strips of vegetation around crops could be considered as of moderate effectiveness.

Technical feasibility

The technical feasibility is high (but it is also important to consider environmental consequences). Nevertheless, there may be difficulties as the farmer does not necessarily own the zones in the vicinity of cultivated plots and because environmental concerns may arise.

Uncertainty

Uncertainty is considered as medium as data are available only in the case of vineyards. Concerning insecticide application in the environment around the crops, uncertainty is high as this method is poorly documented.

Chemical treatments against insect vectors in the case of secondary spread

When secondary spread is important (within the crop, as for the vector *H. vitripennis* in southern California), insecticide applications can be more effective because they target the vector population that lives in the crop and can successfully reduce the vector population (Almeida et al., 2005; Saracco et al., 2008). Nevertheless, recolonisation from borders may occur quickly, and, even with low populations, insects may still transfer the bacterium from plant to plant inside the plot. In addition, this strategy does not prevent the pest from jumping from one plot to the other by means of insect vectors. Furthermore, insects coming from adjacent untreated plots or from the environment can still visit infested plots, acquire the bacterium and transmit it to other plants at distance, which represents a threat to healthy plots. Neighbouring plots could also be treated with insecticides, but this would lead to concerns in terms of technical feasibility and of protection of the environment and health. Sharpshooters and spittlebugs are susceptible to a number of insecticides (Prabhaker et al., 2006a, b) and particularly to neonicotinoids that, being translocated via the xylem, target xylem sap feeders, thus reducing the spread of *X. fastidiosa* from plant to plant in the plot (Krewer et al., 1998; Bethke et al., 2001). Sharpshooters and spittlebugs are unlikely to develop resistance to insecticides quickly because they only have one or two generations per year and they are not very prolific. This hypothesis is confirmed by experimental data on the susceptibility of different life stages of *H. vitripennis* to a number of different insecticides (Prabhaker et al., 2006a, b).

Effectiveness

If secondary spread is prevalent, insecticide applications on the crop are of moderate effectiveness in slowing spread of the disease within a plot.

Technical feasibility

The technical feasibility is high (but one has to consider the environmental and health consequences of sprays).

Uncertainty

Uncertainty is considered as medium as data are available only in the case of vineyards.

Vector control in nurseries

The effectiveness of a permanent vector control by pesticides in nurseries of plant propagation material is increased by growing the crop in a screen house or greenhouse, keeping it free from weeds, applying well-timed insecticides and monitoring for the presence of vectors.

Effectiveness

The effectiveness is evaluated as high.

Technical feasibility

Feasibility is considered as high.

Uncertainty

Uncertainty is low.

Vegetation management

Since the immature life of most, if not all, *X. fastidiosa* vectors and potential vectors is associated with herbaceous hosts and weeds (Table 2), and since this has been verified also for *P. spumarius* in the particular case of the olive groves in Apulia (Cornara and Porcelli, 2014), the elimination of weeds within and around the susceptible crops may help in reducing the vector populations. In the context of an outbreak, the elimination of weeds may help to reduce the dissemination of the disease inside the plot and to other distant plots or to the environment. Weed management techniques should be carefully tailored to the behaviour of insect vectors. A late elimination of weeds (by cutting or herbicide application when adults are already emerged) may result in a massive transfer of the vectors from the weeds to the crop, resulting in increased transmission, while an earlier elimination of the weeds, before the emergence of adults, might prevent the establishment of sharpshooters and spittlebugs in the environment of the crop, thus helping to reduce the dissemination of the bacterium from plant to plant. Keeping the plots and their environment free of weeds is particularly important for nurseries, in both open field and screen house conditions.

Removal of plants other than the main crop from the field and the environment may be difficult for various reasons. Farmers do not necessarily have access to tools adapted for such work, secondary crops may be cultivated under the shade of trees in orchards and herbicide treatments may lead to environmental or health problems.

Effectiveness

The removal of plants from the plots and their environment is a very effective risk reduction option for insect vectors that are not able to accomplish their entire life cycle on the crop. Effectiveness is very high.

Technical feasibility

The technical feasibility ranges from low to high depending on the local conditions in the plots and their environment.

Uncertainty

Uncertainty is high as the behaviour of potential insect vectors in crops such as olive, grapevine, citrus, stonefruits etc., in the EU is not well known.

Insect biocontrol

Successful biocontrol of *H. vitripennis* has been achieved in French Polynesia with the introduction of the egg parasitoid *Gonatocerus ashmeadi* (Grandgirard et al., 2008); however, with *X. fastidiosa* absent from French Polynesia, it is not possible to conclude whether biocontrol of the vector would also result in a significant reduction in the spread of *X. fastidiosa.* Population thresholds for vector insects are generally very low because a few individuals can transmit the pathogen to several plants whilst biological control implies that a balance between the entomophagous and the host population is maintained at a level that can be too high to prevent pathogen spread.

Effectiveness

The effectiveness of biocontrol of insects is considered to be low. Natural control has not prevented the occurrence of large populations of *P. spumarius* in the outbreak area in Apulia. Biological control can have a subsidiary benefit by helping to suppress the vector population, but it is considered to be insufficiently effective by itself.

Technical feasibility

The technical feasibility ranges from low to high as no data are available.

Uncertainty

Uncertainty is high.

4.1.2.2. Resistant or less susceptible varieties

Breeding of resistant or less susceptible varieties

Several studies have addressed the plant varietal resistance and/or tolerance to *X. fastidiosa* infection on different plant host species (He et al., 2000; Krivanek et al., 2005; Ledbetter and Rogers, 2009; Ledbetter et al., 2009; Cao et al., 2011; Wilhem et al., 2011; Sisterson et al., 2012). It is clear that varietal differences within plant species and genera are relevant to the development of *X. fastidiosa* infections and disease symptoms. On the other hand, the role of within-subspecies *X. fastidiosa* diversity on virulence is poorly understood, with only a few examples of phenotypic diversity during infection at that level of pathogen diversity (e.g. Daugherty et al., 2011). Resistant varieties, which do not sustain any *X. fastidiosa* multiplication and persistence, are difficult to identify experimentally. But various degrees of tolerance, whereby plants sustain infections but are not symptomatic, have been identified for various crop species.

The potential effectiveness of resistant or tolerant varieties seems to be moderate to high, at least for grapevine, in the context of a contaminated country. Importantly, however, mathematical modelling has shown that the use of tolerant varieties may increase the incidence of disease for vector-transmitted diseases such as *X. fastidiosa* (Zeilinger and Daugherty, 2014). Tolerant varieties may be a threat to non-contaminated countries as such varieties may host *X. fastidiosa* without showing any symptoms and may escape detection when tested prior to or at import.

Most work on breeding for plant resistance/tolerance has been done with *Vitis vinifera* in California. A combination of traditional and biomolecular approaches was used to identify PdR1 (a quantitative trait locus, QTL) as a primary resistance gene to the development of Pierce's disease in *Vitis* (Krivanek et al., 2006). Differences in susceptibility to *X. fastidiosa* among *Vitis* species were used as the basis for such work (Krivanek et al., 2005). However, even in the case of a 'resistant' *Vitis* variety, bacterial multiplication is observed (Baccari and Lindow, 2011). Within *V. vinifera*, for example, the degree of plant susceptibility and symptom development can be variable in experiments under controlled conditions. Rashed et al. (2013) studied the relative susceptibility of *Vitis vinifera* cultivars to *X. fastidiosa* and indicated that, within *V. vinifera*, the degree of cultivar resistance and tolerance varies over time. Work has been performed to introgress PdR1 into commercial grapevine varieties.

However, as this is only one locus, it is possible that the pathogen may overcome this resistance trait. Furthermore, owing to the extremely large genetic diversity of grapevine cultivars commercially used throughout the EU, it is difficult to envisage a process whereby resistant varieties can be bred and introduced into the marketplace in a timely manner. Although it remains largely unexplained, Wallis et al. (2013) have shown that rootstock could affect *X. fastidiosa* infection and spread in grapevine. If some varieties are currently under field trials, commercially available tolerant varieties are not expected for at least three to six years.

A similar situation is observed with *Citrus*: all *Citrus sinensis* varieties are susceptible, to one degree or another, to *X. fastidiosa* infection. Nevertheless, some varieties appear to be tolerant to the disease (Fadel et al., 2014). Similarly to *Vitis*, there are varying degrees of resistance/tolerance to *X. fastidiosa* within the genus *Citrus* and hybrids within *Citrus* (Laranjeira et al., 1998; Coletta-Filho et al., 2007). Most mandarins (*C. reticulata*) are considered resistant to the disease. Tangors (*C. sinensis* × *C. reticulata*) are usually resistant, with a few exceptions. All lemons, acid lime and pomelos tested to date are resistant (Coletta-Filho et al., 2014). However, experimental work has also indicated that 200 *Citrus sinensis* varieties tested are susceptible (Laranjeira et al., 1998). Hybrids (*C. sinensis* × *C. reticulata*) have been selected for tolerance to the disease and are currently at the field demonstration step in Brazil (De Souza et al., 2014).

The variability in susceptibility among almond cultivars has also been previously demonstrated (Cao et al., 2011; Sisterson et al., 2008, 2012). The use of rootstocks selected for tolerance has been proposed as an aid to control the disease in nurseries (Krugner et al., 2012). Similarly, it was shown that rootstocks were able to influence both *H. vitripennis* feeding behaviour and concentration of *X. fastidiosa* in peach scions (Gould *et al*., 1991).

Nevertheless, the diversity of strains of *X. fastidiosa* makes the evaluation of varieties complex in terms of resistance to the disease. Such diversity may also compromise the development of resistant or tolerant varieties, as resistance to many bacterial genotypes could be necessary to obtain varieties with wide resistance. Research is ongoing to develop genetically modified varieties with resistance to *X. fastidiosa* (De Paoli et al., 2007). Varietal improvement takes years and a complete offer of high resistance and well performing agronomic varieties cannot be envisaged in the coming years.

Effectiveness

The effectiveness of using resistant or tolerant varieties in the near future is rated as moderate.

Technical feasibility

Considering the very wide host range of *X. fastidiosa* and the time needed to breed and introduce new resistant varieties, and also given the diversity of strains, the technical feasibility is considered as low to moderate.

Uncertainty

Uncertainty is considered as high as no information on resistance is available for most of the crops susceptible to *X. fastidiosa.*

Use of new technologies to develop varieties with good resistance to *X. fastidiosa*

Novel strategies have also been considered to control *X. fastidiosa* diseases, primarily on grapevines in the USA. These are primarily derived from basic research done on the biology of this pathogen. Today, they are all considered experimental, some being currently tested in the field while others are still being subjected laboratory or greenhouse testing. Some of these exploit plant genetic transformation and the production of bioengineered plants.

There are reports of different bioengineered plant-based technologies to reduce the impact of *X. fastidiosa* infections on host plants. For example, grapevines expressing a chimeric protein that included a lytic peptide targeting bacterial outer membranes (cecropin B) decreased symptom expression and cell growth (Dandekar et al., 2012). Other cases include proteins that inhibit *X. fastidiosa* enzymes required for host plant cell wall degradation (Agüero et al., 2005). A third concept proposes to block plant-to-plant spread by blocking interactions between *X. fastidiosa* and its insect vectors (Killiny et al., 2012). These and similar approaches require plants to express introduced proteins within plants.

A distinct approach is based on pathogen confusion. The concept is based on the fact that *X. fastidiosa* cells stop colonising plants when populations reach high cell densities (Chatterjee et al., 2008). This process is mediated by a short-chain fatty acid, named DSF (diffusible signal factor), that functions as a signalling molecule that triggers changes in gene expression (Beaulieu et al., 2013). Degradation of DSF by other bacteria coinoculated with *X. fastidiosa* led to suppression of disease symptoms (Newman et al., 2008), while production of DSF by genetically modified grapevines also led to a reduction in disease severity (Lindow et al., 2014). Apart from genetically transforming plants, early efforts are being made to deliver DSF or its analogues by spraying plants or by using other endophytic bacteria that coinhabit the xylem. Sprayable DSF, if viable, could function similarly to regular applications of other chemical compounds on agricultural crops.

Effectiveness

The effectiveness of bioengineered plants that would be resistant to *X. fastidiosa* is rated as moderate as such innovations are not yet proven to work under field conditions.

Technical feasibility

Considering the very wide host range of *X. fastidiosa* and the time needed prepare a risk assessment dossier prior to the release of bioengineered plants in the environment, the technical feasibility is rated as low in the short term.

Uncertainty

Uncertainty is considered as high as no information on novel techologies is available for most of the crops susceptible to *X. fastidiosa.*

4.1.2.3. Growing plants under exclusion conditions (glasshouse, screen, isolation)

Plants for planting can be grown in screen house or greenhouse nurseries that effectively can exclude insect vectors. An important example is the control of citrus variegated chlorosis, a citrus disease caused by *X. fastidiosa* in Brazil, where a major contribution to improvement of the situation came from growing all the citrus nursery plant production system (rootstock, budwood and plants, including mother plants) in a screen house (Carvalho et al., 2002). Screen barriers have also been shown to reduce the movement of *X. fastidiosa* vectors into vineyards or plant nurseries (Blua and Redak, 2003; Almeida et al., 2005). To prevent virus and phytoplasma infections in the propagated material, mother plant vineyards can be grown under a cover of an insect-proof tunnel with double room entrance (Mannini, 2007). This method can be further improved when insecticides are used to control insects.

Effectiveness

The effectiveness of this option is assessed as high, provided that the planting material introduced in the screen house is free of *X. fastidiosa.*

Technical feasibility

Technical feasibility is high, because this is a common practice already implemented in Mediterranean countries for control of viral diseases in citrus nurseries as well as for other tree crops, including grapevines.

Uncertainty

The uncertainty is low.

4.1.2.4. Harvesting of plants at a certain stage of maturity or during a specified time of year

This is not applicable as, once infected, plants remain so for life. The only exception is the phenomenon of winter recovery reported in grapes and some other plants (see section 3.3.2.1). However, this process is not considered to be sufficiently well documented to guarantee the health status of plants for planting.

4.1.2.5. Certification schemes

Certification schemes have been developed worldwide for citrus plants for planting (e.g. Von Broembsen and Lee, 1988; Passos et al., 2000; Vidalakis et al., 2010; Australian Citrus Propagation Association Inc. (www.auscitrus.com.au), as well as for other fruit tree crops. Following the outbreak of citrus variegated chlorosis in 1987, a voluntary certification scheme was implemented in Sao Paulo state in Brazil for the production of citrus budwood and nursery trees free of graft and vector-transmissible diseases, including citrus variegated chlorosis (Carvalho et al., 2002). It is now common practice for all citrus nursery plant production systems (rootstock, budwood and plant) to be in screen houses, including the mother plants. Moreover, there is a restriction on the receipt of citrus vegetative material from other Brazilian states that do not have a certification programme in place. Every lot (2 000 plants) of citrus nursery plants commercialised must be tested for *X. fastidiosa* and other diseases and pests by sampling the plants in the lot and mixing the material (Carvalho et al., 2002).

Nevertheless, because of the length of the incubation period, a recent infection could pass through the certification system without being detected. This means that any certification scheme in areas where the disease and its insect vectors are present should always be coupled with growing plants under exclusion conditions and with monitoring and control of insect vectors.

Effectiveness

In general, well-managed schemes to certify that plants for planting are free of *X. fastidiosa* can be considered to have high effectiveness, particularly in areas with low prevalence of the disease and of the insect vectors. Effectiveness is considered as moderate for certification schemes in areas where the disease and vectors are present. However, it should be noted that, to be effective, this measure, particularly in areas where the disease and vectors are present with a high prevalence, needs to be conducted as part of an integrated approach combining testing and propagation schemes with screen houses and vector control.

Technical feasibility

The feasibility of certification is high, as already shown in Brazil for citrus.

Uncertainty

Uncertainty is moderate as published examples of the success of certification of plant propagation material in areas where *X. fastidiosa* is present are limited to only a few crops (e.g. citrus and grapes).

4.1.3. Options for consignments

4.1.3.1. Prohibition

Prohibition of import of plants for planting of host plant species of *X. fastidiosa* from the areas of its current distribution would very effectively prevent the entry of *X. fastidiosa* and of some of its insect vectors into the risk assessment area along this pathway, which is considered to be the most important.

Prohibitions are already partly in force, as Directive 2000/29/EC bans imports of citrus and grapevines plants and limits imports of *Prunus* species to dormant plants free from leaves, flowers and fruit, for instance. However, many insect vectors (see Table 3 and Appendix D) are not taken into consideration in the EU regulations at the moment and, owing to the very broad range of host species and the number of potential vector species, it may be difficult to impose a ban on such a very large range of species. In addition, the efficacy of such prohibition measures could also be jeopardised because of the lack of extensive studies on the host range of some subspecies/strains of *X. fastidiosa*, as well as the possibility of changes in the host range of a specific strain of *X. fastidiosa* as a result of mutations/recombination or the finding of new vector–host combinations in new areas (Almeida, 2008).

In the absence of scientific data on *in vitro* plants as a pathway for *X. fastidiosa* spread, the Panel noted that *in vitro* plants, unless originating from countries with appropriate certification schemes, present similar risk to other plants for planting. The bacterium grows in the xylem and is difficult to cultivate in artificial media; thus, it could easily pass undetected through the *in vitro* production processes.

Effectiveness

The effectiveness of a prohibition of import of plants for planting of host plant species of *X. fastidiosa* is assessed as very high.

Technical feasibility

The feasibility of such measures is high (such as already done for citrus and grapes); nevertheless, because of trade issues it may be difficult to apply this measure to the entire wide host range of this bacterium.

Uncertainty

Owing to the lack of extensive studies on the host range of some subspecies/strains of *X. fastidiosa*, as well as the possibility of changes in the host range of a specific strain of *X. fastidiosa* as a result of mutations/recombination or the finding of new vector–host combinations in new areas (Almeida, 2008), there is a moderate uncertainty on the ratings above.

4.1.3.2. Prohibition of parts of the host plants

All parts of host plants for planting may carry *X. fastidiosa*, whatever their physiological status (e.g. dormant without leaves or in vegetation); thus, this option is considered, in general, to be of negligible effectiveness to prevent the introduction of *X. fastidiosa.*

Given that xylem sap-feeding vectors infected with *X. fastidiosa* could be carried as 'hitch-hikers' on healthy parts of plants, the import of dormant plants without leaves could represent a risk reduction option since most of the American vector species lay eggs in the leaves or in the green tissues only (Boyd and Hoddle, 2006; Rakitov, 2004; Al-Wahabi et al., 2010). In the case of species eventually laying eggs in the woody plant parts, as *X. fastidiosa* is not transovarially inherited (Freitag, 1951), the import of dormant plant with vector eggs will not result in *X. fastidiosa* spread; however, it may result in the introduction of a new vector species.

Effectiveness

The effectiveness of prohibiting the import of parts of plants for planting of host plants of *X. fastidiosa*, i.e. restricting import to dormant plants without leaves, in preventing the introduction of *X. fastidiosa* is assessed as negligible as the bacterium is present in the xylem of the whole plant.

With regard to the insect vectors that may be carried by imported plants for planting, the effectiveness of importing only dormant plants is rated as high for American sharpshooters laying eggs in the leaves or in the green tissues only and very low for those species laying eggs in the woody plant parts.

Technical feasibility

The feasibility of such measures is high; nevertheless, because of trade issues, it may be difficult to apply it to the entire wide host range of this bacterium.

Uncertainty

Owing to the lack of extensive studies on the host range of some subspecies/strains of *X. fastidiosa*, as well as the possibility of changes in the host range of a specific strain of *X. fastidiosa* as a result of mutations/recombination or the finding of new vector–host combinations in new areas (Almeida, 2008), there is a moderate uncertainty on the ratings above.

4.1.3.3. Prohibition or authorisation of specific genotypes of the host plants

To date, there is only limited information (see section 4.1.2.2) to suggest that some varieties within a host species show particular susceptibility to certain strains of *X. fastidiosa* or are particularly attractive to some insect vectors.

On the other hand, and as explained above, even if theoretically highly satisfying, specific genotypes of host plants cannot be considered as an effective mitigation measure at the moment because the diversity of the bacterium is very high. Moreover, tolerant varieties could be a problem as asymptomatic plants could escape inspections prior to import or at destination. Furthermore, owing to the very wide host range of *X. fastidiosa*, such an approach would certainly not cover the whole range of potential host plants.

Effectiveness

The efficiency is rated as low. Prohibiting or authorising specific plant genotypes or varieties is not considered, to date, to be an effective mitigation method for *X. fastidiosa*.

Technical feasibility

Feasibility would be very low, because of the need to identify resistant varieties for the range of *X. fastidiosa* strains/subspecies and their recorded host plants lists.

Uncertainty

Uncertainty is high owing to continuous adaptation between the pathogenic agent and its host plants.

4.1.3.4. Pest freedom of consignments: inspection or testing

Visual inspection of consignments of plants for planting is not a very powerful and reliable method as infections may be asymptomatic and because exported lots (e.g. trees) are often leafless and dormant. Testing of samples is possible and provides good results provided methods are adapted, reagents good and laboratory staff very well trained. Nevertheless, sampling is a key element: if there is a low incidence of plants infected by *X. fastidiosa* within a consignment, sample size can affect the probability of including such plants in the sample and therefore alter the result. Obtaining a representative sample from a consignment can also be difficult.

Effectiveness

The effectiveness of visual inspections of consignments is considered low. The effectiveness of laboratory tests themselves is high when validated protocols and reagents are used by qualified staff, but the results are highly dependent on the quality of the sampling, on the physiological status of the plant and on the experience of the inspector in charge of controls, which results in a global effectiveness rated as moderate.

Technical feasibility

The feasibility is high for small consignments.

Uncertainty

The uncertainty is moderate owing to the diversity of host plant species, the distribution of the bacterium inside the plants and the heterogeneity of symptoms in different hosts.

4.1.3.5. Pre- or post-entry quarantine system

Pre- or post-entry quarantine systems may be developed for small consignments in commercial trade of plants for planting. Post-entry quarantine is normally applied for import of nursery stock in EU Member States and adapted regulation is implemented (Commission Directive 2008/61/EC[9]), as well as in other countries (e.g. Vidalakis et al., 2010). The effectiveness of pre- and post-entry quarantine systems depends on the level of containment established by the quarantine facilities, the quarantine period, and the methods and intensity of inspection and testing during the quarantine period.

As pre- or post-import quarantine requires the availability of special facilities and procedures, and takes time, costs are often high, and such a solution is often possible only for small consignments with high commercial value. This risk reduction option is currently implemented in the EU and it can be effectively applied to prevent the introduction of *X. fastidiosa,* for example via plant propagation material imported for breeding purposes.

Effectiveness

The effectiveness of pre- or post-entry quarantine is considered high when standards used and their implementation is of high quality. Otherwise, it can be rated as low.

Technical feasibility

The technical feasibility is high.

Uncertainty

The uncertainty is low.

4.1.3.6. Preparation of the consignment

Culling and visual selection measures during preparation of consignments of plants for planting are unlikely to detect *X. fastidiosa*-infected units, particularly in the case of asymptomatic infections and/or when dealing with dormant plants without leaves, or just because exported plants can be in stressing conditions (water stress and other conditions may also lead to symptoms similar to *X. fastidiosa* infection), which may lead to confusion and false positives. Sanderlin and Melanson (2006) also stressed the possibility of transmission of the disease through rootstocks, without apparent symptoms.

[9] Commission Directive 2008/61/EC of 17 June 2008 establishing the conditions under which certain harmful organisms, plants, plant products and other objects listed in Annexes I to V to Council Directive 2000/29/EC may be introduced into or moved within the Community or certain protected zones thereof, for trial or scientific purposes and for work on varietal selections. OJ L 158, 18.6.2008, p. 41–55.

Effectiveness

The effectiveness is low.

Technical feasibility

The technical feasibility is high.

Uncertainty

The uncertainty is low.

4.1.3.7. Specified treatment of the consignment to reduce pest prevalence and/or insect prevalence

Thermotherapy

Heat therapy using hot water has long been recognised as a practical and effective means of eliminating *X. fastidiosa* from infected grape (*Vitis vinifera*) plants for planting (Goheen et al., 1973). Recently Sanderlin and Melanson (2008) showed that hot water treatment (46 °C for 30 minutes) of scion wood of pecan (*Carya illinoinensis*) prior to grafting was effective in producing near-complete elimination of *X. fastidiosa* from wood affected by bacterial leaf scorch. Heat therapy is already applied in grapevine nurseries in Italy for the control of 'flavescence dorée' and 'bois noir', diseases caused by phytoplasmas (Mannini, 2007; Mannini and Marzachì, 2007). No information is available for other species that are hosts of *X. fastidiosa*, and it is not known if all plant species support heat treatment.

Effectiveness

The effectiveness of heat therapy (hot water treatment) of dormant grapevine propagation material is high, and the methods appears effective for cleaning pecan scions prior to grafting, although it is not yet validated for other plant species that are host of *X. fastidiosa.*

Technical feasibility

The feasibility of heat therapy of dormant plant propagation material is high, providing that dedicated equipment is available, as already applied in Europe on grape plant propagation material (Mannini, 2007; Mannini and Marzachì, 2007).

Uncertainty

Uncertainty is low for the studied crops, but it is high for other plant species as the efficacy and feasibility of such measures for plant species other than grapevine and pecan still need to be documented. Uncertainty is therefore rated from low to high, and tests should be performed in the EU to optimise protocols because no research has been performed with the genotype from Apulia.

In vitro *propagation*

In vitro multiplication, providing the plant material originates from meristem cultures tested within certification schemes, is known to be an effective method of regenerating healthy plant material, at least for species such as *Citrus* spp. and *Vitis* spp.

Effectiveness

The effectiveness of *in vitro* regeneration for obtaining health *in vitro* plants from meristem cultures tested within certification schemes is high for plant species that permit such treatment.

Technical feasibility

The feasibility is high because many plants are already propagated *in vitro*.

Uncertainty

Uncertainty is high owing to the wide host range, as studies are not available for all species.

Control of the insect vectors

With regard to insecticide treatments, sharpshooters and spittlebugs are susceptible to a number of insecticides, and particularly to neonicotinoids (Krewer et al., 1998; Bethke et al., 2001; Prabhaker et al., 2006a, b). To date, transovarial transmission of *X. fastidiosa* has not been documented, so eggs of insects are not considered to be of concern for the transmission of *X. fastidiosa.* Nevertheless, if eggs survive insecticides, adults could succeed in entering the territory, increasing the risks of establishment and spread as an invasive vector species. Insecticide treatments should also be applied just before lots are exported from the nursery. Such treatments will nevertheless not affect the presence of bacteria within the plant and are considered to be additional to measures preventing plant infections.

Effectiveness

Insecticide treatments of consignments of plants for planting before export or at destination are therefore considered to be highly effective to stop the entry of *X. fastidiosa* with infectious vectors.

Technical feasibility

Feasibility is high.

Uncertainty

Uncertainty is low.

4.1.3.8. Restriction on end use, distribution and periods of entry

Such restrictions are not applicable to plants for planting to prevent entry and spread of *X. fastidiosa.* The host plants may carry the pathogen all year round, the end use is planting and the distribution is to areas with host plants.

Table 6: Summary of the applicable risk reduction options identified and evaluated for the pathway "plants for planting"

Category of options	Type of measure (for details, see EFSA PLH Panel, 2012)	Position in the pathway	Effectiveness	Technical feasibility	Uncertainty
Options ensuring that the area, place or site of production at the place of origin, remains free from *X. fastidiosa*	4.1.1.1. Limiting import to plants for planting originating in pest-free areas	Before shipment	High	High	Medium
	4.1.1.2. Limiting import to host plants for planting originating in pest-free production places or pest-free production sites	Before shipment	Low	Low	Low
	4.1.1.3. Limiting import to host plants for planting originating in pest-free production places or pest-free production sites where insect vector populations are surveyed and kept under control	Before shipment	Low	Moderate	Medium
Options for the crop at the place of origin	4.1.2.1. Cultural practices at the level of the crop, field or place of production that may reduce pest prevalence	Before shipment			
	• Helping the plant to react against the disease		Negligible	High	Very high
	• Control of the disease *in planta*		Negligible	Low to moderate	Low
	• Control of the vectors through growing season				
	– Chemical treatments against insect vectors in the case of primary infections		Moderate	High	High
	– Chemical treatments against insect vectors in the case of secondary spread		Moderate	High	Medium
	– Vector control in nurseries		High	High	Low
	– Vegetation management		Very high	Low to high	High
	– Insect biocontrol		Low	Low to high	High

Category of options	Type of measure (for details, see EFSA PLH Panel, 2012)	Position in the pathway	Effectiveness	Technical feasibility	Uncertainty
	4.1.2.2. Resistant or less susceptible varieties	Before shipment			
	• Breeding of resistant or tolerant varieties		Moderate	Low to moderate	High
	• New technologies to develop resistant varieties		Moderate	Low	High
	4.1.2.3. Growing plants under exclusion conditions (glasshouse, screen, isolation)	Before shipment	High	High	Low
	4.1.2.4. Harvesting of plants at a certain stage of maturity or during a specified time of year	Before shipment	Not applicable		
	4.1.2.5. Certification scheme	Before shipment	High	High	Medium
Options for consignments	4.1.3.1. Prohibition of plants for planting hosts of *X. fastidiosa*	Before shipment	Very high	Low to high	Medium
	4.1.3.2. Prohibition of parts of the host	Before shipment	Negligible	High	Medium
	4.1.3.3. Prohibition or authorisation of specific genotypes of the host plants	Before shipment	Low	Very low	High
	4.1.3.4. Pest freedom of consignments: inspection or testing	Before shipment	Moderate	High	Medium
	4.1.3.5. Pre- or post-entry quarantine system	Before shipment	Low to high	High	Low
	4.1.3.6. Preparation of consignment	Before shipment	Low	High	Low
	4.1.3.7. Specified treatment of consignment to reduce pest prevalence and/or insect prevalence	Before shipment	Low to high	High	Low to high
	• Thermotherapy		High	High	Low to high
	• *In vitro* multiplication		High	High	High
	• Control for the insect vectors		High	High	Low
	4.1.3.8. Restriction on end use, distribution and periods of entry		Not applicable		

4.2. Identification and evaluation of risk reduction options to reduce the probability of entry and spread for the pathway infected insect vectors

The Panel considers here the entry and spread of infectious insect vectors of *X. fastidiosa* only as hitch-hikers on various types of consignments. "Non-host ornamentals" are rooted plants (potted plants and flowers, bonsais, shrubs, trees, etc.), intended for direct use in public or private gardens and parks, or inside (glasshouses, houses, etc.). These plants may contain infectious insect vectors. The wide range of host plants of both the pathogen and the vectors makes it difficult to qualify a plant species as a non-host.

For consistency with the previous sections, we consider separately host plants and non-host plant material, although some of the risk reduction options described below are common to both categories. A summary of applicable risk reduction options identified and evaluated for the pathway infected insect vectors is given in table 7.

4.2.1. Options ensuring that lots of host plant material for planting are free from infected insect vectors

4.2.1.1. Limiting import to plants for planting originating in insect-free production places or insect-free production sites

As already discussed above (see section 4.1. on the pathway import of plants for planting), it is possible to establish the production of healthy host plants for planting in an area where *X. fastidiosa* is present, relying on the concepts of insect-free production places or sites by use of certified mother plants, screens and appropriate control and monitoring of the insect vectors.

Effectiveness

The effectiveness is considered as moderate, depending on the local conditions. Effectiveness may be increased when a system approach is used, whereby this option is integrated with other risk reduction options, such as growing plants under exclusion (screen houses), certification of plant propagation material and monitoring and control of vectors.

Technical feasibility

Feasibility is high.

Uncertainty

Uncertainty is medium.

4.2.1.2. Cultural practices at the level of the crop, field or place of production that may reduce pest prevalence for *X. fastidiosa* vectors

As discussed above, it is difficult to control the spread of *X. fastidiosa* by spraying vectors with insecticides, unless the epidemiology is very clear and secondary spread within the crop is of major importance. Furthermore, such a control approach is much less documented for ornamentals. Moreover, the population thresholds to be achieved in order to reduce the risk of hitch-hiking vectors being transported with a commodity are likely to be substantially lower than the thresholds required preventing an outbreak.

Effectiveness

The effectiveness of controlling *X. fastidiosa* vectors can vary from low to high, depending on the vector(s) and on the epidemiology of the disease. The effectiveness of vector control (by pesticides or by biocontrol) in reducing prevalence of the disease is low to moderate but is very low in the case of maintaining a crop free from the disease in an area where the disease and vectors are present, particularly polyphagous vector species that can recolonise the crop from the adjacent vegetation.

Technical feasibility

Feasibility is high providing weather conditions for sprays are good.

Uncertainty

Uncertainty is high owing to differences in epidemiology between crops, vectors and bacterial strains, which are still largely unknown.

4.2.1.3. Prohibition of import of certain plant material: restricting import to dormant plants without leaves

As detailed above, the effectiveness of a prohibition on the import of certain plant material, such as plants with leaves, known to commonly harbour insect vectors of *X. fastidiosa*, is assessed as very high. Given that xylem sap-feeding vectors infected with *X. fastidiosa* could be carried as 'hitch-hikers' on healthy parts of plants, the import of dormant plants without leaves could represent a risk reduction option since most American vector species lay eggs in the leaves or in the green tissues only (Boyd and Hoddle, 2006). In the case of species laying eggs in woody plant parts, as *X. fastidiosa* is not transovarially inherited (Freitag, 1951), the import of dormant plant with vector eggs will not result in *X. fastidiosa* spread; however, it may result in the introduction of a new vector species.

Effectiveness

With regard to the insect vectors that may be carried by imported plants for planting, the effectiveness of importing only dormant plants is rated as high for American sharpshooters laying eggs in the leaves or in the green tissues only and very low for those species laying eggs in the woody plant parts.

Technical feasibility

The feasibility of such measures is high; nevertheless, because of trade issues it may be difficult to apply it to the entire wide host range of this bacterium.

Uncertainty

The list of host plants able to shelter the insect vectors is still incomplete; thus, uncertainty is rated as moderate.

4.2.1.4. Pest freedom of consignments: inspection or testing

Effectiveness

It should be noted that some of the vectors, in particular sharpshooters and spittlebugs, are relatively large insects (*H. vitripennis* adult is 12 mm long) that can be visually discovered with a careful inspection of the consignments. The capacity to properly identify insect vectors is considered to be high, but the results are highly dependent on the training level of inspectors, which results in a global effectiveness rated as moderate. Nevertheless, the effectiveness of visual inspections of consignments is considered as low to moderate considering that: insects are difficult to detect in consignments and very low numbers of insects may be sufficient for the entry of *X. fastidiosa*; the effectiveness of visual monitoring decreases with the increase of consignment size.

Technical feasibility

The feasibility is high. This risk reduction option is already applied in California to prevent the spread of *H. vitripennis*.

Uncertainty

The uncertainty is high because it relies mainly on visual inspection and on the effort put into plant health inspections.

4.2.1.5. Specified treatment of the consignment to reduce insect vectors prevalence

Effectiveness

As discussed above, well-applied insecticide treatment of consignments before export or at the destination is considered to be highly effective in preventing the entry of *X. fastidiosa* in insects, although surviving *H. vitripennis* nymphs and adults have been observed in French Polynesia after methyl bromide fumigation of material entering aeroplanes (Grandgirard et al., 2006). A similar programme is already in place in California for plants for planting to prevent the movement of the vector *H. vitripennis.*

Technical feasibility

Feasibility is high.

Uncertainty

Uncertainty is low providing the treatment is done properly.

4.2.2. Options ensuring that lots of other plant material are free from infectious insect vectors

Other plant material, such as cut flowers or cut branches with leaves, may carry insect vectors that can travel on such commodities as hitch-hikers.

"Cut flowers" are the detached, unrooted part of plants (flowers, branches, leaves, etc.) and are used mainly in flower bunches and flower arrangements. Even if stems are kept in water or in any other nutritious medium, the plant vascular sap pressure is generally considered to be too low to allow xylem sap-sucking insects to feed on such plant material. Nevertheless, Bextine and Miller (2005) have shown that it is possible that sharpshooters could feed on cuttings of *Chrysanthemum grandiflora*, a non-host plant, and transmit *X. fastidiosa* under artificial conditions. On fruit, Purcell and Saunders (1995) demonstrated instead that, when the blue-green sharpshooter *Graphocephala atropunctata* and the green sharpshooter *Draeculacephala minerva* were allowed to feed on grapevine fruit clusters from PD-affected vines, the vectors were not able to transmit *X. fastidiosa* to healthy grapevines (see section 3.2.1.1). Overall, insect vectors may be associated with cut flowers or fruit and, if infected by *X. fastidiosa*, those insects may be a means of entry, and later of spread. If not infected, those insects may behave as invasive species and could act as vectors if *X. fastidiosa* is present at the destination.

4.2.2.1. Inspection of consignments

Inspection of consignments is already discussed in section 4.2.1.4.

Effectiveness

Some of the vectors, in particular sharpshooters and spittlebugs, are relatively large insects (*H. vitripennis* adult is 12 mm long) that can be visually discovered with a careful inspection of the consignments. The capacity to properly identify insect vectors is considered to be high, but the results are highly dependent on the training level of inspectors, which results in a global effectiveness rated as moderate. Nevertheless, the effectiveness of visual inspections of consignments is considered as low to moderate considering that: insects are difficult to detect in consignments and very low numbers of insects may be sufficient for the entry of *X. fastidiosa*; the effectiveness of visual monitoring decreases with the increase of consignment size.

Technical feasibility

The technical feasibility is high. This risk reduction option is already applied in California to prevent the spread of *H. vitripennis*. Nevertheless, because of trade issues, it may be difficult to apply it to the entire wide host range of the insect vectors of this bacterium.

Uncertainty

Owing to the lack of data on frequency of xylem sap-feeding insects in traded consignments of cut flowers or cut branches with leaves, uncertainty is considered to be high.

4.2.2.2. Prohibition measures

The long list of insects potentially able to act as vectors for *X. fastidiosa* as well as the list of consignments in which such insects could be found, including as "hitch-hikers", makes prohibition measures highly questionable in terms of practical feasibility, apart perhaps from a short list of key species known to be often associated with insect vectors and/or in a short list of countries where certain crops are known to be widely contaminated. Prohibition measures could be limited to areas where *X. fastidiosa* is known to occur. It may, however, be difficult to limit prohibition measures to areas where insect vectors are known to occur owing to the extended list of insect vectors.

Effectiveness

The effectiveness of a prohibition on the introduction for all insects suspected to be hosts of *X. fastidiosa* on commodities other than plants for planting could be rated as low.

Technical feasibility

The feasibility of such a measure is rated as low for practical and trade reasons.

Uncertainty

Uncertainty is considered high owing to the lack of studies on many host plants.

4.2.2.3. Insecticide treatment of consignments

With regard to insecticide treatments, sharpshooters and spittlebugs are susceptible to a number of insecticides, and particularly to neonicotinoids (Krewer et al., 1998; Bethke et al., 2001; Prabhaker et al., 2006a, b). To date, transovarial transmission has not been documented, so eggs of insects are not considered to be of major concern for the transmission of *X. fastidiosa.* Nevertheless, if eggs survive insecticides, adults could succeed in entering the territory, increasing the risks of establishment and spread as an invasive species.

Effectiveness

Correctly applied insecticide treatment of consignment (cut flowers and/or cut foliage…) before export or at destination is therefore considered to be highly effective to stop the entry of insect vectors of *X. fastidiosa.* However, insects have been observed to escape chemical treatments (Grandgirard et al. 2006; see sections 3.2.2.2. and 3.2.3.1.).

Technical feasibility

Feasibility is high providing that appropriate measures are taken to protect workers in charge of applying the insecticides and of handling the plant material.

Uncertainty

Uncertainty is medium provided the treatment is done just before export, or on arrival at the border.

4.2.2.4. Production under exclusion conditions

See section 4.1.2.3 (Growing plants under exclusion conditions).

Effectiveness is high.

Technical feasibility is moderate, as growing plants in screen houses is already done for other insects (e.g. *Bemisia* see EFSA opinion (EFSA PLH Panel, 2013).

Uncertainty is medium.

4.2.2.5. Pest freedom of consignments

See section 4.2.1.4 (pest freedom or consignement, inspection and testing)

Effectiveness is low.

Technical feasibility is moderate.

Uncertainty is high.

Table 7: Summary of applicable risk reduction options identified and evaluated for the pathway "Infectious insect vectors"

Category of options	Type of measure (for details, see EFSA PLH Panel, 2012)	Position in the pathway	Effectiveness	Technical feasibility	Uncertainty
Options for the crop at the place of origin *(ensuring that lots of host plant material for planting are free from infectious insect vectors)*	4.2.1.1. Limiting import to ornamentals originating in insect-free production places or insect-free production sites	Before shipment	Moderate	High	Medium
	4.2.1.2. Cultural practices at the level of the crop, field or place of production that may reduce pest prevalence	Before shipment	Low to moderate	High	High
	4.2.1.3. Prohibition of import of certain plant material	Before shipment	High	High	Medium
	4.2.1.4. Pest freedom of consignments: inspection or testing	Before shipment	Low to moderate	High	High
	4.2.1.5. Specified treatment of consignment to reduce pest prevalence and/or insect prevalence	Before shipment	High	High	Low
Options for the crop at the place of origin *(ensuring that lots of other plant material are free from infectious insect vectors)*	4.2.2.1 Inspection of consignments		Low to moderate	High	High
	4.2.2.2. Prohibition measures		Low	Low	High
	4.2.2.3. Insecticide treatment of the consignments		High	High	Medium
	4.2.2.4. Production under exclusion conditions		High	Moderate	Medium
	4.2.2.5 Pest freedom of the consignments		Low	Moderate	High

4.3. Systematic identification and evaluation of options to reduce the probability of establishment

4.3.1. Surveillance

Surveillance may consist of general surveillance and specific surveys (refer to ISPM No. 6 (FAO, 1994); EFSA PLH Panel, 2012). Surveillance should address the risks in the entire production and trade chain and its environment: (1) genetic resources (mother plants, varietal collections), on (2) nursery planting material ready to be distributed for plantation and (3) on monitoring of the phytosanitary status of the environment (crops, unmanaged fields, natural environments, gardens and parks). A systematic review of surveys in the EU territory for a large range of pathosystems is available and should be consulted with regard to proper survey design, implementation and documentation (Bell et al 2014).

Surveillance programs for *X. fastidiosa* should adhere to the specifications of Commission Implementing Decision 2014/497/EU. Member States shall conduct annual surveys for the presence of *X. fastidiosa* in their territory, not only on specified host plants but also other possible host plants. This survey shall consist of visual examinations; only when an infection of *X. fastidiosa* is suspected, samples shall be taken and tested. Requirements of survey reliability have not been formulated.

When the presence of *X. fastidiosa* is confirmed, the Member State shall establish a demarcated area, consisting of the infected zone surrounded by a buffer zone with a width of at least 2000 m. The buffer zone may be reduced to a width of at least 1000 m if infected plants, plants showing symptoms and other plants likely to be infected have been removed and a delimiting survey has been carried out in a zone with a distance of at least 2000 m from the border of the infected zone. This survey must be based on testing using a sampling scheme to confirm with 99 % reliability that the level of presence of the specified organism in plants within 2000 m from the border of the infected zone, is below 0,1 %.

When a demarcated area has been established, the Member State shall perform surveys within a radius of 200 m around infected plants, to detect specified plants, plants of the same genus as the infected plants, and all other plants showing symptoms of *X. fastidiosa*, using a sampling scheme to confirm with 99 % reliability that the level of presence of the specified organism in these areas around infested plants is below 0,1 %.

As the host range of *X. fastidiosa* is very wide, and as potential insect vectors are quite numerous and widely present within the EU, eradication of the disease requires drastic measures to be applied as soon as possible to the infected crop, to wild, unmanaged and ornamental plants that may host the bacterium, and to the insect vectors in the infected plots and in their vicinity. The history of the disease in new areas shows that, once largely established, it cannot be eradicated (Lopes et al., 2000; Purcell, 2013; Su et al., 2013).

The observations made in infected olive grove in Apulia in the outbreak on olive trees and on other plants, notified by the Italian authorities at the end on 2013, show the difficulty of early detection of *X. fastidiosa.* It is worth to stress that the disease syndrome on olive trees was initially linked with other possible causal agents (see section 3.1.9).

It is important to set up a system that allows an early identification of causal agents of outbreaks and to have a ready to use action plan with emergency measures to be taken when a positive case occurs. The set up of such system is hampered by the fact that, even if early visual detection of symptomatic plant is feasible, there is a delay between the infection of the plants and the appearance of the visual symptoms.

Also, in many cases, it is not possible to rely only on visual observations for unequivocal identification of symptoms caused by *X. fastidiosa*. There is a period over which the infected plant might be source for secundary infections while not displaying symptoms.

In a situation where no outbreak is known to occur, surveillance should be risk based, focussing on the maintenance of the phytosanitary status of genetic resources and on the most risky import pathways, targeting especially import lines from countries where the pathogen is known to occur. Awareness of the disease and how to spot symptoms should be promoted amongst farmers in the risk area. Active surveillance programs and effective alert systems are also be required for early detection of asymptomatic infection, to establish the presence of infectious vectors and to permit rapid information of phytosanitary services.

Inspectors in charge of surveillance should be well trained in visual on-site inspections and should have access to the necessary sets of information. As symptoms are not always easy to recognise or to discriminate from those of other diseases or disorders, and as asymptomatic infections are possible, laboratory testing by trained specialists is necessary. Owing to the significant role of asymptomatic infection, plants not showing symptoms should also be selected and subject to diagnostic testing for early detection (rather than using diagnostic tests only to confirm visual symptoms). Laboratories are obliged to notify immediately any identification of organisms listed in Directive 2000/29/CE to the competent authority and should preferably have to prove that they have the capacity to identify *X. fastidiosa* according to the highest standards (accreditation according to norm ISO17025, participation to proficiency testings, etc.). Sufficient numbers of samples of each host plant must be taken, and the number of host plants sampled at each location should be sufficient to allow a sufficiently high probability of detection and should be guided by statistical methods for sampling of plant diseases (Madden and Hughes, 1999). General group sampling methods are available to reduce sample sizes whilst retaining incidence information (Hughes et al., 1997) and have been applied to *Citrus tristeza virus* (Hughes and Gottwald, 1998, 2001) and *Plum pox virus* (Hughes et al., 2002) surveillance programmes.

Targeted / risk-based selection of sites

Distance to known outbreak sites clearly contributes to the risk at a particular location. Dispersal is primarily limited to short-range leafhoppers, which fly, on average, 100 metres, but which can also be dispersed at longer distances by wind. Consequently, suitable locations several kilometres from known outbreak sites may also be considered high risk. This is particularly the case where there is relatively unbroken host availability between a particular location and a known outbreak site. In this case host plantings in between act as “stepping stones”, connecting host locations in terms of disease spread.

Aerial photographs and crop maps may offer an additional tool for surveying large surfaces and for early identification of potential outbreaks, providing that field observations and sampling are organised in zones suspected to be infected, i.e. high-risk areas (d’Onghia et al., 2014; Santoro et al., 2014). For example, Gualano et al. (2014) demonstrated how high resolution aerial images processed by visible and near-infrared data could be used to identify trees showing damage by *X. fastidiosa* symptoms.

However, risk based selection of survey locations is subject to error and, in addition, a certain proportion of targeted survey effort should also be allocated to random search (ISPM 6; FAO, 1997). The spread of infectious vectors and planting material by humans over long distances also requires surveillance efforts in areas that are far from known outbreak sites but where the host, vector and climatic conditions are suitable for establishment. One way of addressing these issues is to prioritise a survey based on risk but also to allow for a sampling coverage in some lower-risk areas by stratified sampling. A region is split into regular strata and each stratum is allocated a risk value. The number of sites surveyed in each stratum is then weighted by the relative risk value of the stratum. Clearly, sites where no host or vector is present and where climatic conditions are unsuitable carry a risk value of zero and are not surveyed.

Non-targeted random surveys are also required to establish unbiased estimates of disease incidence and distribution to inform pest risk assessment and provide epidemiological information (refer to ISPM 6 (FAO, 1997)) (see section 4.7.7).

In areas where an outbreak has occurred, intensive detection surveys should be performed to identify all infested sites. In this case, it is particularly important to target surveillance efforts based on maps of disease risk. Investigations should be organised to trace back the outbreaks from audit lines and distribution records, to draw dissemination lines and to identify plots at risk.

Effectiveness

Effectiveness is rated as low to moderate as sufficient resources are unlikely to be available for early detection and there is uncertainty around the epidemiological information available to target surveillance efforts

Technical feasibility

The technical feasibility of surveillance is high, but may vary depending on the type sampling required for effective detection of the pest as well as on the expertise of inspectors

Uncertainty

Uncertainty is considered as low to medium, depending on the type of surveillance and sampling needed (e.g. epidemics versus endemic).

4.3.2. Eradication

In ISPM n°5 (FAO, 2013), eradication is defined as the "application of phytosanitary measures to eliminate a pest from an area". An abundant literature discusses eradication. Dahlsten and Garcia (1989) viewed this approach with a critical look through a series of case stories. Pluess et al. (2012) applied data mining techniques to a dataset of 173 different eradication campaigns against 94 species worldwide to identify factors related to the successful eradication of invertebrates, plants and plant pathogens, and found that half of them had achieved success. However, the authors emphasised that very early campaigns against very local pests were important conditions favouring success. Myers et al. (1998, 2000) listed several conditions favouring eradication success: (1) early detection and rapid initiation of an eradication programme; (2) host or habitat specificity; (3) effective and inexpensive monitoring techniques for low-density populations; (4) powerful suppression methods; (5) sufficient resources to fund the programme until its conclusion; (6) clear lines of authority to take all necessary actions on public and private grounds; (7) biology of the target organism making it susceptible to control procedures; and (8) prevention of reinvasion. The link between success and very early intervention is also stressed by other authors, e.g. Genovesi (2007).

In the case of *X. fastidiosa*, most of these conditions could be met, provided the initial infection focus is identified and delimited very early. This would require extremely fast and accurate identification methods as well as a very high level of intra- and transnational coordination, bringing all expertise together within a short period of time. However, even in this optimal situation, the multiple hosts and potential vectors of the bacterium would make total eradication of the disease improbable. In the case (Apulia) of an infected area extending over tens of thousands of hectares, several more of these conditions are not fulfilled: condition 1; condition 2 (there are many hosts and many potential vectors, often polyphagous); and condition 3 ("blind" molecular testing of many asymptomatic hosts will be necessary). Other conditions are only partly met: condition 4 (the only suppression methods known are removal of infected plants, and vector chemical or cultural suppression) and condition 7 (probable long-distance spread capacity of the vectors by hitch-hiking). Table 8 summarises these different cases of outbreaks of *X. fastidiosa* in Apulia.

Table 8: Conditions for successful eradication considering the status of the infected area

Conditions (Myers et al., 1998, 2000)	Limited infected spot, detected early	Extensive infected spot, detected late
Early detection and rapid initiation of an eradication programme	Symptoms may appear late, making early detection problematic	Not fulfilled, by definition
Host or habitat specificity	Limited specificity (multiple hosts and potential vectors)	Limited specificity (multiple hosts and potential vectors)
Effective and inexpensive monitoring techniques for low-density populations	Many asymptomatic hosts, depending on host species and infection stage. Intra- and inter-plant heterogeneity in the distribution of the bacteria	The extent of the attacked area precludes effective implementation
Powerful suppression methods	Removal of the attacked plants (but multiple hosts and potential vectors) Vector reduction with insecticide treatment or cultural methods. Vector suppression impossible owing to the polyphagous nature and widespread distribution of the vector	Effectiveness of suppression methods decreases with the size of the infected area
Sufficient resources to fund the programme until its conclusion	A risk manager's decision.	A risk manager's decision
Clear lines of authority to take all necessary actions on public and private grounds	A risk manager's decision	A risk manager's decision
Biology of the target organism making it susceptible to control procedures	Multiple hosts and potential vectors. Mobile vectors (hitch-hiking)	Multiple hosts and potential vectors. Mobile vectors (hitch-hiking)
Prevention of reinvasion	A quarantine issue Many infested hosts are asymptomatic; vectors can hitch-hike	Difficulty grows with the size of infected area

In the case of a single or limited introduction detected at a sufficiently early stage (depending on the biology of the pest and of its potential vectors), eradication should be considered. Measures to eliminate infected plants and vectors are presented in sections 4.3.2.1 and 4.3.2.2 in the context of an eradication programme. These options can be combined. Similar measures can also be used for containment of an outbreak (see section 4.3.3).

4.3.2.1. Eradication of *X. fastidiosa* by the complete removal of infected plants

Eradication would consist here in removing all infected plants, including crops, unmanaged plants and ornamentals. Such eradication, as described in the EU implementing Decision 2014/497/UE, to be effective, should be applied to all plants showing symptoms, asymptomatic plants found infected based on sensitive laboratory tests and neighbouring plants and should include all host plants of *X. fastidiosa*. This is practically difficult due to the wide host range including species for crops, ornamentals, plants from the environment and weeds. The significant role of asymptomatic infection and problems with low detection effectiveness in many hosts further contributes to the impracticality of eradication.

Attempts to eradicate *X. fastidiosa* have been made worldwide, including eradication of citrus variegated chlorosis on citrus in Brazil (Lopes et al., 2000; Machado et al., 2011) and of Pierce's disease on grape in central Taiwan (Su et al., 2013). Despite these attempts, the percentage of infected plants in Brazil increased from 15.7 % in 1994 to 34 % in 1996 (Amaro et al., 1998, in Lopes et al., 2000) and, according to recent surveys (www.fundecitrus.com.br), approximately 40 % of the 200 million sweet orange plants in São Paulo are infected with *X. fastidiosa* (Almeida et al., 2014). In

Taiwan, the disease persists, despite the timely removal of thousands of grapevines affected by Pierce's disease since the first record of the disease in 2002 (Su et al., 2013). In California, Pierce's disease is endemic. Purcell (2013) remarks that "Despite this eradication of PD [Pierce's disease] vines in several locations that involved large plots over multiple years, there was no evidence that the removal effort had any measurable benefit".

No treatment is currently available to cure diseased plants in the field and, most often, plants that are contaminated remain infected throughout their life or collapse quickly. Changes in cropping systems could have some impact on the disease (e.g. pruning, fertilisation and irrigation), but this is generally not enough to cure plants.

In Apulia, severe pruning of infected olive trees resulted in the emission of new sprouts from the base of the tree (Martelli, 2014), but, so far, this has not been shown to cure the plants and prevent them from dying. In some particular conditions, and on some plant species, it seems that the bacterium may not survive cold winters (see section 3.3.2.1), but it is highly uncertain that this could occur in the Apulia region and with the plant species affected by the pathogen in the risk assessment area.

Effectiveness

The effectiveness of the eradication of infected plants is rated high, as this measure would restore an area to its initial state of pest absence.

Technical feasibility

The technical feasibility is considered as moderate to high for localised and small outbreaks at the appearance of the first infections, particularly in protected cultivations, but it is very low when the disease becomes widespread and several host species in the natural vegetation as well as in cultivated and urban areas are also infected. An additional difficulty stems from the high social and cultural value of the plants (e.g. olive trees in the Apulia region), which generates high public resistance.

Uncertainty

The uncertainty is high as plants may be symptomless or infected too recently for detection and as many species other than crops can host the bacterium, with or without symptoms.

4.3.2.2. Eradication of infectious vectors

Eradication could be theoretically possible only when referring to *a single exotic insect species* recently introduced into a new area and still at very limited population level. Xylem sap-feeding insect vectors are susceptible to commonly used biocides, but insecticide treatments on specific host crops do not eliminate the infectious vector(s) from several other (wild) hosts in the environment. In addition, insecticides should be repeatedly applied in large cultivated, natural and privately owned areas, as long as infected plants remain. Such large-scale application of insecticides may lead to the development of insecticide resistance as well as to environmental and human health issues. In California, eradication of the exotic vector *H. vitripennis* appears to have been successful very locally, at the county level (Rathé et al., 2012).

With regard to *native or endemic insect species*, potential insect vectors are widely distributed in the risk assessment area (Table 4 and Figure 5); they belong to many different species and their populations can be locally important. Those vectors are polyphagous and may change host depending on the season, growing conditions and host availability. They feed on crops, wild plants, ornamentals and weeds, and they may move from one plot to another, or from one plot to the surrounding environment, so eradication schemes are likely to reach a useful level of efficiency only if they are applied to all plots and their surroundings at the same time. In addition, as observed in the Apulian area, insect vectors may hitch-hike for rather long distances on or in vehicles, even without plants (see Figure 12). This means that infectious vectors may disseminate far from plots where the disease is

present, which implies that eradication of indigenous insect vectors on a large area is not possible, as there are plenty of indigenous xylem sap feeder species associated with many kind of plants.

Figure 12: Adult *Philaenus spumarius* on the external bodywork and on the inner glass window of a vehicle (in an olive orchard near Gallipoli, Apulia, Italy, Octobre 2014).

Effectiveness

The effectiveness is rated as high for exotic vectors recently introduced into a new area and still at very limited population level.

Technical feasibility

The technical feasibility of the eradication of an exotic insect vector is moderate when the outbreak has been detected early, is of very limited size and is rather isolated. It would then be possible to regularly spray insecticides in the outbreak area and in a large perimeter around it. However, owing to many constraints, particularly environmental and human health concerns arising from wide-scale repeated insecticide applications, the overall feasibility is low.

When outbreaks are large, the technical feasibility of the eradication of an exotic or native insect vector is negligible as insects may escape the applications of insecticides, or become resistant, and because it is difficult to extensively spray crops, natural and semi-natural areas, urban areas, parks and individual gardens. Large pesticide applications may also give rise to concerns about pollution of the environment and animal/human health.

Uncertainty

The uncertainty is medium as, even if adequate measures are taken on time, some insects may escape treatments.

4.3.3. Containment strategies

Containment of *X. fastidiosa* within an outbreak area requires the demarcation of the infested area by delimiting surveys (refer to ISPM No.6, FAO, 1997), prohibition of movement of infested host plant material from the demarcated area to non-infested areas and prevention of the movement of insect vectors from the demarcated area to non-infested areas. Additional measures must be implemented to mimimize the incidence of the pest in the demarcated area by eliminating infested plants and minimizing the number of infectious insect vectors that acquired *X. fastidiosa* from infected plants. Intensive detection surveys are necessary in the areas bordering the demarcated infested area. Because of the very large host range of *X. fastidiosa*, including species of crop plants, ornamental plants, plants from the environment and weeds, the persistence of the bacterium in plants and in insects, and the large populations of insect vectors in the environment, containment of an outbreak is a difficult task. It is therefore necessary to combine various methods to reach an appropriate level of containment.

4.3.3.1. Demarcation of infested areas

Demarcation of infested areas is the first measure to take to contain a pest.

4.3.3.2. Limitation of the sources of bacterial inoculum

Infected plants, symptomatic or not, constitute a perennial reservoir for the bacterium where insect vectors can become infected. Measures described in section 4.3.2.1 can be applied and lead to similar outcomes.

Methods consisting in severe pruning of infected trees may temporarily limit the availability of bacterial inoculum for insect vectors, but sprouts that grow later also constitute a source of inoculum, so these methods cannot be recommended.

The effectiveness of the removal of infected plants is correlated with the proportion of infected plants that are destroyed and to the rapidity of effective destruction after a positive diagnosis. Nevertheless, no scientific data are available to assess removal effectiveness as a single measure.

4.3.3.3. Limitation of the number of infectious insect vectors

Native infectious insect vectors cannot be eradicated, of course, but their populations can be limited by insecticides, as described in section 4.3.2.2. This strategy leads to similar conclusions as reported in that section.

Vector biological control does not appear to be an option as even small populations of insect vectors are sufficient to ensure *X. fastidiosa* transmission.

The efficiency of the removal of infectious insects is correlated with the proportion of these insects that are destroyed and the rapidity of effective destruction after a positive diagnosis. Nevertheless, no scientific data are available to assess removal efficiency as a single measure.

4.3.3.4. Limitation of the transfer of the bacterium from plant to plant by insect vectors

All measures that can limit the transfer of insect vector populations from infected plants to healthy hosts (crops, ornamentals, plants from the environment, weeds) may reduce the number of resulting infected plants and, thus, the quantity of inoculum available for further infections.

Nevertheless, such methods could have some unexpected results under certain circumstances, making it difficult to evaluate *ex ante* the consequences of potential mitigation measures.

Good control of weeds, for instance, can be seen as an appropriate method to limit populations of insect vectors that need those plants to accomplish part of their life cycle. But, by removing weeds, food scarcity could also force some insect vectors to feed on crops as their preferred source of food is no longer available.

Similarly, insecticide treatments could have a negative result by modifying insect population dynamics and favouring insect vectors, e.g. by placing proportionally higher pressure on the insects' natural enemies.

4.3.3.5. Prohibition of movement of infected plant for planting material

By prohibiting the movement of infected host plant material from the demarcated area the dissemination of the disease is limited, as detailed in sections 4.1 and 4.2. This requires testing and other measures to guarantee absence of bacteria in plants.

4.3.3.6. Adaptation of containment measures to local situations

The intensity of containment measures might be adapted to local situations. In countries or areas where the disease is already widely present, containment is no more possible and the only realistic objective is to slow down the dissemination and to protect, first, plant material used for plantation. In countries or areas where the extension of the contaminated locations is still limited and where the objective is to strongly protect the adjacent non-infested regions, intensive strict containment measures must be implemented to effectively keep these latter free from the disease. In all cases, a systems approach (FAO, 1998), combining various methods of containment, is recommended. All measures should be applied to the outbreak zone and to large surrounding buffer zones. Buffer zones are areas around the outbreak zone where no infected plant or insects have yet been detected. Various buffer zones can be drawn depending on the specific levels of risks and containment measures. Buffer zones should be designed according to geographical and biological issues (topography, cropping context, ecological context, and presence of host plants or insect vectors, vector flight capacity) and should be large enough to avoid any escape. Those buffer zones should be regularly reviewed on the basis of the results of surveys, samplings and analysis. As soon as a plant or an insect in a buffer zone is identified as being contaminated, that zone shall be considered as part of the outbreak zone.

First, measures should be taken to minimise the amount of inoculum remaining in the environment (in plants, in insects). This requires surveys, visual inspections, sampling and laboratory testing of crops and other host plants (see section 4.6.8 below) as well as the rapid destruction of all infected plants. As the disease is spread by insect vectors from plant to plant, and as there is a delay between the inoculation of the bacterium by the vector and the appearance of symptoms, and even the possibility of detecting the bacterium *in planta*, it is of key importance when eradicating known infected plants to also destroy all the other plants in their vicinity. Such an approach may also imply good control of vector populations, as these could remain after the eradication of infected plants, as some may have escaped and may serve as inoculum for re-emergence. Additional measures to avoid re-infestation of treated zones are also important, and new plantations should involve only healthy plants coming from outside the outbreak zone.

As data on the incubation period between first infection and first symptoms are lacking, the time required for plants to serve as pathogen sources is unknown. Similar uncertainties concern the potential for dissemination of insect vectors. Therefore, as local conditions may lead to different cases, it is difficult to give general and precise indications on how wide the buffer zone should be. The wider is the designed buffer zone, the higher is the possibility of containing an outbreak.

In addition, measures should be taken to avoid exporting the pathogen (in plants, in insects) from the outbreak area to buffer or healthy zones. Nurseries and plots of plants for planting in the outbreak and buffer zones should be protected by screen houses and treated against the insect vectors. Plant material exported from the outbreak or buffer zones should be subjected to risk reduction measures that can guarantee that infected insects cannot escape. Measures should concern commercial as well as non-commercial flows of plant material.

Effectiveness of combined containment strategies

The effectiveness of such containment strategies varies from negligible to moderate, depending on (1) the local situation (size of the outbreak, delay between first occurrence and identification of the disease, abundance of host plants and insect vectors in the area, etc.) and (2) how strict and stringent are the implemented measures.

Technical feasibility of combined containment strategies

The technical feasibility varies from low to moderate depending on the same constraints. The possibility of effectively preventing any movements of infectious vectors through buffer zones appears to be low, as vectors are likely to move long distances by hitch-hiking.

Uncertainty of combined containment strategies

The uncertainty is high as the biology and epidemiology of the bacterium and of its insect vectors remain largely unknown under European conditions, and as the effect of mitigation measures, alone or combined, is difficult to forecast.

Table 9: Summary of the risk reduction options identified and evaluated to reduce the probability of establishment and spread

Type of measure (for details, see EFSA PLH Panel, 2012)	**Position in the pathway**	**Effectiveness**	**Technical feasibility**	**Uncertainty**
4.3.1. Surveillance	After entry	Low to moderate	High	Low to medium
4.3.2. Eradication	After entry			
4.3.2.1. Eradication of infected plants		High	Very low to moderate	High
4.3.2.2. Eradication of exotic vectors		High	Negligible to moderate	Medium
4.3.3. Containment strategies (combination of the following) 4.3.3.1. Limitation of the source of the bacterial inoculum 4.3.3.2. Limitation of the number of infectious insect vectors 4.3.3.3. Limitations of the transfer of the bacterium from plant to plant by insect vectors 4.3.3.4. Limitation of the transfer of plant for planting material 4.3.3.5. Adaptation of containment measure to local situations	After entry	Negligible to moderate, depending on local situation and implementation	Low to moderate	High

4.4. Analysis of the risk reduction options included in Directive 2000/29/EC

The current requirements that are laid down in Directive 2000/29/EC assume that *X. fastidiosa* is not known to occur in the EU and, therefore, the bacterium is listed in Annex I, Part A, Section 1. As the bacterium is not known to occur, the Directive does not contain specific measures against the spread of the disease within the EU.

Nevertheless, some measures already implemented in the Directive may help to mitigate the risk of introduction and spread of the pathogen.

4.4.1. General measures against the introduction of *X. fastidiosa*

The inclusion of *X. fastidiosa* in Annex I of Council Directive 2000/29/EC means that its introduction into the EU and spread within the EU is banned, whatever the bacterium is associated with (isolated bacterium as pure cultures, on plant material for planting, for consumption or for industry uses, in insects, etc.). *X. fastidiosa* should be absent from all plant material imported into the EU and the phytosanitary certificate issued by the exporting country for all plant for planting imported into the EU should be delivered in compliance with this requirement. Such a measure is theoretically very effective provided that exporting countries are in a position to guarantee the absence of the bacterium in all cases. The effectiveness of that measure is reduced by the following facts: (1) the bacterium may infect a wide range of cultivated and wild host plants in exporting countries, sometimes in asymptomatic association, (2) the number of plant species introduced into the EU is very large, (3) plants for planting material originates from numerous exporting countries where *X. fastidiosa* is present, and (4) insect vectors can be common in crop and natural environments of exporting countries.

4.4.2. Specific measures for certain species of plant for planting

X. fastidiosa is known to cause severe damage on plants belonging to the genera *Citrus* and *Vitis*. The prohibition of introduction of plants from those genera, originating in third countries, is an effective measure to prevent the introduction of *X. fastidiosa* with plant from those host species. Nevertheless, many other host plants can still be imported and may carry the bacterium, as shown by the recent documented introductions into the EU of coffee plants infected by *X. fastidiosa* (Legendre et al., 2014; Van Eck, 2014).

Restrictions on the introduction of plants for planting of *Prunus* from non European origins are not suitable for reducing the risks of introduction of *X. fastidiosa* as plants free from leaves, flower and fruit can still be imported.

In conclusion, measures already implemented in Directive 2000/29/CE to limit the risks of introduction of *X. fastidiosa* into the EU territory through the import of plant material are only partially effective.

Considering the measures that aim at preventing the spread of *X. fastidiosa* within and between Member States, the list of plant species that requires a plant passport and the corresponding inspections and traceability cover only a very small part of the complete list of hosts of *X. fastidiosa.* Thus, should it be present in the EU, *X. fastidiosa* may be spread via plant material that does not require a plant passport.

Council Directive 2000/29/CE allows exemption from official registration for small producers whose entire production and sale of relevant plants are intended for final use by persons on the local market and who are not professionally involved in plant production. In the case of outbreaks of *X. fastidiosa*, considering the very wide host range, such an exemption from official inspections and plant passport requirements could facilitate the local dissemination of the pathogenic agent.

4.4.3. Specific measures for certain insect vectors

According to Directive 2000/29/CE, the introduction of insects belonging to non-European Cicadellidae known to be vectors of Pierce's disease (caused by *X. fastidiosa*), such as *Xyphon fulgida*, *Draeculacephala minerva* and *Graphocephala atropunctata*, is forbidden. However, the wording and scope of this measure are difficult to interpret: What is the definition of non-European insects? Does the measure consider only strains of *X. fastidiosa* that cause Pierce's disease in grapevine? Insect vectors outside the Cicadellidae (e.g. Cercopoidea, Cicadoidea) escape such measures. Furthermore, insect vector species that are present both in the country of origin and in the EU may also escape the measure. That measure is also difficult to implement as insects are not always strictly associated with plant material and can travel on their own or as stowaways, making inspections and interceptions at the destination difficult.

In conclusion, measures implemented in Directive 2000/29/CE to prevent the introduction of *X. fastidiosa* into the EU territory through insect vectors are useful, but only partially address the problem and are difficult to implement.

Plant passports also testify that no regulated insects are present in the consignments. This measure prevents the spread of insects that are or may be vectors of the pathogen, but only a small part of the list of potential vectors is considered by the present EU legislation. In addition, insect vectors of *X. fastidiosa* are already present throughout the EU and can naturally spread on plant material, by wind or other natural means, and even in vehicles. Therefore, measures targeting insects are of limited effectiveness.

4.4.4. Notification of the presence of *X. fastidiosa*

According to Article 16 of Directive 2000/29/CE, each Member State shall immediately notify in writing the Commission and the other Member States of the presence of any harmful organisms listed in Annex I, Part A, Section I, whose presence was previously unknown in its territory, which is the case for *X. fastidiosa*. That measure is very important as only recent outbreaks that are limited in size can be effectively managed and the bacterium eradicated. Early warning is then of first importance.

However, to be effective in practice, notifications should lead Member States to quickly and widely inform professional bodies and field inspectors so that diseased plants can be identified quickly. A set of appropriate management measures should be set in place urgently. Similarly, as *X. fastidiosa* also affects ornamental plants, it is also useful to raise awareness amongst citizens in general.

Given the wide host range of *X. fastidiosa*, which includes a large range of plant species, the insect vectors that are present in the EU, and the limitation of existing measures and exemptions laid down into Directive 2000/29/CE, the bacterium, once introduced into the EU, can hardly be kept under control. Dedicated measures to address that problem are described in emergency measures (see section 4.6).

4.5. Scenario in the absence of the current legislation or effect of removing the current legislation

If current EU import legislation were to be repealed, the probability of introduction into the EU of contaminated plant material would increase greatly as an even wider range of host plants from contaminated areas could be imported. The probability of introducing some of the already known vectors would increase as, for instance, insecticide treatments prior to export could be avoided. The absence of any plant passport would also increase the probability of spread from contaminated EU areas.

As the bacterium may be hosted not only by susceptible crops, but also by a rather wide range of other plant species, and as insect vectors are able to move to the environment surrounding infected plots, it is not expected that management measures taken on a voluntary basis on infected plots will be

sufficient to eradicate *X. fastidiosa.* In addition, the development of the disease may take some time before the host plant dies or is removed, and infected plants may serve in between as reservoirs and sources of the bacterium for vectors for a rather long period, even before symptoms are expressed. As a result, if the current EU legislation were to be repealed, the probability of spread within a contaminated area, thus increasing the inoculum, and from contaminated EU areas through the movement of plant material as well as through vectors would increase dramatically. In addition, the removal of mandatory notifications of outbreaks and of the existing traceability rules (plant passport) would make more difficult the monitoring of the phytosanitary situation in Member States.

As a consequence, the removal of existing EU regulation would make the compliance of lots of plants for export to the regulation of importing countries much more difficult and costly for producers and official services, especially in the case of plants for planting material.

Considering the crops endangered and the direct and indirect damage caused by *X. fastidiosa*, the consequences may be large.

4.6. Analysis of the risk reduction options included in Commission Implementing Decision 2014/497/EU

Commission Implementing Decision 2014/497/EC provides emergency measures added to risk reduction options already implemented in Directive 2000/29/CE. Those measures are taken in order to prevent the entry into, and spread within, the EU of *X. fastidiosa.*

They consist in:

- requirements for the introduction into the EU of specified plant species originating in third countries where the specified organism is known to be present (Article 2, Annex I, Sections I and II);
- requirements for movement within the EU of specified plants grown in a demarcated area/infected zones (Article 3);
- surveys for the presence of *X. fastidiosa* in all Member States (Article 4);
- the need for immediate report of suspected cases of *X. fastidiosa* to a competent authority (Article 5);
- a procedure for confirmation and notification of the presence of *X. fastidiosa* (Article 6);
- definition and establishment of demarcated areas and buffer zones (Article7);
- reporting on measures (Article 8).

The emergency measures proposed (2014/497/EU) have been taken in the light of the Italian situation in Apulia but apply to the whole EU. It is worth emphasising that, owing to the diversity of strains of *X. fastidiosa* and its potential insect vectors, it might be difficult to generalise measures adopted based on the specific properties (host range, targeted crop, insect vectors) of a given strain. New information may therefore lead to adapted measures.

4.6.1. Definitions—specified organism—specified plants (Article 1)

The authors associated with the designation of the name of the specified organism, *X. fastidiosa* provided in the emergency measures should be corrected: Wells et al. instead of Wells and Raju (Wells et al., 1987).

The scope of the implementing decision is limited to plants for planting, excluding seeds, of the following species, the so-called "specified plants": *Catharanthus*, *Nerium*, *Olea*, *Prunus*, *Vinca*, *Malva*, *Portulaca*, *Quercus* and *Sorghum*.

The possibility that *X. fastidiosa* can be seed transmitted is controversial and is not supported by scientifically sound tests. Therefore, it is considered that seed is not a pathway for transmission of *X. fastidiosa*. Thus, the decision by the European Commission to exclude seeds from the plants for planting subject to the emergency measures appears to be justified.

The current list of plant species (cultivated or naturally occurring) already known to be hosts of *X. fastidiosa* is very large (see Table 2, Appendix B).

As already mentioned, it is worth considering separately the specific situation in Apulia (new syndrome on olive trees, with a strain of *X. fastidiosa* for which the precise host range is still partially known) and the more general case of a possible introduction of *X. fastidiosa*, which could display a different host range. Other than this, the list of plants that are susceptible to the Apulian strain of *X. fastidiosa* is not fully known and, considering the wide range of plant species that are grown outdoors and in nurseries in the Mediterranean area, it is expected that some of them could belong to the current list (see Table 2, Appendix B) of plants susceptible to *X. fastidiosa* or could be close relatives that would need further investigations.

Some of the plant genera in which the *X. fastidiosa* Apulian strain has been detected are not included in the list, in particular *Acacia*, *Polygala*, *Spartium* and *Westringia*. Those genera have been recently described as hosts for the strain occurring in south Italy, although Koch's postulates have not yet been tested for most of them. *Citrus* and *Vitis* genera have not yet been shown to be hosts for the strain involved in the Apulia outbreak (Maria Saponari and Donato Boscia, CNR, Institute for Sustainable Plant Protection, personal communication, November 2014). Nevertheless, at this stage, it cannot yet be definitively concluded that the genera *Citrus* and *Vitis* are not able to host the Apulian strain of *X. fastidiosa*.

Some of the plant species listed in the implementing decision (*Malva*, *Quercus*) have not yet been confirmed as hosts of the strain present in south Italy (Donato Boscia, CNR, Institute for Sustainable Plant Protection, personal communication). In general, there is very high uncertainty on the host range of the Apulian strain of *X. fastidiosa* as research is ongoing. It is useful to stress that the *X. fastidiosa* Apulian strain, although described as similar to the subspecies *pauca*, has been found in hosts plants that were not associated previously with that subspecies, like *Vinca* sp., *Spartium junceum* and *Nerium oleander*. EFSA has requested that some additional work be carried out on the host range of the Apulian strain.

4.6.2. Requirements for the introduction into the EU of specified plants originating in third countries where the specified organism is known to be present (Article 2, Annex I, Sections I and II)

The implementing decision provides a series of additional declarations that shall be indicated on the phytosanitary certificate (in the section "additional declarations") attached to the plants for planting material intended to be imported into the EU from third countries where the specified organism is known to be present, but only for certain plant genera (*Catharanthus*, *Nerium*, *Olea*, *Prunus*, *Vinca*, *Malva*, *Portulaca*, *Quercus* and *Sorghum)*.

Those additional declarations (see Annex I, Section I, of the implementing decision) are related to the following measures to be stated by the exporting countries that:

- the plants have been grown throughout their life in a site of production which is registered and supervised by the National Plant Protection Organisation in the country of origin, and situated

in a pest-free area established by that organisation in accordance with relevant International Standards for Phytosanitary Measures,

- and that:
  - the plants have been grown throughout their life in a site of production which is free from *X. fastidiosa*, and where neither the disease nor the insect vectors have been observed in the past, which is registered and supervised by the National Plant Protection Organisation in the country of origin, which is physically protected against the introduction of *X. fastidiosa* and its vectors, which is subjected to at least two official inspections per year, at appropriate times, and,
  - phytosanitary treatments against the vectors of the specified organism have been applied to guarantee that no bacteria where transmitted, and
  - the lots of plants have been subjected to testing, and
  - the specified plants have been transported in conditions that prevent contamination, and
  - the plant lots were subjected to official inspection, sampling and testing.

Those additional declarations are in accordance with risk reduction options that have already been discussed and evaluated in this opinion (see Tables 6 and 7). In general, and if applied to all plants that may host *X. fastidiosa* and to insect vectors that may transfer the bacterium from plant to plant, they are considered adapted to provide a good level of confidence on the sanitary status of the exported or moved plant material. However, these measures are considered as partly ineffective owing to the limitations on the restricted list of plant species, as already discussed in section 4.6.1. *X. fastidiosa* has extensive large list of host plant genera (see Table 2 and Appendix B) in the areas of its current distribution.

4.6.3. Requirements for movement within the EU of specified plants grown in a demarcated area/infected zones (Article 3)

Limitations related to the list of "specified plants" (*Catharanthus*, *Nerium*, *Olea*, *Prunus*, *Vinca*, *Malva*, *Portulaca*, *Quercus* and *Sorghum*), as given in section 4.6.1, are also valid for this article. The general conditions given in Annex II, point 2, of the implementing decision for plants grown at least during part of their life cycle in a demarcated zone are in accordance with the risk reduction options detailed above in this opinion. These measures correspond to an integrated approach that is considered to be effective, including pest-free production sites (section 4.1.1), growing plants under exclusion (section 4.1.2.3) and cultural practices including vector control (section 4.1.2.1), inspection and testing.

Nevertheless, because of the short growing period of certain plants, of the time needed for symptom expression and of the rapidity of infections by insect vectors, performing laboratory tests on an annual basis (Emergency Measures, Annex II.2b) does not provide sufficient confidence. In addition, as no indications are given regarding the laboratory test to be performed, the samples to be collected and the sampling pressure to be used, such a measure appears to be of limited efficiency.

The EU implementing decision stipulates (Emergency Measures, Annex II.3) that "Specified plants moving through or within demarcated areas shall be transported outside the flight season of any of the known vectors of the specified organism, or in closed containers or packaging, ensuring that infection with the specified organism or any of its known vectors cannot occur".

The flying season of the adults of the known local vector *P. spumarius* is reported from May to December in Apulia (Cornara and Porcelli, 2014), therefore the movement of these listed plant species

in that period should always be in closed containers. Nevertheless, the vector is also known to travel as a stowaway on or in vehicles for instance. So there is a risk that some insect vectors present in the risk assessment area could travel out of the area and transmit the bacterium. Uncertainties are very high as the behaviour of *P. spumarius* as a stowaway is not yet fully documented in Italy and as the behaviour of other potential insect vectors present in the risk assessment area is largely unknown. That concern reduces the effectiveness of the control measure.

Nevertheless, this control measure could be of help in reducing the movement of the bacterium in insect vectors, when applied in an integrated approach together with preparation, treatment and inspection of consignments, particularly considering the possibility of stowaway infectious vectors (see section 4.2.1).

4.6.4. Conduct surveys for the presence of *X. fastidiosa* in all Member States (Article 4)

Member States shall "conduct official annual surveys for the presence of *X. fastidiosa* on plants and plant products in their territory" and notify the results to the Commission (Article 4).

Nevertheless, the EU implementing decision provides no indications of the expected minimum requirements for those surveys expect that they shall be based on "sound scientific and technical principles, and shall be carried out at appropriate times with regard to the possibility to detect the specified organism". This may result in large discrepancies between areas, and the results of such surveys might not be able to provide a clear view of on the actual situation within the EU territory.

In addition to recording information about sites where the disease has been found, it is also crucial to record details about sites that are surveyed but also where the disease is not found, i.e. "negative data", which is different from "absence of data". This includes sites that have been visited but where no symptoms were observed, as well as sites where symptoms were observed but laboratory tests were negative. Negative data are valuable and without the recording of negative data it is difficult to make accurate estimates of the incidence and spatial distribution of the disease in a region. This information is crucial to understand the extent of the problem in a particular region and also presents valuable epidemiological information to improve current understanding of the disease in the risk assessment area and to quantify rates and patterns of spread.

4.6.5. Need for immediate report of suspected cases of *X. fastidiosa* to competent authority (Article 5)

Member States also have to make sure that anyone who becomes aware of the presence of the specified organism, or has reason to suspect such a presence, shall notify the competent authority within 10 calendar days and that, if so requested by the competent authority, that person shall provide that authority with the information which is in his or her possession concerning the presence of *X. fastidiosa* (Article 5). However, to implement this option there is a need for a general awareness campaign aimed at professional operators such as extension services and farmers. As the disease also affects ornamental plants, any such general awareness campaign should also target citizens in general. Therefore, this measure could be very effective for early detection of new occurrences provided that communication campaigns have raised public awareness.

4.6.6. Procedure for confirmation and notification of presence of *X. fastidiosa* (Article 6)

This is an important measure for early warning of new outbreaks.

4.6.7. Establishment of demarcated areas (Article 7, Annex III, Sections 1 and 2)

The implementing decision considers infected zones, demarcated areas and buffer zones. According to the implementing decision, "The infected zone shall include all plants known to be infected by the specified organism, all plants showing symptoms indicating possible infection by that organism, and all other plants liable to be infected by that organism due to their close proximity to infected plants, or common source of production, if known, with infected plants, or plants grown from them".

It also states that "The buffer zone shall have a width of at least 2 000 m", which can be reduced to 1 000 m under certain circumstances. Notwithstanding those definitions, the implementing decision indicates that "The exact delimitation of the zones shall be based on sound scientific principles, the biology of the specified organism and its vectors, the level of infection, the presence of the vectors, and the distribution of possible host plants in the area concerned". Furthermore, the level of presence of the specified organism within the demarcated area must be less than 0.1 %, with 99 % reliability.

Considering the large list of plant species that may host *X. fastidiosa*, the long distances between some of the infected areas in the Apulia region (up to ca. 10-20 km according to Fig. 6), as well as the possibility of passive transportation of infectious vectors as stowaways, for example on/in vehicles or by wind (see sections 3.4.1 and 3.4.2 and Figure 12), it is now clear that, if the eradication strategy is not able to regulate the disease, alternative containment strategies should be implemented. It is important to keep in mind that due to the above limitations, a buffer zone of 2000 m is likely to be overcome and that intensive surveys and sampling need to be in place also farther away from the infected zones.

4.6.8. Measures to be taken in demarcated areas

The first measure (item a) consists in the removal "as soon as possible" of "all plants infected (…) as well as plants showing symptoms indicating possible infection (…) and all plants which have been identified as likely to be infected (…) taking all necessary precautions to avoid spreading of (*X. fastidiosa*) during and after removal".

That measure is effective in reducing the amount of bacterial inoculum. Nevertheless, the expression "as soon as possible" may be interpreted in different ways, which may result in delays between detection of the disease and removal of infected plant material. In addition, the concept of "likely to be infected" is not clearly defined and may also lead to discrepancies in the way in which demarcated zones are managed.

As potential insect vectors may move from infected plants being removed to other plants, it is advisable first to spray insecticides on plants to be removed and in their vicinity.

The second measure (item b) states that "sampling and testing of specified plants, plants of the same genus as the infected plants, and all other plants showing symptoms (…) within a radius of 200 m around infected plants" should be organised "using a sampling scheme able to confirm with 99 % reliability that the level of presence of (*X. fastidiosa*) in those plants is below 0.1 %".

To be effective, this measure should be implemented immediately after infected plants are identified. A radius of 200 m is not supported by strong scientific data to date, but, providing that any identification of a new infected plant through the sampling and testing period results in the definition of a new 200 m radius, it may help to mitigate the extension of the disease.

As the bacterium can be present at very low densities in plants, depending on seasons and stage of infection for instance, as only parts of plants can be infected and as insect vectors can bring the bacterium from outside the radius zone, sampling and testing should be followed up on a regular basis.

The third measure (item c) deals with the destruction of contaminated plant material. As the disease is spread either by plants for planting material, or by insect vectors that suck on turgescent plants, there is no risk of dissemination with dead plant material or plant material with no green parts. Dead plants (naturally or after chemical devitalisation), cut branches without turgescent leaves and wood do not represent any risk of spread of the bacterium.

Nevertheless, new twigs that may emerge from strongly pruned diseased plants or from recently cut branches represent a risk of further spread of the disease.

When destroying infected plant material, special care should be taken to avoid the escape of insect vectors.

The fourth measure (item d) considers only "plant material originating from pruning of specified plants and of plants of the same genus as the infected plants".

As explained in this opinion, pruning can generally not be considered as an appropriate method to manage outbreaks of *X. fastidiosa.* Pruning has only been shown to be effective in a limited number of cases, on very early symptoms and together with vectors control and certification

The fifth measure (item e) deals with "appropriate phytosanitary treatments of specified plants and plants that may host the vectors of (*X. fastidiosa*) to prevent spread".

That measure alone is of poor effectiveness as it is in practice difficult to spray what are often large areas, as described above in this opinion. Insecticides should be considered only in conjunction with other management measures, for instance just before the removal and destruction of infected plants, in order to avoid the transfer of insect populations from infected plants to others.

The sixth measure (item f) states that "it shall trace back to the origin of the infection and tracing forward of the specified plants associated with the case of infection concerned, which may have been moved before a demarcated area was established".

That measure is highly appropriate and such work should be initiated immediately after any plant is identified as infected by *X. fastidiosa.* It may nevertheless be difficult as the first occurrence of the disease cannot always be identified.

The seventh measure (item g) aims to "prohibit the planting of the specified plants and plants of the same genus as the infected plants in sites which are not vector-proof".

The prohibition of the planting of plants known to be host of the occurring strain of *X. fastidiosa* is an effective risk reduction option. As the host range of *X. fastidiosa* is large but not fully known, a risk is nevertheless that a plant species not already known to be host appears to be a host in practice.

The extension of that measure to plants of the same genus as the infected plants can be considered as a precaution, but it is not supported by the available scientific literature.

The eighth measure (item h) consists in requiring "intensive monitoring for the presence of (*X. fastidiosa*) by at least annual inspections at appropriate times, with specific focus of the buffer zone and on the specified plants and the plants of the same genus as the infected plants, including testing, in particular of any symptomatic plants".

No indication is provided on the level of intensity of such a monitoring, which may therefore be interpreted very differently. As insects spread the disease, the surveillance of buffer zones is of key important to prevent the spread. Search for symptomatic plants is a necessity in the buffer zone, but as infected plants may remain asymptomatic, even if infectious, special efforts should be made to identify those potential asymptomatic plants through appropriate laboratory analysis. As early contamination of plants is highly difficult to detect, and as the disease may take time to develop in an infected plant, monitoring should take place several times a year.

The ninth measure (item i) promotes an increase of the "public awareness concerning the threat of (*X. fastidiosa*) and (…) the measures adopted to prevent its introduction (…)".

That measure is necessary as it may help targeting new infected plants and taking appropriate measures not only in field planted for commercial matters (private gardens, parks, etc.).

Nevertheless, such a measure is at least as important in buffer zones where the disease is not yet present and where early warning is a condition for an appropriate effectiveness of all the decided risk reduction measures. In addition, as early detection of infected plants is of key importance for the success of an eradication scheme, and as *X. fastidiosa* can infect plants that are grown in all kinds of environments (fields, parks, gardens, etc.), it is advisable that public awareness is also increased, largely in the areas around the demarcated and buffer zones.

The tenth measure (item j) aims to overcome potential difficulties that may arise when trying to eradicate the bacterium, in particular in terms of access to plants to be eradicated.

The eleventh measure (item k) simply indicates that ISPM measures n° 9 (FAO, 1998) and n° 14 (FAO, 2002) should be followed.

4.6.9. Reporting on measures

This is an important measure to ensure that measures taken are based on a scientific and technical analysis.

4.7. Opportunity to improve knowledge

Although much research on *X. fastidiosa*, the associated diseases and the insect vectors outside the EU has already been conducted or is ongoing, there are still many knowledge gaps, especially for the EU context. Those gaps lead to high uncertainties both in the assessment of risks and in the assessment of the efficacy of potential control measures.

The outbreak occurring in the Apulia region of Italy provides the opportunity to at least partly fill those gaps. It could lead to a better understanding of the disease and of the measures that could be taken either to eradicate the bacterium or to contain it when eradication is no longer a feasible option. Recent interceptions of coffee plants for planting material in the EU suggest that control measures at import can be improved.

4.7.1. Towards a better understanding of the bacterium

Recent scientific publications reveal that the genetic diversity of *X. fastidiosa* is large. Nevertheless, that diversity is still partly unknown or not fully understood, and its consequences in the field need to be further evaluated.

The distribution of *X. fastidiosa* among various subspecies makes it difficult to predict the host range and the association with vectors of any given strain, and the severity of the disease that strain can potentially cause. It is also important to know the extent to which the various subspecies of *X. fastidiosa* can be vulnerable to cold temperatures and winter recovery. More knowledge in this area is necessary, unless it can be shown that subspecies as defined today for *X. fastidiosa* are not an appropriate tool for such predictions.

A recent paper (Nunney et al., 2014) states that recombinations between *X. fastidiosa* strains, even if they are attributed to different subspecies, may be possible and may result in new strains with unpredictable characteristics. This should be further studied as it may greatly impact the risks associated with *X. fastidiosa* in terms of host range, association with vectors and severity of the disease.

4.7.2. Towards a better understanding of the host range

According to the scientific literature, the host range of *X. fastidiosa* is very large. Nevertheless, it mainly includes cultivated plants and little information is available on weeds, forest trees and wild species. In some cultivated plant species, coffee for instance, it appears that infection is most often asymptomatic.

The outbreak in the Apulia region provides the opportunity to determine under natural conditions which plants can or cannot host this particular strain. However, these findings would be valid only for the bacterial strain present in Apulia.

Investigation of naturally occurring potential host plants (cultivated or not) requires the testing of a large number of specimens of each plant species originating in zones where the disease is widely present, to ensure that the results are statistically valid. Testing a limited number of specimens from areas where the disease is not widely present is certainly not conclusive. In addition, there is no indication that the distribution of the bacterium is homogeneous in plants and that the density of bacteria is stable throughout the year. As plants do not always show symptoms, analytical detection tools of sufficient quality (see below) are required. Thus, evaluating plant species under natural conditions is a difficult task that requires very-well planned experiments and takes time.

Studies in contained facilities may help (mechanical inoculations of the bacterium to a range of plant specimens, insect-mediated inoculations, etc.). Nevertheless, such analyses require special facilities and the results are not completely satisfactory as they may be influenced by growing conditions.

Such experimental work could help field inspectors to conduct surveys and manage eradication programmes. It could also help policy makers to adapt the emergency measures (e.g. limitation of movement of plants for planting material from demarcated and buffer zones) to achieve improved effectiveness. Nevertheless, the main limitation is that those results would be valid only for the strain of *X. fastidiosa* that is present in Apulia and for plants that are growing in that environment.

For the EU territory, the question of the susceptibility to various strains of *X. fastidiosa* of important agriculture (e.g. citrus, grapevine, olive, stonefruits) and forestry hosts (e.g. oak) is also crucial. However, as bacterial strains are very diverse, as are the genotypes of those potential host plants, such studies are difficult. Nevertheless, such results could help decision makers to improve the current list of plants considered in both EU Directive 2000/29/CE and Implementing Decision 2014/497/EU. In addition, to spread, the pathogen also needs an appropriate vector.

The role of the identified host plants in Apulia region in the epidemiology of the disease is unclear. Which hosts play a major role in the dissemination of the bacterium? Are unmanaged plants, weeds and ornamentals important in terms of epidemiology? Those questions could be answered by studying the outbreak in detail. Even if the results are not conclusive for the entire EU territory, as agro-eco-climatic conditions are different, they could help to fine tune containment measures.

The question of the susceptibility of various olive varieties to *X. fastidiosa* is also an important one for growers in the Mediterranean region and should be extensively tested in Apulia.

4.7.3. Towards a better understanding of the insect vectors and their behaviour

Many insect species are potential vectors for *X. fastidiosa.* Apparently, species of importance vary from one area to the other and potentially depend on bacterial strains. Preliminary studies from the Apulian outbreak could even indicate that insect populations might be infectious only during certain periods of the year, which would be new information, even if still uncertain. Further work is then needed to better understand which insects can be vectors for which strains, and to clarify the possible periods when insects are infectious. Such work should be carried out in the Apulia region, where it is possible to work with local insect populations that are exposed to the bacterium.

There is also a great deal of uncertainty on the distribution of various potential insect vectors in the risk assessment area, which causes uncertainties regarding the area where *X. fastidiosa* may cause problems. In particular, there is a need to determine the species of potential vectors in the other EU olive growing areas and their ecology in the olive orchards including their overwintering behaviour.

Insect populations can also move from weed to trees or from weed to crops at certain periods or because of certain agricultural practices (removal of weeds for instance). Such movements may have strong epidemiological consequences for the disease and should therefore be studied in detail so that, if necessary, agricultural practices and disease management procedures can be fine tuned. Therefore, a better understanding of the biology and ecology of insect populations is necessary to be able to assess how far a given mitigation measure can be effective or counterproductive.

4.7.4. Towards a better understanding of the Apulian outbreak

To date, there is no information on the origin of the outbreak in Apulia region. Where was the first infected plant in Apulia? How did the bacterium enter the region (in a plant or in an insect)? When did the corresponding introduction occur? As no genetic diversity has so far been shown on strains isolated in the region, it seems reasonable to consider that a single introduction occurred. It also seems reasonable to consider that *X. fastidiosa* entered the Apulia region many years ago, but this should still be investigated. Although growers experienced problems in olive trees, the causal agent remained unidentified for a long time, resulting in delays in implementing appropriate eradication measures.

Thus, further work is needed to answer these questions in order to evaluate which measures could be taken to avoid any new introduction and to make the rapid detection of outbreaks and appropriate identification of the causal agent more effective. Such work may also help to identify new measures or to upgrade existing measures at the EU level.

In the Apulia region, *X. fastidiosa* has spread widely since its introduction, but the information available does not yet permit a detailed analysis of the spread characteristics. Did the bacterium move from an infected plant to another host plant through insect vectors moving on their own on limited distances, still to be estimated? Or did infectious insect vectors travel as stowaways over much large distances, still to be estimated? Did that spread occur quickly or did it take many years, still to be estimated?

A detailed analysis of the outbreak, supported by appropriate field observations, interviews with growers and with field technicians, analysis of movements of plants for planting material inside the demarcated area, laboratory analysis of plants and insects and any other appropriate methods, is necessary to document the spread distance of the bacterium and, therefore, to justify the values chosen by decision makers to delimit the demarcated area and the buffer zone in a way that effectively reduces spread.

4.7.5. Re-evaluation of pathways at import

Recent interceptions at the EU border reveal that some plants not previously thought to be major potential sources of bacterial inoculum should be considered. This is the case especially for coffee plants.

A re-evaluation of potential host plants to be checked at the border for the presence *of X. fastidiosa* is advisable.

4.7.6. Laboratory capacities

The detection of *X. fastidiosa* from plants showing symptoms is not always easy and it requires highly experienced staff. That task is even more difficult for plants that do not show any symptoms. In addition, routine analyses are different from those carried out for research purposes and therefore should be performed by different laboratories. Protocols should be in line with the highest international standards, should be internationally validated according to appropriate standards and should be used under the supervision of official services.

When *X. fastidiosa* is to be detected on asymptomatic plants from areas where the bacterium is present at low to very low prevalence (for instance for appropriate surveillance around demarcated areas, in

large buffer zones and in neighbouring areas where the disease is not yet known to occur), huge numbers of samples have to be processed in laboratories each year if the results of surveillance programmes have to be statistically significant. Statistical figures given in the EU implementing Decision 2014/497/UE ("99 % reliability that the level of presence of the specified organism in those plants is below 0,1%") imply for a large outbreak area the need to perform several thousands of analyses.

4.8. Conclusions on risk reduction options

There is no record of successful eradication of *X. fastidiosa* once established outdoors owing to the broad host range of the pathogen and its vectors. Therefore, the priority should be to prevent introduction. Strategies for preventing the introduction from areas where the pathogen is present and for the containment of an outbreak should focus on the two main pathways (plants for planting and infectious insects in plant consignments) and be based on an integrated system approach, combining, when applicable, the most effective options (e.g. pest-free areas, surveillance; certification, screen house production, control of vectors and testing for plant propagation material, preparation, treatment and inspection of consignments for the pathway of the infectious vectors in plant consignments).

In the case of the plants for planting pathway, some risk reduction options are considered more effective at reducing the likelihood of introduction of *X. fastidiosa* and/or infectious insect vectors:

- Prohibiting the import of *X. fastidiosa* host species plants for planting would be highly effective but its application would be constrained by the very wide potential host range of this pathogen and the large trade volumes. This is, however, a feasible option for high-risk commodities.

- Limiting the import of plants for planting to pest-free areas is considered to be highly effective, whereas pest-free production sites are assessed as having lower effectiveness unless combined with other measures (e.g. screen house production, certification and testing, vector control) in an integrated approach.

- Certification schemes, growing plants under exclusion conditions and vector control have high effectiveness, particularly when combined in an integrated approach.

- Among consignment treatments, the thermotherapy of dormant plants has been applied effectively to control *X. fastidiosa* in grapevine plants for planting. This practice is already applied to control other pathogens in *Vitis* plant propagation material. The import of dormant plants for planting is also effective in preventing the introduction of exotic sharpshooter vectors species that lay eggs only on leaves or green tissues, whereas it is not effective against sharpshooters that lay eggs on wood, unless combined with thermotherapy.

- Specific insecticide treatments of consignments of plants for planting can effectively reduce the likelihood of infective insect vectors being carried together with traded plants.

In the case of infective insect vectors, the likelihood of entry with other plant material, such as cut flowers or green foliage, can be reduced by appropriate treatment of the consignments and by an integrated approach in production sites free of *X. fastidiosa.*

The Panel has also reviewed the effectiveness of risk reduction options for *X. fastidiosa* and its vectors listed in Directive 2000/29/EC and in EU Implementing Decision 2014/497/EU for this pathogen.

With regard to Directive 2000/29/EC the Panel concluded that:

- The prohibition of introduction of *Citrus*, *Fortunella*, *Poncirus* and their hybrids, other than fruit and seeds, *Vitis*, other than fruit, originating in third countries is an effective measure to

prevent the introduction of *X. fastidiosa.* However, the restrictions on the introduction of *Prunus* do not reduce the risks of introduction of *X. fastidiosa* since plants free from leaves, flowers and fruit can still be imported and harbour the bacterium. Nevertheless, many other host plants can still be imported and may carry the bacterium, as shown by the recently documented interceptions of coffee plants that harbour *X. fastidiosa.*

- The exemption from official registration for small producers whose entire production and sale of relevant plants are intended for final use by persons on the local market and who are not professionally involved in plant production could facilitate the local dissemination of the pathogenic agent considering the very wide host range of *X. fastidiosa*.

With regard to Implementing Decision 2014/497/EU, the Panel concluded that:

- The exemption of seeds is scientifically justified.

- There is very high uncertainty on the host range of the strain of *X. fastidiosa* occurring in Apulia because research is still ongoing. More generally, the host range of *X. fastidiosa* is still uncertain. It is very likely that the bacterium has a wider host range than the species listed in the emergency measures. Nevertheless, some of the already known host plants of the Apulian strain are not mentioned in the implementing decision (the genera *Acacia, Polygala, Spartium* and *Westringia*).

- The reinforcement of conditions for imports from third countries is assessed as effective, but only some of the host plant genera are included (*Catharanthus, Nerium, Olea, Prunus, Vinca, Malva, Portulaca, Quercus* and *Sorghum*), which mitigates the effectiveness of that measure.

- There is a need for detailed and harmonised protocols for survey, sampling and testing, with at least guidelines regarding minimum requirements to be achieved in demarcated areas, buffer zones and areas not known to be infected.

- Asymptomatic hosts, asymptomatic infections or low infections can escape surveys based solely on visual inspection and even based on laboratory tests as early infections or heterogeneous distribution of the bacterium in the plant may lead to false-negative results.

- There is a need to limit the infectious insect vector populations (e.g. by vector control, vegetation management, inoculum reduction by removal of infected plants) in the outbreak area and to prevent their movement from infected plants. Particular care is necessary when removing infected plants or weeds, for instance, as this may result in movement of infectious insect vectors.

- The ban on planting of "specified plants" in demarcated areas is good, but all known host plants should be considered.

- Public awareness is important for diseases that can infect plants in gardens, natural or unmanaged environments. Awareness-raising campaigns should be organised for all people in demarcated areas, buffer zones and in their vicinity

CONCLUSIONS

The current distribution of *X. fastidiosa* in the EU is restricted to one strain within one province of the Apulia region in south Italy, where several thousand hectares of olive plantations are affected, and it is under official control. *X. fastidiosa* is also reported in Apulia on *Prunus cerasifera, Prunus dulcis, Nerium oleander, Acacia saligna, Polygala myrtifolia, Westringia fruticosa, Spartium junceum* and

Vinca spp. The genotype of *X. fastidiosa* of the Apulian outbreak has been attributed to the subspecies *pauca*. Nevertheless, this pest risk assessment considers all subspecies of *X. fastidiosa.*

X. fastidiosa presents a major risk to the EU territory because it has the potential to cause diseases in the risk assessment area once it establishes, as hosts are present and the environmental conditions are favourable. *X. fastidiosa* may affect several crops in Europe, such as citrus, grapevine, olive and stone fruits (almond, peach, plum, cherry), but also several tree and ornamental plants, such as oak, sycamore and oleander. *X. fastidiosa* has a very broad host range, including many cultivated and wild plants common in Europe. There is some host differentiation between the generally accepted four subspecies of *X. fastidiosa* with regard to symptomatic hosts; however, there is high uncertainty with regard to the potential host range of *X. fastidiosa* in the European flora as a wide range of European wild plant species have never met the bacterium and it is not known whether they would be hosts, and, if so, whether they would be symptomatic or asymptomatic.

All xylem fluid-feeding insects in Europe are considered to be potential vectors. Members of the families Cicadellidae, Aphrophoridae and Cercopidae are vectors in the Americas and, hence, should be considered as potential vectors in Europe. The Cicadidae and Tibicinidae should also be considered potential vectors. The hemipteran *Philaenus spumarius* has been identified as a vector in Apulia, Italy.

With regard to the assessment of the risk to plant health for the EU territory, the conclusions are as follows:

The probability of entry for plants for planting is rated very likely because:

- The association with the pathway at origin is rated as very likely for plants for planting due to the fact that (1) plants for planting have been found to be a source of the bacterium for outbreaks, (2) host plants can be asymptomatic and often remain undetected, (3) a very large number of plant species are recorded as hosts and (4) very high quantities of plants for planting are imported from countries where *X. fastidiosa* is reported.

- The probability of the bacteria surviving during transport is very likely.

- The probability of the pest surviving any existing management procedure is very likely.

- Additionally, the probability of transfer to a suitable host is rated as very likely, based on the intended use of the plant material for planting (rootstocks) or grafting (scions, budwood) as well as on the fact that host plants are extensively present in the risk assessment area. Insect vectors are also distributed throughout the risk assessment area.

The likelihood of entry for the infectious insect vectors is moderately likely, because the pest:

- is often associated with the pathway at the origin,

- is moderately able to survive during transport or storage,

- is affected by the current pest management procedures existing in the risk assessment area,

- has some limitations for transfer to a suitable host in the risk assessment area.

Entry is considered to have medium uncertainty, because the distribution of *X. fastidiosa* in the countries of origin is not fully known, knowledge of host plant susceptibility is only partial and only a few interceptions of infected plants have been made, taking into account also the difficulty of detecting asymptomatically contaminated plants. The difficulties in assessing precisely the quantities of plants for planting imported within the EU are also a matter of uncertainty. Additionally, only

limited data are available on vectors' capacity to survive long-distance transportation on their own in vehicles and they are restricted to only one species on *Homalodisca vitripennis*. Similarly, only limited data are available on vectors' autonomous dispersal capacity, and only for *H. vitripennis*. There are no data in the EUROPHYT database on the interception of vectors.

The probability of establishment is rated as very likely, based on the very high probability that the pathogen will find a suitable host owing to the very large range of host plants and potential host plants, and to the wide distribution and polyphagy of known and potential vectors. Other elements taken into account are the high probability of finding a climatically suitable environment, that is one with few adverse abiotic factors and no known effective natural enemies of *X. fastidiosa.* The information available regarding winter recovery in infected plants mostly relates to grapevine and the subspecies *X. fastidiosa.* The lack of efficient cultural practices or control measures also increases the probability of establishment.

The uncertainty level for establishment is rated as low, based on the fact that *X. fastidiosa* is already reported in Apulia. There is no uncertainty regarding the availability of a wide range of host plants, but questions remain regarding the susceptibility of the indigenous European flora. There is one confirmed vector species (*Philaenus spumarius*), that is widespread, abundant and polyphagous; a large range of additional potential vectors has yet to be studied. A large range of suitable climate is available in the risk assessment area. There is a lack of data regarding the overwintering capacity at low temperature and, more generally, regarding the range of temperature over which the bacteria can thrive and this makes it very difficult to assess the northernmost limit to its distribution in the EU.

The probability of spread from established infestations of *X. fastidiosa* is rated as very likely, because of the large number of confirmed or potential host plants and the abundance and widespread distribution of known (*P. spumarius*) or potential vectors. Spread over short to long distances by human assistance is very likely: this may occur via infected plants for planting or by passive transport of infectious insects in vehicles. Infectious vectors may spread locally by flying or be transported longer distances by wind.

Concerning the spread, the uncertainty is rated as medium. The contribution of human- and wind -mediated spread mechanisms are still uncertain. There is a lack of data on how far the insect vectors can fly. There is also a lack of precise indications on how current farming practices could possibly impact potential insect vectors and limit the spread of the disease.

The overall potential consequences of *X. fastidiosa* in the European territory are rated as major considering the severe losses on olive in the Apulian outbreak, on citrus in South America and on grapes in North America. In commercial crops, when conditions are suitable for symptom expression and efficient insect vectors are present, yield losses and damage would be high and imply costly control measures. The disease also has a negative social impact since it is not readily controllable in smallholdings and family gardens. Depending on the host range of the *X. fastidiosa* subspecies introduced, major crops, ornamental plants or forest trees could be affected, as in other areas of the world. In addition to these elements, the use of insecticide may have environmental impacts. Breeding and nursery activities might also be affected.

The uncertainty for the consequences is rated as low, based on a worst -case scenario approach. The exact host range of a given strain, the lack of knowledge on the potential vectors in the risk assessment area and the agro-ecological complexity of the diseases shall nevertheless be taken into account.

With regard to risk reduction options, the Panel reached the following conclusions.

A thorough review of the literature yielded no indication that eradication is a successful option once the disease is established in an area. Past attempts, in Taiwan and in Brazil, proved unsuccessful, probably because of the broad host range of the pathogen and its vectors. Therefore, the priority should be to prevent introduction. Strategies for the preventing introduction from areas where the

pathogen is present and for the containment of outbreak should focus on the two main pathways (plants for planting and infectious insects in plant consignments) and be based on an integrated system approach, combining, when applicable, the most effective options (e.g. pest-free areas, surveillance; certification, screen house production, control of vectors and testing for plant propagation material, preparation, treatment and inspection of consignments for the pathway of the infectious vectors in plant consignments).

For the plants for planting pathway, some risk reduction options have been considered more effective at reducing the likelihood of introduction of *X. fastidiosa* and/or infective insect vectors:

- Prohibiting of import of *X. fastidiosa* host species plants for planting would be highly effective but its application would be constrained by the very wide potential host range of this pathogen and the large trade volumes. This is, however, a feasible option for high-risk commodities.

- Limiting the import of plants for planting to pest-free areas is considered to be highly effective, whereas pest-free production sites are assessed as having lower effectiveness unless combined with other measures (e.g. screen house production, certification and testing, vectors control) in an integrated approach.

- Certification schemes, growing plants under exclusion conditions and vectors control have high effectiveness, particularly when combined in an integrated approach.

- Among consignment treatments, the thermotherapy of dormant plants has been applied effectively to control *X, fastidiosa* in grapevine plants for planting. This practice is already applied to control other pathogens in *Vitis* plant propagation material. The import of dormant plants for planting is also effective in preventing the introduction of exotic sharpshooter vectors species that lay eggs only on leaves or green tissues, whereas it is not effective against the sharpshooters that lay eggs on wood, unless combined with thermotherapy.

- Specific insecticide treatments of consignments of plants for planting can effectively reduce the likelihood of infective insect vectors being carried together with traded plants.

For the infective insect vectors, the likelihood of entry with other plant material such as cut flowers or green foliage can be reduced by appropriate treatment of the consignments and by an integrated approach in production sites free of *X. fastidiosa.*

The Panel has also reviewed the effectiveness of risk reduction options for *X. fastidiosa* and its vectors listed in Directive 2000/29/EC and in EU Implementing Decision 2014/497/EU for this pathogen.

With regard to Directive 2000/29/EC, the Panel concluded that:

- The prohibition of introduction of *Citrus*, *Fortunella*, *Poncirus* and their hybrids, other than fruit and seeds, *Vitis*, other than fruit, originating in third countries is an efficient measure to prevent the introduction of *X. fastidiosa* with these species from countries where *X. fastidiosa* is present. However, restrictions on the introduction of *Prunus* do not reduce the risks of introduction of *X. fastidiosa* since plants free from leaves, flower and fruit can still be imported and harbour the bacterium. Furthermore, many other host plants can still be imported and may carry the bacterium, as shown by the recently documented introductions of coffee plants that harbour *X. fastidiosa.*

- The exemption from official registration for small producers whose entire production and sale of relevant plants are intended for final use by persons on the local market and who are not

professionally involved in plant production could facilitate the local dissemination of the pathogenic agent considering the very wide host range of *X. fastidiosa*.

With regard to the Implementing Decision 2014/497/EU the Panel concluded that:

- The exemption of seeds is scientifically justified.
- There is very high uncertainty on the host range of the strain of *X. fastidiosa* occurring in Apulia because research is still ongoing. More generally, the host range of *X. fastidiosa* is still uncertain. It is very likely that the bacterium has a wider host range than the species listed in the emergency measures. Nevertheless, some of the already known host plants of the Apulian strain are not mentioned in the implementing decision (i.e. plants of the genera *Acacia*, *Polygala*, *Spartium* and *Westringia*).
- The reinforcement of conditions for imports from third countries is assessed as effective, but only some genera of host plants are included (*Catharanthus*, *Nerium*, *Olea*, *Prunus*, *Vinca*, *Malva*, *Portulaca*, *Quercus* and *Sorghum*), which mitigates the effectiveness of that measure.
- There is a need for detailed and harmonised protocols for survey, sampling and testing, with at least guidelines regarding minimum requirements to be achieved in demarcated areas, buffer zones and areas not known to be infected.
- Asymptomatic hosts, asymptomatic infections or low infections can escape surveys based solely on visual inspection and even based on laboratory tests as early infections or heterogeneous distribution of the bacterium in the plant may lead to false-negative results.
- There is a need to reduce the infectious insect vector populations (e.g. by vector control, vegetation management, inoculum reduction by removal of infected plants) in the outbreak area and to prevent their movement from infected plants. Special care is necessary when removing infected plants or weeds, for instance, as this may result in movement of infectious insect vectors.
- The ban on planting of "specified plants" in demarcated areas is appropriate, but all known host plants should be considered.
- Public awareness of diseases that can infect plants in gardens or natural or unmanaged environments is important, and awareness-raising activities should be organised for all people in demarcated areas or buffer zones and their vicinity.

The Panel recommends the continuation and intensification of research activities on the host range, epidemiology and control of the Apulian outbreak of *X. fastidiosa.* Based on the knowledge acquired by this research, uncertainties could be substantially reduced and a more thorough assessment of the risk and of the mitigation measures could be conducted for the Apulian strain of *X. fastidiosa.*

DOCUMENTATION PROVIDED TO EFSA

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APPENDICES

Appendix A. Extensive literature search

An extensive literature search (ELS) on *Xylella fastidiosa* host plants was performed on 24/06/2014 following the methodology presented in the EFSA Guidance on Systematic Review Methodology (EFSA, 2010). The objective of this ELS was to retrieve the scientific literature and the scientific evidence required for elaborating a comprehensive list of the host plant species of *Xylella fastidiosa*.

Extensive literature search on the host plants of *X. fastidiosa*

The search question was: "which plants can host *Xylella fastidiosa*?"

This search question was chosen in line with a systematic approach, and was classified as a population–outcome (PO) type, where, in this case, P was the known host plants of *Xylella fastidiosa* and O was bacterial infection (EFSA PLH Panel, 2010).

1. Information sources

The information sources used to produce relevant evidence, that was consulted when performing the pest categorisation of *Xylella fastidiosa*, were:

- ISI Web of Knowledge (Web of Science™ Core Collection (1975–present)); BIOSIS Citation Index℠ (1926–present); CABI: CAB Abstracts® (1910–present); Chinese Science Citation Database℠ (1989–present); Current Contents Connect® (1998–present); Data Citation Index℠ (1900–present); FSTA® (the food science resource (1969–present)); MEDLINE® (1950–present); SciELO Citation Index (1997–present); Zoological Record® (1864–present);

- web-based search utilities, e.g. Google Scholar, and also grey literature (technical reports, conference proceedings);

- expert knowledge.

2. Search strategy

The literature search was articulated around various names of the pest and the corresponding diseases caused (i.e. Latin name, synonyms, common names, acronyms and disease names), in combination with key words for host plants (i.e. host plant and host range), as shown in Tables A10 and A11, and was performed using the ISI Web of Knowledge.

Table A10: Search topics and terms used for search algorithm

Topic	Search terms	No of hits
Organism	*Xylella fastidiosa*	2 150
Organism synonyms	FXIB	3
	Xylem inhabiting bacteria	69
	Xylem inhabiting bacterium	69
	Rickettsialike bacteria	34
	RLB	429
Disease name	PD	Approximately 403 017
	Pierce's disease	990
	PLS	Approximately 51 113
	Plum leaf scald	160
	Phony disease	257
	ALS	Approximately 111 063
	Almond leaf scorch	167
	CVC	Approximately 10 721
	Citrus variegated chlorosis	473
	BLS	Approximately 6 241
	Bacterial leaf scorch	742
	CLS	Approximately 12 136
	Coffee leaf scorch	130
	Crespera disease	11
	MLS	Approximately 16 525
	Mulberry leaf scorch	45
	OLS	Approximately 23 474
	Oleander leaf scorch,	68
	Periwinkle wilt	87
	Ragweed stunt	27

Table A11: Final search equation in ISI Web of Knowledge

Combinations of search terms	Summary of search results
'*Xylella*' OR '*Xylella fastidiosa*' OR 'FXIB' OR 'Xylem inhabiting bacteri*' OR 'Rickettsialike bacteria' OR 'RLB'	208 hits 202 retained for screening (duplications removed)
AND	
'PD' OR 'Pierce* disease' OR 'PLS' OR 'Plum leaf scald' OR 'Phony disease' OR 'ALS' OR 'Almond leaf scorch' OR 'CVC' OR 'Citrus variegated chlorosis' OR 'BLS' OR 'Bacterial leaf scorch' OR 'CLS' OR 'Coffee leaf scorch' OR 'Crespera disease' OR 'MLS' OR 'Mulberry leaf scorch' OR 'OLS' OR 'Oleander leaf scorch' OR 'Periwinkle wilt' OR 'Ragweed stunt'	73 deemed as relevant (in extraction table)
AND	
'host* NEAR/2 plant*' OR 'host* NEAR/2 range'	

Timespan: All years (1864–2014).

Search language: Search was done in English.

Search field: Topic.

As a result, 208 hits were obtained by running the search equation and, after removing duplicates, 202 publications were retained for screening. No further filtering was applied to the search results.

3. Screening

The 202 publications were screened for relevance by their titles and abstracts. The screening process was unmasked and performed on the basis of irrelevance to the subject of this work, i.e. documents not dealing with the pest and host plants (species) were considered irrelevant. In addition, the following review papers were scrutinised, and the primary information cited in their references lists were consulted and selected according to relevance: Hopkins (1977), Hopkins (1989), Grousson (1992), Purcell and Hopkins (1996), Purcell (1997), Purcell and Saunders (1999) and Sherald (2001, 2007). As a result of this extensive literature search, 73 references were retained as relevant evidence for the study of *Xylella fastidiosa* host plants. Additional articles (77) were suggested by the experts, and/or identified through web-based search engines, such as Google and Google Scholar, and by consulting the websites of national authorities such as Biosecurity Australia, USDA-APHIS, etc. Overall, data on host plants was extracted from 150 articles. Appendix B presents the list of *Xylella fastidiosa* host plants resulting from the ELS.

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Appendix B. List of host plants of *Xylella fastidiosa* on the base of literature search

Abbreviations used in the Table below are given below for easier reference.

Notes:
*This is the new subspecies of *Xylella fastidiosa* described in 2014 by Nunney et al. (the precise nomenclature has not yet been confirmed).
E: experimental; H: host plant; L: location; MEIF: membrane entrapment immunofluorescence; NA: not avialble, P: phylogenetic studies; S: survey, SEM: scanning electron microscopy, TEM, transmission electron microscopy; ?: no information.

Plant family	Plant species	Plant common name	Country of detection/ experimentation	Location of detection/ experimentation	*X.fastidiosa* subspecies mentioned in the paper	*X. fastidiosa* putative subspecies	Justification for putative subspecies	Method by which infection determined	Detection protocol	Citation
Adoxaceae	*Sambucus* spp.	Elderberry	USA	Temecula, CA	NA	NA	P	S	ELISA	Costa et al., 2004
Adoxaceae	*Sambucus canadensis*	American elderberry	USA	Leesburg, FL (wild plant species within 50 miles of the Central Florida Research and Education Centre)	NA	fastidiosa	H	E	ELISA, fluorescence microscopy	Hopkins and Adlerz, 1988
Adoxaceae	*Sambucus canadensis*	American elderberry	USA	FL	fastidiosa	fastidiosa	P	NA	NA	Nunney et al., 2013
Adoxaceae	*Sambucus canadensis*	American elderberry	USA	Leesburg Lake Co., FL	fastidiosa	fastidiosa	P	NA	NA	Yuan et al., 2010
Adoxaceae	*Sambucus cerulea*	Blue elder	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Adoxaceae	*Sambucus cerulea*	Blue elder	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Adoxaceae	*Sambucus cerulea*	Blue elder	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Adoxaceae	*Sambucus mexicana*	Mexican elderberry	USA	Oakville (Napa County), CA	NA	fastidiosa	L	E	Real-time PCR, culturing	Baumgartner and Warren, 2005
Adoxaceae	*Sambucus mexicana*	Mexican elderberry	USA	Hopland (Mendocino County), CA	NA	fastidiosa	L	E	Real-time PCR, culturing	Baumgartner and Warren, 2005
Adoxaceae	*Sambucus mexicana*	Mexican elderberry	USA	Greenhouse, Temecula, CA	NA	fastidiosa	H	E	ELISA, PCR, culture	Costa et al., 2004
Adoxaceae	*Sambucus mexicana*	Mexican elderberry	USA	Napa Valley, CA	NA	fastidiosa	L	E	PCR and culturing assays	Purcell and Saunders, 1999a
Altingiaceae	*Liquidambar styraciflua*	American sweetgum	USA	DC	NA	NA	NA	S	ELISA, PCR	Harris et al., 2014

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Altingiaceae	*Liquidambar styraciflua*	American sweetgum	USA	Riverside, CA	multiplex	multiplex	P	NA	NA	Nunney et al., 2010
Altingiaceae	*Liquidambar styraciflua*	American sweetgum	USA	CA (Riverside and Redlands areas)	multiplex	multiplex	P	S	Symptoms, ELISA, PCR, culture	Wong's report: http://celosangeles.ucanr.edu/newsletters/Fall_200534798.pdf; Wong et al., 2004
Altingiaceae	*Liquidambar styraciflua*	American sweetgum	USA	Lexington, KY	NA	NA	H	S	ELISA, symptoms, electron microscopy	Hartman et al., 1996
Altingiaceae	*Liquidambar styraciflua*	American sweetgum	USA	Riverside Co., CA	multiplex	multiplex	P	NA	NA	Nunney et al., 2013
Altingiaceae	*Liquidambar styraciflua*	American sweetgum	USA	San Diego Co., CA	multiplex	multiplex	P	NA	NA	Nunney et al., 2013
Altingiaceae	*Liquidambar styraciflua*	American sweetgum	USA	Riverside, CA	multiplex	multiplex	P	NA	NA	Nunney et al., 2010
Altingiaceae	*Liquidambar styraciflua*	American sweetgum	USA	San Bernardino Co., CA	multiplex	multiplex	P	NA	NA	Nunney et al., 2013 supplementary data
Altingiaceae	*Liquidambar tulipifera*		USA	DC	NA	NA	NA	S	ELISA, PCR	Harris et al., 2014
Amaranthaceae	*Alternanthera* sp.	Caruru	Brazil	Boa Esperanca	NA	pauca	P	S and E	PCR	Lopes et al., 2003
Amaranthaceae	*Alternanthera blitoides*	Prostrate pigweed	USA	San Joaquin Valley, CA	NA	fastidiosa	L	E	Vectors	Wistrom and Purcell, 2005
Amaranthaceae	*Alternanthera tenella*	Apaga-fogo	Brazil	Boa Esperanca	NA	pauca	P	S and E	PCR	Lopes et al., 2003
Amaranthaceae	*Alternanthera tenella*	Apaga-fogo	Brazil	Cajobi	NA	pauca	P	S and E	PCR	Lopes et al., 2003
Amaranthaceae	*Alternanthera tenella*	Apaga-fogo	Brazil	Luis Antonio, SP	NA	pauca	P	S and E	PCR	Lopes et al., 2003
Amaranthaceae	*Chenopodium ambrosioides*	Mexican tea	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Amaranthaceae	*Chenopodium ambrosioides*	Mexican tea	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Amaranthaceae	*Chenopodium ambrosioides*	Mexican tea	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951

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Amaranthaceae	*Chenopodium quinoa*	Quinoa	USA	Lake Valley Seed, Boulder, CO, and Botanical Interests Inc., Broomfield, CO	NA	fastidiosa	H	NA	NA	Chatelet et al., 2011
Amaranthaceae	*Chenopodium quinoa*	Quinoa	USA	San Joaquin Valley, CA	NA	fastidiosa	L	E	Vectors	Wistrom and Purcell, 2005
Amaranthaceae	*Salsola tragus*	Kali tragus	USA	Weedy alfalfa fields near USDA-ARS research centre in Parlier, CA	NA	NA	NA	S	ELISA	Krugner et al., 2012
Anacardiaceae	*Pistachia vera*	Pistachio	USA	Temecula, CA	NA	NA	P	S	ELISA	Costa et al., 2004
Anacardiaceae	*Rhus* sp.	NA	USA	Leesburg, FL (wild plant species within 50 miles of the Central Florida Research and Education Centre)	NA	fastidiosa	H	E	ELISA, fluorescence microscopy	Hopkins and Adlerz, 1988
Anacardiaceae	*Rhus diversiloba*	Poison oak	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Anacardiaceae	*Rhus diversiloba*	Poison oak	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Anacardiaceae	*Rhus diversiloba*	Poison oak	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Anacardiaceae	*Schinus molle*	Pepper tree	USA	Temecula, CA	NA	NA	P	S	ELISA	Costa et al., 2004
Anacardiaceae	*Toxicodendron diversilobum*	Pacific poison oak	USA	Napa Valley, CA	NA	fastidiosa	L	E	PCR and culturing assays	Purcell and Saunders, 1999a
Apiaceae	*Conium maculatum*	Poison hemlock	USA	Napa Valley, CA	NA	fastidiosa	L	E	PCR and culturing assays	Purcell and Saunders, 1999a
Apiaceae	*Conium maculatum*	Poison hemlock	USA	San Joaquin Valley, CA	NA	fastidiosa	L	E	vectors	Wistrom and Purcell, 2005
Apiaceae	*Conium maculatum*	Poison hemlock	USA	Vineyards in Napa River, CA	NA	fastidiosa	L	S	ELISA, electron microscopy and light microscopy	Raju et al., 1980a
Apiaceae	*Datura wrightii*	Sacred datura	USA	San Joaquin Valley, CA	NA	fastidiosa	L	E	vectors	Wistrom and Purcell, 2005
Apiaceae	*Daucus carota*	Short white carrot	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951

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Apiaceae	*Daucus carota*	Short white carrot	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Apiaceae	*Daucus carota*	Short white carrot	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Apiaceae	*Oenanthe sarmetosa*	Water parsley	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Apiaceae	*Oenanthe sarmetosa*	Water parsley	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Apiaceae	*Oenanthe sarmetosa*	Water parsley	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Apocynaceae	*Catharanthus* sp.	Madagascar rosy periwinkle	Brazil	São Paulo	NA	multiplex	H	S	PCR, cultures	Rodrigues et al., 2003
Apocynaceae	*Catharanthus roseus*	Madagascar rosy periwinkle	Italy	Salento peninsula (Apulia, southern Italy, Lecce province)	pauca	pauca	P	S	Symptoms, ELISA, PCR, culture	Cariddi et al., 2014
Apocynaceae	*Catharanthus roseus*	Madagascar rosy periwinkle	Brazil	NA	NA	pauca	H	E	SEM, fluorescence microscopy	Ferreira et al., 2012
Apocynaceae	*Catharanthus roseus*	Madagascar rosy periwinkle	USA	Fort Lauderdale, FL	NA	NA	H	S and E	Phase contrast microscope, electron microscopy	McCoy et al., 1978
Apocynaceae	*Catharanthus roseus* cv. Peppermint Cooler	Madagascar rosy periwinkle	Brazil	Not described	NA	pauca	H	E	PCR, cultures, immunofluorescence	Monteiro et al., 2001
Apocynaceae	*Catharanthus roseus*	Madagascar rosy periwinkle	USA	FL	NA	NA	NA	NA	NA	Montero-Astúa et al., 2007
Apocynaceae	*Catharanthus roseus*	Madagascar rosy periwinkle	USA	Greenhouse experiment, CA	NA	sandyi	H	E	Culturing, ELISA, PCR	Purcell et al., 1999
Apocynaceae	*Catharanthus roseus*	Madagascar rosy periwinkle	USA	NA	NA	NA	H	?	Primary isolations obtained from contributors	Wells et al., 1987
Apocynaceae	*Catharanthus roseus*	Madagascar rosy periwinkle	USA	FL	NA	NA	NA	E	Direct immunofluorescence, ELISA, cultures, electron microscopy, re-isolation	Timmer et al., 1983
Apocynaceae	*Nerium oleander*	Oleander	USA	Temecula, CA	NA	sandyi	P	S	ELISA, PCR	Bextine and Miller, 2004

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Apocynaceae	*Nerium oleander*	Oleander	USA	University of California, Riverside, CA	NA	sandyi	P	S	ELISA, PCR	Bextine and Miller, 2004
Apocynaceae	*Nerium oleander*	Oleander	USA	University of California, Riverside, CA	NA	sandyi	P	S	ELISA, PCR	Bextine and Miller, 2004
Apocynaceae	*Nerium oleander*	Oleander	Italy	Salento pennisula (Apulia, southern Italy, Lecce province)	pauca	pauca	P	S	Symptoms, ELISA, PCR, culture	Cariddi et al., 2014
Apocynaceae	*Nerium oleander*	Oleander	USA	Baton Rouge, LA	sandyi	sandyi	P	NA	NA	Melanson et al., 2012
Apocynaceae	*Nerium oleander*	Oleander	USA	NA	sandyi	sandyi	P	NA	NA	Nunney et al., 2010
Apocynaceae	*Nerium oleander*	Oleander	USA	Riverside Co., CA	sandyi	sandyi	P	NA	NA	Yuan et al., 2010
Apocynaceae	*Nerium oleander*	Oleander	USA	TX	sandyi	sandyi	P	NA	NA	Yuan et al., 2010
Apocynaceae	*Nerium oleander*	Oleander	USA	Orange Co., CA	sandyi	sandyi	P	NA	NA	Yuan et al., 2010
Apocynaceae	*Nerium oleander*	Oleander	USA	CA	sandyi	sandyi	P	NA	NA	Yuan et al., 2010
Apocynaceae	*Nerium oleander*	Oleander	USA	Uvalde Co., TX	sandyi	sandyi	P	NA	NA	Yuan et al., 2010
Apocynaceae	*Nerium oleander*	Oleander	USA	Medina Co., TX	sandyi	sandyi	P	NA	NA	Yuan et al., 2010
Apocynaceae	*Nerium oleander*	Oleander	USA	Los Angeles Co., CA	sandyi	sandyi	P	NA	NA	Yuan et al., 2010
Apocynaceae	*Nerium oleander*	Oleander	USA	NA	NA	NA	H	NA	ELISA, PCR	Bextine and Miller 2003
Apocynaceae	*Nerium oleander*	Oleander	USA	Greenhouse, Temecula, CA	NA	fastidiosa	P	E	ELISA	Costa et al., 2004
Apocynaceae	*Nerium oleander*	Oleander	USA	Temecula, CA	NA	NA	P	S	ELISA, PCR, Culture	Costa et al., 2004
Apocynaceae	*Nerium oleander*	Oleander	USA	Galveston, TX	NA	NA	P	S	ELISA, PCR, culture, MEIF (membrane entrapment immunofluorescence)	Huang et al., 2004
Apocynaceae	*Nerium oleander*	Oleander	USA	Harlingen, TX	NA	NA	P	S	ELISA, symptoms	Huang et al., 2004
Apocynaceae	*Nerium oleander*	Oleander	USA	Austin, TX	NA	NA	P	E	ELISA, symptoms	Huang et al., 2004

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Apocynaceae	*Nerium oleander*	Oleander	USA	San Antonio, TX	NA	NA	P	E	ELISA, symptoms	Huang et al., 2004
Apocynaceae	*Nerium oleander*	Oleander	USA	El Campo, TX	NA	NA	H	E	ELISA, symptoms	Huang et al., 2004
Apocynaceae	*Nerium oleander*	Oleander	Costa Rica	Central Valley	NA	fastidiosa	L	NA	ELISA, immunofluorescence assay, nested PCR, BLAST programme to compare the sequences, visual symptoms	Montero-Astúa et al., 2008a
Apocynaceae	*Nerium oleander*	Oleander	USA	CA	sandyi	sandyi	P	NA	NA	Nunney et al., 2013
Apocynaceae	*Nerium oleander*	Oleander	USA	TX	sandyi	sandyi	P	NA	NA	Nunney et al., 2013
Apocynaceae	*Nerium oleander*	Oleander	USA	Greenhouse experiment, Riverside, CA	NA	sandyi	H	E	Culturing, ELISA, PCR	Purcell et al., 1999
Apocynaceae	*Nerium oleander*	Oleander	USA	Palm Springs (landscape hedge), CA	NA	sandyi	H	S	Culturing	Purcell et al., 1999
Apocynaceae	*Nerium oleander*	Oleander	USA	Cathedral City	NA	sandyi	H	S	Culturing	Purcell et al., 1999
Apocynaceae	*Nerium oleander*	Oleander	USA	Cathedral City	NA	sandyi	H	S	PCR	Purcell et al., 1999
Apocynaceae	*Nerium oleander*	Oleander	USA	Tustin (shopping centre)	NA	sandyi	H	S	Culturing	Purcell et al., 1999
Apocynaceae	*Nerium oleander*	Oleander	USA	Tustin (shopping centre)	NA	sandyi	H	S	PCR	Purcell et al., 1999
Apocynaceae	*Nerium oleander*	Oleander	USA	Tustin Ranch (residential hedge)	NA	sandyi	H	S	Culturing	Purcell et al., 1999
Apocynaceae	*Nerium oleander*	Oleander	USA	Tustin Ranch (residential hedge)	NA	sandyi	H	S	PCR	Purcell et al., 1999
Apocynaceae	*Nerium oleander*	Oleander	USA	Palm Springs, CA	sandyi	sandyi	P	NA	NA	Schuenzel et al., 2005
Apocynaceae	*Nerium oleander*	Oleander	USA	Riverside, CA	sandyi	sandyi	P	NA	NA	Schuenzel et al., 2005
Apocynaceae	*Nerium oleander*	Oleander	USA	TX	sandyi	sandyi	P	NA	NA	Schuenzel et al., 2005
Apocynaceae	*Nerium oleander*	Oleander	USA	Orange, CA	sandyi	sandyi	P	NA	NA	Schuenzel et al., 2005

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Apocynaceae	*Nerium oleander*	Oleander	USA	CA (Riverside and Redlands areas)	sandyi	sandyi	P	S	Symptoms, ELISA, PCR, culturing	Wong's report: http://celosangeles.ucanr.edu/newsletters/Fall_200534798.pdf; Wong et al., 2004
Apocynaceae	*Vinca* sp.	Periwinkle	USA	FL	multiplex	multiplex	P	NA	NA	Nunney et al., 2013 supplementary data
Apocynaceae	*Vinca major*	Periwinkle	USA	Hopland (Mendocino County), CA	NA	fastidiosa	L	E	Real-time PCR, culturing	Baumgartner and Warren, 2005
Apocynaceae	*Vinca minor*	Periwinkle	USA	FL	NA	multiplex	H	S	PCR, cultures	Rodrigues et al., 2003
Apocynaceae	*Vinca major*	Periwinkle	USA	Oakville (Napa County), CA	NA	fastidiosa	L	E	Real-time PCR, culturing	Baumgartner and Warren, 2005
Apocynaceae	*Vinca major*	Large periwinkle	USA	US Davis campus	NA	fastidiosa	H	NA	NA	Chatelet et al., 2011
Apocynaceae	*Vinca major*	Periwinkle	USA	Greenhouse experiment CA (cuttings from Ashland, OR)	NA	sandyi	H	E	Culturing, ELISA, PCR	Purcell et al., 1999
Apocynaecaae	*Vinca major*	Periwinkle	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Apocynaecaae	*Vinca major*	Periwinkle	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Apocynaecaae	*Vinca major*	Periwinkle	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Apocynaecaae	*Vinca major*	Periwinkle	USA	Napa Valley, CA	NA	fastidiosa	L	E	PCR and culturing assays	Purcell et al., 1999
Apocynaecaae	*Vinca minor*	Periwinkle	USA	Napa County, CA	NA	fastidiosa	H	E	ELISA	Raju et al., 1983

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Aquifoliaceae	*Ilex vomitoria*	Yaupon holly	USA	American hybrid vineyard in the Texas Gulf Coast (Austin County Vineyards, a 4.5-acre vineyard located in Cat Spring, TX, 70 miles west of Houston)	NA	NA	NA	S	ELISA, PCR, immunofluorescence	Buzombo et al., 2006
Araliaceae	*Hedera helix*	Ivy	USA	Temecula, CA	NA	NA	P	S	ELISA	Costa et al., 2004
Araliaceae	*Hedera helix*	Variegated ivy	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Araliaceae	*Hedera helix*	Variegated ivy	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Araliaceae	*Hedera helix*	Variegated ivy	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Araliaceae	*Hedera helix*	English ivy	USA	National Park Service Daingerfield Island Nursery in Alexandria, VA	NA	multiplex	L	S	PCR	McElrone et al., 1999
Araliaceae	*Hedera helix*	English ivy	USA	National parks in Washington DC	NA	multiplex	L	S	PCR	McElrone et al., 1999
Araliaceae	*Hedera helix*	Variegated ivy	USA	Napa Valley, CA	NA	fastidiosa	L	E	PCR and culturing assays	Purcell and Saunders, 1999a
Arecaceae	*Phoenix reclinata*	Senegal date plum	USA	CA (Riverside and Redlands areas)	NA	NA	P	S	Symptoms, ELISA, PCR	Wong's report: http://celosangeles.ucanr.edu/newsletters/Fall_200534798.pdf; Wong et al., 2004
Arecaceae	*Phoenix roebelenii*	Pygmy date plum	USA	CA (Riverside and Redlands areas)	NA	NA	P	S	Symptoms, ELISA, PCR	Wong's report: http://celosangeles.ucanr.edu/newsletters/Fall_200534798.pdf; Wong et al., 2004
Asteraceae	*Acanthospermum hispidum*	Carrapicho de carneiro	Brazil	Boa Esperanca	NA	pauca	P	S and E	PCR	Lopes et al., 2003

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Asteraceae	*Ambrosia acanthicarpa*	annual bur sage	USA	San Joaquin Valley, CA	NA	fastidiosa	L	E	Vectors	Wistrom and Purcell, 2005
Asteraceae	*Ambrosia artemisiifolia*	Ragweed	USA	FL	NA	NA	NA	NA	NA	Montero-Astúa et al., 2007
Asteraceae	*Ambrosia artemisiifolia*	Ragweed	USA	FL	NA	multiplex	H	S	PCR, cultures	Rodrigues et al., 2003
Asteraceae	*Ambrosia artemisiifolia*	Ragweed	USA	FL	NA	NA	NA	E	Direct immunofluorescence, ELISA, cultures, electron microscopy, re-isolation	Timmer et al., 1983.
Asteraceae	*Ambrosia trifida*	Gigant ragweed	USA	Medina Co., TX	multiplex	multiplex	P	NA	NA	Nunney et al., 2013
Asteraceae	*Ambrosia trifida*	Gigant ragweed	USA	Gillespie Co., TX	multiplex	multiplex	P	NA	NA	Nunney et al., 2013
Asteraceae	*Artemisia douglasiana*	California mugwort	USA	US Davis campus, CA	NA	fastidiosa	H	NA	NA	Chatelet et al., 2011
Asteraceae	*Artemisia douglasiana*	California mugwort	USA	Napa Valley, CA	NA	fastidiosa	L	E	PCR and culturing assays	Purcell and Saunders, 1999a
Asteraceae	*Artemisia douglasiana*	California mugwort	USA	CA	NA	fastidiosa	H	E	ELISA, culturing	Hill and Purcell, 1997
Asteraceae	*Artemisia douglasiana*	California mugwort	USA	CA	NA	fastidiosa	H	E	ELISA	Hill and Purcell, 1995
Asteraceae	*Artemisia vulgaris* var. *heterophylla*,	California mugwort	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Asteraceae	*Artemisia vulgaris* var. *heterophylla*,	California mugwort	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Asteraceae	*Artemisia vulgaris* var. *heterophylla*,	California mugwort	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Asteraceae	*Baccharis halimifolia*	Saltbush	USA	Leesburg, FL (wild plant species within 50 miles of the Central Florida Research and Education Centre)	NA	fastidiosa	H	E	ELISA, fluorescence microscopy	Hopkins and Adlerz, 1988
Asteraceae	*Baccharis halimifolia*	Eastern Baccharis	USA	Houston area, TX	NA	NA	NA	S	ELISA, indirect immunofluorescence, cell cultures	Carbajal et al., 2004

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Asteraceae	*Baccharis pilularis*	Coyote brush	USA	Greenhouse, Temecula, CA	NA	fastidiosa	P	E	ELISA	Costa et al., 2004
Asteraceae	*Baccharis pilularis*	Coyote brush	USA	Temecula, CA	NA	NA	P	S	ELISA	Costa et al., 2004
Asteraceae	*Baccharis pilularis*	Coyote brush	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Asteraceae	*Baccharis pilularis*	Coyote brush	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Asteraceae	*Baccharis pilularis*	Coyote brush	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Asteraceae	*Baccharis pilularis*	Coyote brush	USA	Napa Valley, CA	NA	fastidiosa	L	E	PCR and culturing assays	Purcell and Saunders, 1999a
Asteraceae	*Baccharis salicifolia*	Mule fat	USA	Napa Valley, CA	NA	fastidiosa	L	E	PCR and culturing assays	Purcell and Saunders, 1999a
Asteraceae	*Bidens pilosa*	Spanish needle (Picao preto)	Brazil	Boa Esperanca	NA	pauca	P	S and E	PCR	Lopes et al., 2003
Asteraceae	*Callistephus chinensis*	China aster	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Asteraceae	*Callistephus chinensis*	China aster	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Asteraceae	*Callistephus chinensis*	China aster	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Asteraceae	*Conyza canadensis*	Horseweed	USA	Weedy alfalfa fields near USDA-ARS research centre in Parlier, CA	NA	NA	NA	S	ELISA	Krugner et al., 2012
Asteraceae	*Conyza canadensis*	Horseweed	USA	San Joaquin Valley, CA	NA	fastidiosa	L	E	Vectors	Wistrom and Purcell, 2005
Asteraceae	*Encelia farinosa*	Brittlebush	USA	Greenhouse, Temecula, CA	NA	fastidiosa	P	E	ELISA	Costa et al., 2004
Asteraceae	*Encelia farinosa*	Brittlebush	USA	CA	multiplex	multiplex	P	NA	NA	Nunney et al., 2013
Asteraceae	*Encelia farinosa*	Brittlebush	USA	Riverside Co., CA	multiplex	multiplex	P	NA	NA	Nunney et al., 2013 supplementary data
Asteraceae	*Franseria acanthicarpa*	Annual bur-weed	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951

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Asteraceae	*Franseria acanthicarpa*	Annual bur-weed	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Asteraceae	*Franseria acanthicarpa*	Annual bur-weed	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Asteraceae	*Helianthus annuus*	Common sunflower	USA	Lake Valley Seed, Boulder, CO, and Botanical Interests Inc., Broomfield, CO	NA	fastidiosa	H	NA	NA	Chatelet et al., 2011
Asteraceae	*Helianthus annuus*	Annual sunflower	USA	Gillespie Co., TX	multiplex	multiplex	P	NA	NA	Nunney et al., 2013
Asteraceae	*Helianthus annuus*	Common sunflower	USA	San Joaquin Valley, CA	NA	fastidiosa	L	E	Vectors	Wistrom and Purcell, 2005
Asteraceae	*Iva annua*	Narrow leaf sumpweed	USA	Llano Co., TX	multiplex	multiplex	P	NA	NA	Nunney et al., 2013
Asteraceae	*Lactuca serriola*	Priekly lettuce	USA	Weedy alfalfa fields near USDA-ARS research centre in Parlier, CA	NA	NA	NA	S	ELISA	Krugner et al., 2012
Asteraceae	*Lactuca serriola*	Priekly lettuce	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Asteraceae	*Lactuca serriola*	Priekly lettuce	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Asteraceae	*Lactuca serriola*	Priekly lettuce	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Asteraceae	*Lactuca serriola*	Prickly lettuce	USA	San Joaquin Valley, CA	NA	fastidiosa	L	E	Vectors	Wistrom and Purcell, 2005
Asteraceae	*Pluchea odorata*	Sweet scent	USA	NA	fastidiosa	fastidiosa	P	NA	NA	Nunney et al., 2013
Asteraceae	*Pluchea odorata*	Sweet scent	USA	Riverside Co., CA	fastidiosa	fastidiosa	P	NA	NA	Yuan et al., 2010
Asteraceae	*Ratibida columnaris*	Mexican hat flower	USA	Bandera Co., TX	multiplex	multiplex	P	NA	NA	Nunney et al., 2013
Asteraceae	*Ratibida columnifera*		USA	Gulf Coast, TX	?	?	?	?	ELISA, PCR	McGaha et al., 2007
Asteraceae	*Senecio vulgaris*	Common groundsel	USA	Weedy alfalfa fields near USDA-ARS research centre in Parlier, CA	NA	NA	NA	S	ELISA	Krugner et al., 2012
Asteraceae	*Senecio vulgaris*	Common groundsel	USA	California's central valley	NA	multiplex	P	S	Immunocapture DNA separation and PCR	Shapland et al., 2006

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Asteraceae	*Silybum marianum*	Cardus marianus	USA	Weedy alfalfa fields near USDA-ARS research centre in Parlier, CA	NA	NA	NA	S	ELISA	Krugner et al., 2012
Asteraceae	*Solidago fistulosa*	Pine-barren goldenrod	USA	Leesburg, FL (wild plant species within 50 miles of the Central Florida Research and Education Centre)	NA	fastidiosa	H	E	ELISA, fluorescence microscopy	Hopkins and Adlerz, 1988
Asteraceae	*Solidago virgaurea*	Golden rod	USA	Bandera Co., TX	multiplex	multiplex	P	NA	NA	Nunney et al., 2013
Asteraceae	*Sonchus* spp.	Sowthistle	USA	California's central valley	NA	multiplex	P	S	Immunocapture DNA separation and PCR	Shapland et al., 2006
Asteraceae	*Sonchus asper*	Piekly sowthistle	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Asteraceae	*Sonchus asper*	Piekly sowthistle	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Asteraceae	*Sonchus asper*	Piekly sowthistle	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Asteraceae	*Sonchus oleraceus*	Annual sowthistle	USA	Weedy alfalfa fields near USDA-ARS research centre in Parlier, CA	NA	NA	NA	S	ELISA	Krugner et al., 2012
Asteraceae	*Sonchus oleraceus*	Annual sowthistle	USA	San Joaquin Valley, CA	NA	fastidiosa	L	E	Vectors	Wistrom and Purcell, 2005
Asteraceae	*Xanthium spinosum*	Spiny cocklebur	USA	Weedy alfalfa fields near USDA-ARS research centre in Parlier, CA	NA	NA	NA	S	ELISA	Krugner et al., 2012
Asteraceae	*Xanthium canadense*	Cocklebur	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Asteraceae	*Xanthium canadense*	Cocklebur	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Asteraceae	*Xanthium canadense*	Cocklebur	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Asteraceae	*Xanthium strumarium*	Cocklebur	USA	Riverside Co., CA	multiplex	multiplex	P	NA	NA	Nunney et al., 2013
Asteraceae	*Xanthium strumarium*	Cocklebur	USA	San Joaquin Valley, CA	NA	fastidiosa	L	E	Vectors	Wistrom and Purcell, 2005

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Berberidaceae	*Nandina domestica*	Heavenly Bamboo	USA	CA (Riverside and Redlands areas)	NA	*morus**	P	S	Symptoms, ELISA, PCR, culture	Wong's report: http://celosangeles.ucanr.edu/newsletters/Fall_200534798.pdf; Wong et al., 2004
Betulaceae	*Alnus rhombifolia*	White alder	USA	US Davis campus	NA	fastidiosa	H	NA	NA	Chatelet et al., 2011
Betulaceae	*Alnus rombifolia*	White alder	USA	Riverside Co., CA	multiplex	multiplex	P	NA	NA	Nunney et al., 2013
Betulaceae	*Alnus rhombifolia*	White alder	USA	Napa Valley, CA	NA	fastidiosa	L	E	PCR and culturing assays	Purcell and Saunders, 1999a
Bignoniaceae	*Chitalpa tashkinensis*	Chitalpa	USA	CA	NA	NA	NA	S	ELISA, PCR, culture	Randall et al., 2009
Bignoniaceae	*Chitalpa tashkinensis*	Chitalpa	USA	AZ	NA	NA	NA	S	ELISA, PCR, culture	Randall et al., 2009
Bignoniaceae	*Chitalpa tashkinensis*	Chitalpa	USA	Las Cruces, NM	NA	NA	NA	S	ELISA, PCR, culture	Randall et al., 2007
Bignoniaceae	*Jacaranda mimosifolia*	Jacaranda	USA	CA (Riverside and Redlands areas)	sandyi	sandyi	P	S	Symptoms, ELISA, PCR, culturing	Wong's report: http://celosangeles.ucanr.edu/newsletters/Fall_200534798.pdf; Wong et al., 2004
Bignoniaceae	*Jacaranda mimosifolia*	Jacaranda	USA	Riverside Co., CA	sandyi	sandyi	P	NA	NA	Yuan et al., 2010
Boraginaceae	*Amsinckia douglasiana*	Buckthorn weed	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Boraginaceae	*Amsinckia douglasiana*	Buckthorn weed	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Boraginaceae	*Amsinckia douglasiana*	Buckthorn weed	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Brassicaceae	*Brassica* spp.	Wild mustard	USA	Temecula, CA	NA	NA	P	S	ELISA, PCR, Culture	Costa et al., 2004
Brassicaceae	*Brassica nigra*	Black mustard	USA	Greenhouse, Temecula, CA	NA	fastidiosa	P	E	ELISA, PCR, culture	Costa et al., 2004
Brassicaceae	*Capsella bursa - pastoris*	Shepherd's purse	USA	Weedy alfalfa fields near USDA-ARS research centre in Parlier, CA	NA	NA	NA	S	ELISA	Krugner et al., 2012

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Brassicaceae	*Capsella bursa - pastoris*	Shepherd's purse	USA	CA's Central Valley	NA	multiplex	P	S	Immunocapture DNA separation and PCR	Shapland et al., 2006
Brassicaceae	*Coronopus didymus*	Lesser swine-cress	USA	Weedy alfalfa fields near USDA-ARS research centre in Parlier, CA	NA	NA	NA	S	ELISA	Krugner et al., 2012
Brassicaceae	*Sisymbrium irio*	London rocket	USA	CA's Central Valley	NA	multiplex	P	S	Immunocapture DNA separation and PCR	Shapland et al., 2006
Cannaceae	*Canna* sp.	NA	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Cannaceae	*Canna* sp.	NA	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Cannaceae	*Canna* sp.	NA	USA	Los Angeles, CA	not mention subspecies	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Caprifoliaceae	*Lonicera japonica*	Japanese honeysuckle	USA	American hybrid vineyard in the Texas Gulf Coast (Austin County Vineyards, a 4.5-acre vineyard located in Cat Spring, TX, 70 miles west of Houston)	NA	NA	NA	S	ELISA, PCR	Buzombo et al., 2006
Caprifoliaceae	*Lonicera japonica*	Japanese honeysuckle	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Caprifoliaceae	*Lonicera japonica*	Japanese honeysuckle	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Caprifoliaceae	*Lonicera japonica*	Japanese honeysuckle	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Caryophyllaceae	*Stellaria media*	Chickweed	USA	Weedy alfalfa fields near USDA-ARS research centre in Parlier, CA	NA	NA	NA	S	ELISA	Krugner et al., 2012
Caryophyllaceae	*Stellaria media*	Chickweed	USA	CA's Central Valley	NA	multiplex	P	S	Immunocapture DNA separation and PCR	Shapland et al., 2006
Caprifoliaceae	*Symphoricarpos albus*	Snowberry	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Caprifoliaceae	*Symphoricarpos albus*	Snowberry	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Caprifoliaceae	*Symphoricarpos albus*	Snowberry	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951

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Caprifoliaceae	*Symphoricarpos albus*	Snowberry	USA	Napa Valley, CA	NA	fastidiosa	L	E	PCR and culturing assays	Purcell and Saunders, 1999a
Celastraceae	*Celastrus orbiculata*	Bittersweet	USA	National Park Service Daingerfield Island Nursery in Alexandria, VA	NA	multiplex	L	S	PCR	McElrone et al., 1999
Celastraceae	*Celastrus orbiculata*	Bittersweet	USA	National parks in Washington, DC	NA	multiplex	L	S	PCR	McElrone et al., 1999
Commelinaceae	*Commelina benghalensis*	Trapoeraba	Brazil	Boa Esperanca and San José Farm	NA	pauca	P	S and E	PCR	Lopes et al., 2003
Convolvulaceae	*Convolvulus arvensis*	Field bindweed	USA	weedy alfalfa fields near USDA-ARS research centre in Parlier, CA	NA	NA	NA	S	ELISA	Krugner et al., 2012
Convolvulaceae	*Convolvulus arvensis*	Field bindweed	USA	San Joaquin Valley, CA	NA	fastidiosa	L	E	Vectors	Wistrom and Purcell, 2005
Convolvulaceae	*Ipomoea* sp.	Corda de viola	Brazil	Boa Esperanca	NA	pauca	P	S and E	PCR	Lopes et al., 2003
Convolvulaceae	*Ipomoea purpurea*	Common morning glory	USA	Lake Valley Seed, Boulder, CO, and Botanical Interests Inc., Broomfield, CO	NA	fastidiosa	H	NA	NA	Chatelet et al., 2011
Convolvulaceae	*Ipomoea purpurea*	Common morning glory	USA	San Joaquin Valley, CA	NA	fastidiosa	L	E	Vectors	Wistrom and Purcell, 2005
Cornaceae	*Cornus florida*	Flowering dogwood	USA	National park Service Daingerfield Island Nursery in Alexandria, VA	NA	multiplex	L	S	PCR	McElrone et al., 1999
Cornaceae	*Cornus florida*	Flowering dogwood	USA	National parks in Washington DC	NA	multiplex	L	S	PCR	McElrone et al., 1999
Cyperaceae	*Carex* sp.	Sedges	USA	Weedy alfalfa fields near USDA-ARS research centre in Parlier, CA	NA	NA	NA	S	ELISA	Krugner et al., 2012
Cyperaceae	*Cyperus eragrostis*	Poison hemlock	USA	Weedy alfalfa fields near USDA-ARS research centre in Parlier, CA	NA	NA	NA	S	ELISA	Krugner et al., 2012

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Cyperaceae	*Cyperus eragrostis*	Poison hemlock	USA	Napa Valley, CA	NA	fastidiosa	L	E	PCR and culturing assays	Purcell and Saunders, 1999a
Cyperaceae	*Cyperus eragrostis*	Poison hemlock	USA	Vineyards in Napa River in CA	NA	fastidiosa	L	S	ELISA, electron microscopy and light microscopy	Raju et al., 1980a
Cyperaceae	*Cyperus esculentus*	Yellow nutgrass	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Cyperaceae	*Cyperus esculentus*	Yellow nutgrass	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Cyperaceae	*Cyperus esculentus*	Yellow nutgrass	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Cyperaceae	*Cyperus esculentus*	Yellow nutsedge	USA	San Joaquin Valley, CA	NA	fastidiosa	L	E	Vectors	Wistrom and Purcell, 2005
Cypressaceae	*Juniperus ashei*		USA	Gulf Coast, TX	NA	NA	NA	NA	ELISA, PCR	McGaha et al., 2007
Ericaceae	*Vaccinium* sp.	Bluberry	USA	GA	multiplex	multiplex	P	E	NA	Nunney et al., 2014
Ericaceae	*Vaccinium* sp.	Bluberry	USA	FL	multiplex	multiplex	P	E	NA	Nunney et al., 2014
Ericaceae	*Vaccinium corymbosum*	Southern highbush blueberry	USA	Blueberry farm in southern Georgia	NA	multiplex	H	S	ELISA	Chang et al., 2009
Ericaceae	*Vaccinium corymbosum*	Southern highbush blueberry	USA	Blueberry farm in southern Georgia	NA	multiplex	H	E	Culturing	Chang et al., 2009
Euphorbiaceae	*Euphorbia hirta*	Erva de S.Luiza	Brazil	Boa Esperanca and San José farm	NA	pauca	P	S and E	PCR	Lopes et al., 2003
Euphorbiaceae	*Phyllanthus tenellus*	Querba pedra	Brazil	Boa Esperanca	NA	pauca	P	S and E	PCR	Lopes et al., 2003
Fabaceae	*Acacia longifolia*	Sydney golden wattle	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Fabaceae	*Acacia longifolia*	Sydney golden wattle	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Fabaceae	*Acacia longifolia*	Sydney golden wattle	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Fabaceae	*Acacia plumosa*	Arranha-gato	Brazil	Boa Esperanca	NA	pauca	P	S and E	PCR	Lopes et al., 2003

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Fabaceae	*Albizia julibrissin*	Silk tree	USA	CA (Riverside and Redlands areas)	NA	NA	P	S	Symptoms, ELISA, PCR	Wong's report: http://celosangeles.ucanr.edu/newsletters/Fall_200534798.pdf; Wong et al., 2004
Fabaceae	*Cassia tora*	Sickle pod	USA	GA	NA	multiplex?	H	S	Immunofluorescent reaction IMF, microscopy	Wells et al., 1980
Fabaceae	*Cercis canadensis*	Redbud	USA	Kimble Co.,TX	multiplex	multiplex	P	NA	NA	Nunney et al., 2013
Fabaceae	*Cercis canadensis*	Redbud	USA	Uvalde Co., TX	multiplex	multiplex	P	NA	NA	Nunney et al., 2013
Fabaceae	*Cercis occidentalis*	Western Redbud	USA	Riverside Co., CA	multiplex	multiplex	P	NA	NA	Nunney et al., 2013
Fabaceae	*Cercis occidentalis*	Western redbud	USA	Riverside Co., CA	multiplex	multiplex	P	NA	NA	Nunney et al.,. 2013 supplementary data
Fabaceae	*Cercis occidentalis*	Western redbud	USA	CA (Riverside and Redlands areas)	multiplex	multiplex	P	S	Symptoms, ELISA, PCR	Wong's report: http://celosangeles.ucanr.edu/newsletters/Fall_200534798.pdf; Wong et al., 2004
Fabaceae	*Cercis occidentalis*	Western redbud	USA	Riverside Co., CA	fastidiosa	fastidiosa	P	NA	NA	Yuan et al., 2010
Fabaceae	*Cercis occidentalis*	Western redbud	USA	CA (Riverside and Redlands areas)	fastidiosa	fastidiosa	P	S	Symptoms, ELISA, PCR, direct culturing	Wong's report: http://celosangeles.ucanr.edu/newsletters/Fall_200534798.pdf; Wong et al., 2004
Fabaceae	*Chamaecrista fasciculata*		USA	Gulf coast, TX	?	?	?	?	ELISA, PCR	McGaha et al., 2007
Fabaceae	*Cytisus scoparius*	Scotch broom	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Fabaceae	*Cytisus scoparius*	Scotch broom	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951

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Fabaceae	*Cytisus scoparius*	Scotch broom	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Fabaceae	*Cytisus scoparius*	Scotch broom	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Fabaceae	*Cytisus scoparius*	Scotch broom	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Fabaceae	*Cytisus scoparius*	Scotch broom	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Fabaceae	*Genista monspessulanus*	French broom	USA	Napa Valley, CA	NA	fastidiosa	L	E	PCR and culturing assays	Purcell and Saunders, 1999
Fabaceae	*Gleditsia triacanthos*	Honey locust	USA	Riverside Co., CA	multiplex	multiplex	P	NA	NA	Nunney et al., 2013
Fabaceae	*Lathyrus ciecra*	Red pea	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Fabaceae	*Lathyrus ciecra*	Red pea	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Fabaceae	*Lathyrus ciecra*	Red pea	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Fabaceae	*Lathyrus clymenum*	Spanish vetchling	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Fabaceae	*Lathyrus clymenum*	Spanish vetchling	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Fabaceae	*Lathyrus clymenum*	Spanish vetchling	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Fabaceae	*Lathyrus saliva*	Grass pea	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Fabaceae	*Lathyrus saliva*	Grass pea	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Fabaceae	*Lathyrus saliva*	Grass pea	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951.
Fabaceae	*Lupinus villosus*	Lupine	USA	Levy Co., FL	multiplex	multiplex	P	NA	NA	Nunney et al.,. 2013 supplementary data
Fabaceae	*Lupinus aridorum*	Lupine	USA	Orange Co., CA	fastidiosa	fastidiosa	P	NA	NA	Yuan et al., 2010
Fabaceae	*Medicago*	Burclover	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Fabaceae	*Medicago hispida*	Burclover	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Fabaceae	*Medicago hispida*	Burclover	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951

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Fabaceae	*Medicago polymorpha*	Burclover	USA	California's central valley	NA	multiplex	P	S	Immunocapture DNA separation and PCR	Shapland et al., 2006
Fabaceae	*Medicago polymorpha*	Burclover	USA	Weedy alfalfa fields near USDA-ARS research centre in Parlier, CA	NA	NA	NA	S	ELISA	Krugner et al., 2012
Fabaceae	*Medicago sativa*	Alfalfa	USA	Napa Valley, CA	NA	fastidiosa	H	E	Electron microscopy	Goheen et al., 1973
Fabaceae	*Medicago sativa*	Alfalfa	?	NA	NA	fastidiosa	L	E	NA	Hewitt et al., 1942
Fabaceae	*Medicago sativa*	Alfalfa	USA	Greenhouse, Temecula, CA	NA	fastidiosa	P	E	ELISA, PCR	Costa et al., 2004
Fabaceae	*Medicago sativa*	Alfalfa	USA	greenhouse in Davis and various localities in CA	NA	fastidiosa	H	E	Symptoms	Esau, 1948
Fabaceae	*Medicago sativa*	Alfalfa	USA	Berkeley	NA	fastidiosa	H	E	Not described in the article	Frazier and Freitag, 1946
Fabaceae	*Medicago sativa*	Alfalfa	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Fabaceae	*Medicago sativa*	Alfalfa	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Fabaceae	*Medicago sativa*	Alfalfa	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Fabaceae	*Medicago sativa* "Moapa"	Alfalfa	USA	CA	NA	fastidiosa	H	E	ELISA, culturing	Hill and Purcell, 1997
Fabaceae	*Medicago sativa*	Alfalfa	USA	Fresno County, CA	fastidiosa	fastidiosa	P	S	NA	Lopes et al., 2009
Fabaceae	*Medicago sativa*	Alfalfa	USA	CA	fastidiosa	fastidiosa	P	NA	NA	Nunney et al., 2013
Fabaceae	*Medicago sativa*	Alfalfa	USA	Napa Valley, CA	NA	fastidiosa	L	E	PCR and culturing assays	Purcell and Saunders, 1999a
Fabaceae	*Medicago sativa*	Alfalfa	USA	San Joaquin Valley Agricultural Centre (USDA, Parlier, CA)	NA	fastidiosa	L	E	PCR, culturing	Wistrom et al., 2010
Fabaceae	*Medicago sativa*	Alfalfa	USA	CA	fastidiosa	fastidiosa	P	NA	NA	Yuan et al., 2010
Fabaceae	*Medicago sativa*	Alfalfa (California common variety)	USA	NA	NA	fastidiosa	H	E	Symptoms	Houston et al., 1947

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Fabaceae	*Medicago sativa*	Alfalfa	USA	weedy alfalfa fields near USDA-ARS research centre in Parlier, CA	NA	NA	NA	S	ELISA	Krugner et al., 2012
Fabaceae	*Medicago sativa*	Alfalfa	Brazil	Cajobi	NA	pauca	P	S and E	PCR	Lopes et al., 2003
Fabaceae	*Medicago sativa*	Alfalfa	Brazil	Luis Antonio, SP	NA	pauca	P	S and E	PCR	Lopes et al., 2003
Fabaceae	*Melilotus* sp.	Sweet clover	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Fabaceae	*Melilotus* sp.	Sweet clover	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Fabaceae	*Melilotus* sp.	Sweet clover	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Fabaceae	*Melilotus alba*	White melilot	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Fabaceae	*Melilotus alba*	White melilot	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Fabaceae	*Melilotus alba*	White melilot	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Fabaceae	*Melilotus alba* var. *annua Coe*	Hubam clover	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Fabaceae	*Melilotus alba* var. *annua Coe*	Hubam clover	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Fabaceae	*Melilotus alba* var. *annua Coe*	Hubam clover	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Fabaceae	*Melilotus indica*	Annual yellow sweet clover	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Fabaceae	*Melilotus indica*	Annual yellow sweet clover	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Fabaceae	*Melilotus indica*	Annual yellow sweet clover	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Fabaceae	*Melilotus officinalis*	Yellow sweet clover	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Fabaceae	*Melilotus officinalis*	Yellow sweet clover	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Fabaceae	*Melilotus officinalis*	Yellow sweet clover	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951

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Fabaceae	*Senna obtusifolia*	Fedegoso	Brazil	Boa Esperanca	NA	pauca	P	S and E	PCR	Lopes et al., 2003
Fabaceae	*Spartium junceum*	Spanish broom	USA	Greenhouse, Temecula, CA	NA	fastidiosa	P	E	ELISA, PCR, culture	Costa et al., 2004
Fabaceae	*Spartium junceum*	Spanish broom	USA	Temecula, CA	NA	NA	P	S	ELISA, PCR, culture	Costa et al., 2004
Fabaceae	*Spartium junceum*	Spanish broom	USA	Riverside Co., CA	fastidiosa	fastidiosa	P	NA	NA	Yuan et al., 2004
Fabaceae	*Trifolium fragerum*	Strawberry clover	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Fabaceae	*Trifolium fragerum*	Strawberry clover	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Fabaceae	*Trifolium fragerum*	Strawberry clover	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Fabaceae	*Trifolium hybridum*	Alsike clover	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Fabaceae	*Trifolium hybridum*	Alsike clover	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Fabaceae	*Trifolium hybridum*	Alsike clover	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Fabaceae	*Trifolium incarnatum*	Crimson clover	USA	CA	NA	fastidiosa?	L	E	Symptoms and infecting with vectors	Freitag, 1951
Fabaceae	*Trifolium pratense*	Red clover	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Fabaceae	*Trifolium pratense*	Red clover	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Fabaceae	*Trifolium pratense*	Red clover	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Fabaceae	*Trifolium repens*	White clover	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Fabaceae	*Trifolium repens*	White clover	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Fabaceae	*Trifolium repens*	White clover	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Fabaceae	*Trifolium repens* var. *latum*	Ladino clover	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Fabaceae	*Trifolium repens* var. *latum*	Ladino clover	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951

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Fabaceae	*Trifolium repens* var. *latum*	Ladino clover	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Fabaceae	*Vicia faba* cv. Aquadulce	Fava bean	USA	San Joaquin Valley, CA	NA	fastidiosa	L	E	Vectors	Wistrom and Purcell, 2005
Fabaceae	*Vicia monanthus*	Vetch	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Fabaceae	*Vicia monanthus*	Vetch	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Fabaceae	*Vicia monanthus*	Vetch	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Fagaceae	*Fagus crenata*	Japaneese beech	USA	US National Arboretum	NA	multiplex	P	S	ELISA, PCR	Huang et al., 2003
Fagaceae	*Quercus* sp.	Red oak	USA	GA	NA	NA	NA	NA	NA	Montero-Astúa et al., 2007
Fagaceae	*Quercus* sp. (others)	Oak	USA	FL	NA	NA	P	NA	NA	Nunney et al., 2013
Fagaceae	*Quercus* sp. (others)	Oak	USA	KY	NA	NA	P	NA	NA	Nunney et al., 2013
Fagaceae	*Quercus* sp.	Oak	USA	FL	multiplex	multiplex	P	NA	NA	Schuenzel et al., 2005
Fagaceae	*Quercus* sp. (others)	Oak	USA	GA	multiplex	multiplex	P	NA	NA	Nunney et al.,. 2013 supplementary data
Fagaceae	*Quercus* sp.	Oak	USA	GA	multiplex	multiplex	P	NA	NA	Yuan et al., 2010
Fagaceae	*Quercus* sp.	Oak	USA	FL	multiplex	multiplex	P	NA	NA	Yuan et al., 2010
Fagaceae	*Quercus* spp.	Oak	USA	SC	NA	NA	NA	S	ELISA, symptoms	Blake, 1993
Fagaceae	*Quercus* sp.	Oak	North America	NA	multiplex	multiplex	P	NA	NA	Nunney et al., 2010
Fagaceae	*Quercus* sp.	Oak	USA	GA	multiplex	multiplex	P	NA	NA	Schuenzel et al., 2005
Fagaceae	*Quercus agrifolia*	Coast live oak	USA	Greenhouse, Temecula, CA	NA	fastidiosa	P	E	ELISA	Costa et al., 2004
Fagaceae	*Quercus agrifolia*	Coast live oak	USA	Napa Valley, CA	NA	fastidiosa	L	E	PCR and culturing assays	Purcell and Saunders, 1999a

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Fagaceae	*Quercus alba*	Eastern white oak	USA	Saint Joseph's University (SJU) campus in Philadelphia, PA	NA	NA	NA	S	DAS-ELISA	McElrone et al., 2008
Fagaceae	*Quercus alba*	The white oak	USA	16 Kentucky cities	NA	multiplex	H	S	Symptoms, ELISA, electron microscopy	Hartman et al., 1995
Fagaceae	*Quercus alba*	The white oak	USA	Rockport, southern IN	NA	multiplex	H	S	Symptoms, ELISA, electron microscopy	Hartman et al., 1995
Fagaceae	*Quercus alba*	The white oak	USA	Knoxville, TN	NA	multiplex	H	S	Symptoms, ELISA, electron microscopy	Hartman et al., 1995
Fagaceae	*Quercus coccinea*	Scarlet oak	USA	DC	multiplex	multiplex	P	S	ELISA, PCR	Harris et al., 2014
Fagaceae	*Quercus coccinea*	Red scarlet	USA	Washington, DC	NA	multiplex	H	S	Symptoms, TEM	Hearon et al., 1980
Fagaceae	*Quercus coccinea*	Red scarlet	USA	Washington, DC	NA	multiplex	H	S	Symptoms, TEM	Hearon et al., 1980
Fagaceae	*Quercus coccinea*	Scarlet oak	USA	Fayette Co., KY	multiplex	multiplex	P	NA	NA	Nunney et al., 2013
Fagaceae	*Quercus coccinea*	Red scarlet	USA	From northern Virginia to New York City, Wilmington (DE)	NA	multiplex	H	S	Culturing	Kostka et al., 1984
Fagaceae	*Quercus falcata*	Southern red oak	USA	Leesburg, FL (wild plant species within 50 miles of the Central Florida Research and Education Centre)	NA	fastidiosa	H	E	ELISA, fluorescence microscopy	Hopkins and Adlerz, 1988
Fagaceae	*Quercus falcata*	Southern red oak	USA	FL	NA	NA	L	S	DAS-ELISA, also asymptomatic trees	Barnard et al., 1998
Fagaceae	*Quercus falcata*	Southern red oak	USA	Washington Co., FL	multiplex	multiplex	P	NA	NA	Yuan et al., 2010
Fagaceae	*Quercus imbricaria*	Shingle oak	USA	16 Kentucky cities	NA	multiplex	H	S	Symptoms, ELISA, electron microscopy	Hartman et al., 1995
Fagaceae	*Quercus imbricaria*	Shingle oak	USA	Rockport, IN	NA	multiplex	H	S	Symptoms, ELISA, electron microscopy	Hartman et al., 1995
Fagaceae	*Quercus imbricaria*	Shingle oak	USA	Knoxville, TN	NA	multiplex	H	S	Symptoms, ELISA, electron microscopy	Hartman et al., 1995
Fagaceae	*Quercus incana*	Bluejack oak	USA	FL	NA	NA	L	S	DAS-ELISA, also asymptomatic trees	Barnard et al., 1998
Fagaceae	*Quercus laevis*	Turkey oak	USA	FL	NA	NA	L	S	DAS-ELISA, also asymptomatic trees	Barnard et al., 1998

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Fagaceae	*Quercus laevis*	Turkey oak	USA	FL	multiplex	multiplex	P	NA	NA	Nunney et al.,. 2013 supplementary data
Fagaceae	*Quercus laevis*	Turkey oak	USA	Palm Beach Co., FL	multiplex	multiplex	P	NA	NA	Nunney et al., 2013
Fagaceae	*Quercus latifolia*		USA	Leesburg, FL (wild plant species within 50 miles of the Central Florida Research and Education Centre)	NA	fastidiosa	H	E	ELISA, fluorescence microscopy	Hopkins and Adlerz, 1988
Fagaceae	*Quercus laurifolia*	Laurel oak	USA	FL	NA	NA	L	S	DAS-ELISA, also asymptomatic trees	Barnard et al., 1998
Fagaceae	*Quercus lobata*	Valley oak	USA	Napa Valley, CA	NA	fastidiosa	L	E	PCR and culturing assays	Purcell and Saunders, 1999a
Fagaceae	*Quercus macrocarpa*	Bur oak	USA	16 Kentucky cities	NA	multiplex	H	S	Symptoms, ELISA, electron microscopy	Hartman et al., 1995
Fagaceae	*Quercus macrocarpa*	Bur oak	USA	Rockport, IN	NA	multiplex	H	S	Symptoms, ELISA, electron microscopy	Hartman et al., 1995
Fagaceae	*Quercus macrocarpa*	Bur oak	USA	Knoxville, TN	NA	multiplex	H	S	Symptoms, ELISA, electron microscopy	Hartman et al., 1995
Fagaceae	*Quercus macrocarpa*	Bur oak	USA	DC	multiplex	multiplex	P	S	ELISA:PCR	Harris et al.,2014
Fagaceae	*Quercus nigra*	Water oak	USA	FL	NA	NA	L	S	DAS-ELISA, also asymptomatic trees	Barnard et al., 1998
Fagaceae	*Quercus nigra*	Water oak	USA	Leesburg, FL (wild plant species within 50 miles of the Central Florida Research and Education Centre)	NA	fastidiosa	H	E	ELISA, fluorescence microscopy	Hopkins and Adlerz, 1988
Fagaceae	*Quercus nigra*	Water oak	USA	Lake Co., FL	multiplex	multiplex	P	NA	NA	Nunney et al., 2013
Fagaceae	*Quercus nigra*	Water oak	USA	Lake Co., FL	multiplex	multiplex	P	NA	NA	Nunney et al., 2013
Fagaceae	*Quercus palustris*	Pin oaks	USA	Washington, DC	multiplex	multiplex	P	S	ELISA, symptoms, PCR	Di Bello et al., 2012
Fagaceae	*Quercus palustris*	Pin oak	USA	New Jersey	NA	multiplex	H	S	Symptoms	Gould et al.,2004
Fagaceae	*Quercus palustris*	Pin oak	USA	DC	multiplex	multiplex	P	S	ELISA:PCR	Harris et al., 2014

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Fagaceae	*Quercus palustris*	Pin oak	USA	NJ	NA	multiplex	H	S	Symptoms	Gould et al.,2004
Fagaceae	*Quercus palustris*	Pin oak	USA	DC	multiplex	multiplex	P	S	ELISA:PCR	Harris et al.,2014
Fagaceae	*Quercus palustris*	Pin oak	USA	Saint Joseph's University (SJU) campus in Philadelphia, PA	NA	NA	NA	S	DAS-ELISA	McElrone et al., 2008
Fagaceae	*Quercus palustris*	Pin oak	USA	Fayette Co., KY	multiplex	multiplex	P	NA	NA	Nunney et al., 2013
Fagaceae	*Quercus palustris*	Pin oak	USA	From northern Virginia to New York City, Wilmington (DE)	NA	multiplex	H	S	Culturing	Kostka et al., 1984
Fagaceae	*Quercus palustris*	Pin oak	USA	From northern Virginia to New York City, Wilmington (DE)	NA	multiplex	H	S	Culturing	Kostka et al., 1984
Fagaceae	*Quercus palustris*	Pin oak	USA	Knox Co., TN	multiplex	multiplex	P	NA	NA	Nunney et al., 2013
Fagaceae	*Quercus palustris*	Pin oak	USA	16 Kentucky cities	NA	multiplex	H	S	Symptoms, ELISA, electron microscopy	Hartman et al., 1995
Fagaceae	*Quercus palustris*	Pin oak	USA	Rockport, IN	NA	multiplex	H	S	Symptoms, ELISA, electron microscopy	Hartman et al., 1995
Fagaceae	*Quercus palustris*	Pin oak	USA	Knoxville, TN	NA	multiplex	H	S	Symptoms, ELISA, electron microscopy	Hartman et al., 1995
Fagaceae	*Quercus phellos*	Willow oak	USA	DC	multiplex	multiplex	P	S	ELISA, PCR	Harris et al., 2014
Fagaceae	*Quercus robur*	English oak	USA	Fayette Co., KY	multiplex	multiplex	P	NA	NA	Nunney et al., 2013
Fagaceae	*Quercus rubra*	Northern red oak	USA	Georiga Experiment Station (University of Georgia), GA	NA	multiplex?	H	S and E	Culturing, microscopy	Chang and Walker, 1988
Fagaceae	*Quercus rubra*	Northern red oak	USA	Washington, DC	multiplex	multiplex	P	S	ELISA, symptoms, PCR	Di Bello et al., 2012
Fagaceae	*Quercus rubra*	Northern red oak	USA	NJ	NA	multiplex	H	S	Symptoms	Gould et al., 2004
Fagaceae	*Quercus rubra*	Northern red oak	USA	DC	multiplex	multiplex	P	S	ELISA:PCR	Harris et al., 2014
Fagaceae	*Quercus rubra*	Northern red oak	USA	Washington, DC	NA	multiplex	H	S	Symptoms, TEM	Hearon et al., 1980

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Fagaceae	*Quercus rubra*	Northern red oak	USA	Washington, DC	NA	multiplex	H	S	Symptoms, TEM	Hearon et al., 1980
Fagaceae	*Quercus rubra*	Red oak	USA	Fayette Co., KY	multiplex	multiplex	P	NA	NA	Nunney et al., 2013
Fagaceae	*Quercus rubra*	Northern red oak	USA	National Mall in Washington DC	NA	multiplex	H	NA	ELISA	Sherald and Lei, 1991
Fagaceae	*Quercus rubra*	Red oak	USA	Washington, DC	multiplex	multiplex	P	NA	NA	Nunney et al.,. 2013 supplementary data
Fagaceae	*Quercus rubra*	Red oak	USA	GA	multiplex	multiplex	P	NA	NA	Nunney et al.,. 2013 supplementary data
Fagaceae	*Quercus rubra*	Northern red oak	USA	NA	NA	multiplex	H	?	Primary isolations obtained from contributors	Wells et al., 1987
Fagaceae	*Quercus rubra*	Northern red oak	USA	Knoxville, TN	NA	multiplex	H	S	Symptoms, ELISA, electron microscopy	Hartman et al., 1995
Fagaceae	*Quercus rubra*	Northern red oak	USA	16 Kentucky cities	NA	multiplex	H	S	Symptoms, ELISA, electron microscopy	Hartman et al., 1995
Fagaceae	*Quercus rubra*	Northern red oak	USA	Rockport, IN	NA	multiplex	H	S	Symptoms, ELISA, electron microscopy	Hartman et al., 1995
Fagaceae	*Quercus rubra*	Northern red oak	USA	Saint Joseph's University (SJU) campus in Philadelphia, PA	NA	NA	NA	S	DAS-ELISA	McElrone, et al., 2008
Fagaceae	*Quercus schumardii*	Schumard oak	USA	Franklin Co., KY	multiplex	multiplex	P	NA	NA	Nunney et al., 2013
Fagaceae	*Quercus velutina*	Black oak	USA	National Arboretum Washington, DC	NA	NA	P	S	ELISA, PCR, symptoms, culture	Huang, 2004
Fagaceae	*Quercus virginiana*	Southern live oak	USA	FL	NA	NA	L	S	DAS-ELISA, also asymptomatic trees	Barnard et al., 1998
Fagaceae	*Quercus virginiana*	Southern live oak	USA	FL	NA	NA	L	S	DAS-ELISA, also asymptomatic trees	Barnard et al., 1998
Fagaceae	*Quercus virginiana*	Southern live oak	USA	South-west FL	NA	multiplex	H	S	ELISA, culturing	McGovern et al., 1994
Fagaceae	*Quercus virginiana*	Southern live oak	USA	South-west and central-west FL	NA	multiplex	H	S	ELISA, culturing, PCR	McGovern et al., 1994
Geraniaceae	*Erodium botrys*	Broadleaf filaree	USA	Weedy alfalfa fields near USDA-ARS research centre in Parlier, CA	NA	NA	NA	S	ELISA	Krugner et al., 2012

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Geraniaceae	*Erodium moschatum*	Whitestem filaree	USA	Weedy alfalfa fields near USDA-ARS research centre in Parlier, CA	NA	NA	NA	S	ELISA	Krugner et al., 2012
Geraniaceae	*Geranium dissectum*	Cut-leaved Cranesbill	USA	Weedy alfalfa fields near USDA-ARS research centre in Parlier, CA	NA	NA	NA	S	ELISA	Krugner et al., 2012
Ginkgoaceae	*Ginkgo biloba*	Maidenhair tree or ginkgo	USA	DC	NA	NA	NA	S	ELISA:PCR	Harris et al., 2014
Ginkgoaceae	*Ginkgo biloba*	Maidenhair tree or ginkgo	USA	CA (Riverside and Redlands areas)	multiplex	multiplex	P	S	Symptoms, ELISA, PCR, culture	Wong's report: http://celosangeles.ucanr.edu/newsletters/Fall_200534798.pdf; Wong et al., 2004
Juglandaceae	*Carya illinoinensis*	Pecan (cape fear)	USA	Shreveport, LA	multiplex	multiplex	P	NA	NA	Melanson et al., 2012
Juglandaceae	*Carya illinoinensis*	Pecan (Oconee)	USA	Hessmer, LA	multiplex	multiplex	P	NA	NA	Melanson et al., 2012
Juglandaceae	*Carya illinoinensis*	Pecan (Desirable)	USA	Hessmer, LA	multiplex	multiplex	P	NA	NA	Melanson et al., 2012
Juglandaceae	*Carya illinoinensis*	Pecan	USA	LA	NA	multiplex	H	S and E	ELISA, symptoms	Sanderlin and Heyderich-Alger, 2000
Juglandaceae	*Carya illinoinensis*	Pecan	USA	Medina Co., TX	multiplex	multiplex	P	NA	NA	Nunney et al., 2013
Juglandaceae	*Carya illinoinensis*	Pecan	USA	TX	NA	NA	P	NA	NA	Nunney et al., 2013
Juglandaceae	*Carya illinoinensis*	Pecan	USA	Gulf Coast, TX	NA	NA	NA	NA	ELISA, PCR	McGaha et al., 2007
Juglandaceae	*Juglans* sp.	Walnut	USA	CA (Riverside and Redlands areas)	NA	NA	P	S	Symptoms, ELISA, PCR	Wong's report: http://celosangeles.ucanr.edu/newsletters/Fall_200534798.pdf; Wong et al., 2004
Juglandaceae	*Juglans californica*	Walnut	USA	Temecula, CA	NA	NA	P	S	ELISA	Costa et al., 2004

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Juglandaceae	*Juglans hindsii*	California black walnut	USA	Napa Valley, CA	NA	fastidiosa	L	E	PCR and culturing assays	Purcell and Saunders, 1999a
Lamiaceae	*Callicarpa americana*	American beautyberry	USA	Leesburg, FL (wild plant species within 50 miles of the Central Florida Research and Education Centre)	NA	fastidiosa	H	E	ELISA, fluorescence microscopy	Hopkins and Adlerz, 1988
Lamiaceae	*Lavandula dentata*	Lavender	USA	CA (Riverside and Redlands areas)	NA	NA	P	S	Symptoms, ELISA, PCR	Wong's report: http://celosangeles.ucanr.edu/newsletters/Fall_200534798.pdf; Wong et al., 2004
Lamiaceae	*Majorana hortensia*	Sweet Marjoram	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Lamiaceae	*Majorana hortensia*	Sweet Marjoram	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Lamiaceae	*Majorana hortensia*	Sweet Marjoram	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Lamiaceae	*Marrubium vulgare*	White horehound	USA	Weedy alfalfa fields near USDA-ARS research centre in Parlier, CA	NA	NA	NA	S	ELISA	Krugner et al., 2012
Lamiaceae	*Melissa officinalis*	Garden balm	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Lamiaceae	*Melissa officinalis*	Garden balm	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Lamiaceae	*Melissa officinalis*	Garden balm	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Lamiaceae	*Mentha* sp.	Mint	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Lamiaceae	*Mentha* sp.	Mint	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Lamiaceae	*Mentha* sp.	Mint	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Lamiaceae	*Rosmarinus officinalis*	Rosemary	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Lamiaceae	*Rosmarinus officinalis*	Rosemary	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951

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Lamiaceae	*Rosmarinus officinalis*	Rosemary	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Lamiaceae	*Rosmarinus officinalis*	Rosemery	USA	CA (Riverside and Redlands areas)	NA	NA	P	S	Symptoms, ELISA, PCR	Wong's report: http://celosangeles.ucanr.edu/newsletters/Fall_200534798.pdf; Wong et al., 2004
Lamiaceae	*Salvia apiana*	White sage	USA	Greenhouse, Temecula, CA	NA	fastidiosa	P	E	ELISA, PCR, culture	Costa et al., 2004
Lamiaceae	*Salvia mellifera*	Black sage	USA	Greenhouse, Temecula, CA	NA	fastidiosa	P	E	ELISA, PCR, culture	Costa et al., 2004
Lamiaceae	*Salvia mellifera*	Black Sage	USA	CA	multiplex	multiplex	P	NA	NA	Nunney et al., 2013
Lamiaceae	*Salvia mellifera*	Black Sage	USA	Riverside Co., CA	multiplex	multiplex	P	NA	NA	Nunney et al.,. 2013 supplementary data
Lamiaceae	*Westringia fruticosa*	Coastal rosemary	Italy	Salento area (Apulia)	pauca	pauca	P	S	Symptoms, ELISA, PCR	Saponari et al., 2014
Lauraceae	*Persea americana*		Costa Rica	Alajuela and San José provinces	NA	fastidiosa	L	S and E (seedlings, 15 trees)	DAS-ELISA with *X.fastidiosa* specific antiserum, visual symptoms, TEM, PCR (mucilaginous sap from avocado)	Montero-Astúa et al., 2008a
Lauraceae	*Umbellularia californica*	California bay (laurel)	USA	Napa Valley, CA	NA	fastidiosa	L	E	PCR and culturing assays	Purcell and Saunders, 1999a
Lauraceae	*Umbellularia californica*	California bay (laurel)	USA	US Davis campus	NA	fastidiosa	H	NA	NA	Chatelet et al., 2011
Lythraceae	*Lagerstroemia indica*	Crape Myrtle	USA	CA (Riverside and Redlands areas)	multiplex	multiplex	P	S	Symptoms, ELISA, PCR, culture	Wong's report: http://celosangeles.ucanr.edu/newsletters/Fall_200534798.pdf; Wong et al., 2004
Magnoliaceae	*Liriodendron tulipifera*	American tulip tree	USA	Washington, DC	multiplex	multiplex	P	S	ELISA, symptoms, PCR	Di Bello et al., 2012

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Magnoliaceae	*Magnolia grandifolia*	Southern magnolia	USA	CA (Riverside and Redlands areas)	fastidiosa	fastidiosa	P	S	Symptoms, ELISA, PCR, direct culturing	Wong's report: http://celosangeles.ucanr.edu/newsletters/Fall_200534798.pdf; Wong et al., 2004
Magnoliaceae	*Magnolia grandifolia*	Southern magnolia	USA	CA (Riverside and Redlands areas)	sandyi	sandyi	P	S	Symptoms, ELISA, PCR, culturing	Wong's report: http://celosangeles.ucanr.edu/newsletters/Fall_200534798.pdf; Wong et al., 2004
Magnoliaceae	*Magnolia grandiflora*	Magnolia	USA	San Bernardino Co., CA	sandyi	sandyi	P	NA	NA	Yuan et al., 2010
Magnoliaceae	*Magnolia grandiflora*	Magnolia	USA	Gulf Coast, TX	?	?	?	?	ELISA, PCR	McGaha et al., 2007
Malvaceae	*Hibiscus schizopetalus*	Japanese lantern	Brazil	Brasília	NA	pauca	H	S	PCR, cultures	Rodrigues et al., 2003
Malvaceae	*Hibiscus syriacus*		USA	Gulf Coast, TX	NA	?	?	?	ELISA	McGaha et al., 2007
Malvaceae	*Malva parviflora*	Cheeseweed	USA	CA's Central Valley	NA	multiplex	P	S	Immunocapture DNA separation and PCR	Shapland et al., 2006
Malvaceae	*Malva parviflora*	Cheeseweed	USA	Weedy alfalfa fields near USDA-ARS research centre in Parlier, CA	NA	NA	NA	S	ELISA	Krugner et al., 2012
Malvaceae	*Malva parviflora*	Cheeseweed	USA	San Joaquin Valley, CA	NA	fastidiosa	L	E	Vectors	Wistrom and Purcell, 2005
Malvaceae	*Modiola caroliniana*		USA	Gulf Coast, TX	NA	?	?	?	ELISA, PCR	McGaha et al., 2007
Malvaceae	*Sida* spp.	Guanxuma	Brazil	Boa Esperanca and San José farm	NA	pauca	P	S and E	PCR	Lopes et al., 2003
Moraceae	*Ficus carica*		USA	Gulf Coast, TX	NA	?	?	?	ELISA, PCR	McGaha et al., 2007

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Moraceae	*Morus* sp.	Mulberry	USA	CA	multiplex × fastidiosa (massive recombination between two of the subspecies, an equal mix)	NA	NA	NA	NA	Nunney, 2011
Moraceae	*Morus* sp.	Mulberry	USA	Massachusetts	NA	NA	NA	NA	NA	Montero-Astúa et al., 2007
Moraceae	*Morus alba*	White mulberry	USA	DC	sandyi	sandyi	P	S	ELISA, PCR	Harris et al.,2014
Moraceae	*Morus alba*	White mulberry	USA	CA (Riverside and Redlands areas)	NA	*morus**	P	S	ELISA, PCR, culture	Wong's report: http://celosangeles.ucanr.edu/newsletters/Fall_200534798.pdf; Wong et al., 2004
Moraceae	*Morus nigra*	Mulberry	USA	Massachusetts	NA	NA	H	S	PCR, cultures	Rodrigues et al., 2003
Moraceae	*Morus rubra*	Red mulberry	USA	National Mall in Washington DC	NA	multiplex	H	?	ELISA	Sherald and Lei, 1991

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Moraceae	*Morus rubra*	Red mulberry	USA	Washington DC area (natural population of red mulberries along 3 km of the George Washington Memorial Parkway in Alexandria, VA); also mulberries growing in both rural and urban roadsides and natural sites were surveyed from northern VA through the eastern mid-Atlantic states to the northern range of red mulberry in southern England to determine disease distribution)	NA	multiplex	H	S	A gram-negative, xylem inhabiting bacterium morphologically similar to and serologically related to the Pierce's disease and elm leaf scorch was isolated form plants with MLS-affected by incubating wood chips in supplemented PW broth or PD-2 broth (5–7 days). (phase-contrast microscopy) and samples from seedlings (electron microscopy)	Kostka and Tattar, 1986b
Moraceae	*Morus rubra*	Red mulberry	USA	NA	NA	NA	H	?	Primary isolations obtained from contributors	Wells et al., 1987
Myrtaceae	*Eucalyptus globulus*	Blue gum	USA	San Joaquin Valley, CA	NA	fastidiosa	L	E	Vectors	Wistrom and Purcell, 2005
Myrtaceae	*Eucalyptus globulus*	Blue gum	USA	US Davis campus CA	NA	fastidiosa	H	NA	NA	Chatelet et al., 2011
Myrtaceae	*Eucalyptus camaldulensis*	Red gum	USA	San Joaquin Valley, CA	NA	fastidiosa	L	E	Vectors	Wistrom and Purcell, 2005
Myrtaceae	*Eugenia myrtifolia*	Australian brush cherry	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Myrtaceae	*Eugenia myrtifolia*	Australian brush cherry	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Myrtaceae	*Eugenia myrtifolia*	Australian brush cherry	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Myrtaceae	*Metrosideros* sp.	New Zealand Christmas tree	USA	Riverside Co., CA	fastidiosa	fastidiosa	P	NA	NA	Yuan et al., 2010
Myrtaceae	*Metrosideros* sp.	New Zealand Christmas tree	USA	Orange Co., CA	fastidiosa	fastidiosa	P	NA	NA	Yuan et al., 2010

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Myrtaceae	*Metrosideros* sp.	New Zealand Christmas tree	USA	CA	fastidiosa	fastidiosa	P	NA	NA	Nunney et al., 2013
Oleaceae	*Chionanthus* sp.	Fringe tree	USA	Fayette Co., KY	multiplex	multiplex	P	NA	NA	Nunney et al., 2013 supplementary data
Oleaceae	*Chionanthus retusus*	Chinese fringe tree	USA	CA (Riverside and Redlands areas)	NA	NA	P	S	Symptoms, ELISA, PCR	Wong's report: http://celosangeles.ucanr.edu/newsletters/Fall_200534798.pdf; Wong et al., 2004
Oleaceae	*Fraxinus americana*	White ash	USA	Fayette Co., KY	multiplex	multiplex	P	NA	NA	Nunney et al., 2013
Oleaceae	*Fraxinus dipetala*	Foothill ash	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Oleaceae	*Fraxinus dipetala*	Foothill ash	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Oleaceae	*Fraxinus dipetala*	Foothill ash	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Oleaceae	*Fraxinus latifolia*	Oregon ash	USA	Napa Valley, CA	NA	fastidiosa	L	E	PCR and culturing assays	Purcell and Saunders, 1999a
Oleaceae	*Fraxinus pennsylvanica*	Green ash	USA	IN	multiplex	multiplex	P	NA	NA	Nunney et al., 2013
Oleaceae	*Fraxinus pennsylvanica*	Green ash	USA	KY	multiplex	multiplex	P	NA	NA	Nunney et al., 2013
Oleaceae	*Fraxinus pennsylvanica*	Green ash	USA	Gulf Coast, TX	NA	?	?	?	ELISA, PCR	McGaha et al., 2007
Oleaceae	*Ligustrum lucidum*	Glossy privet	USA	CA (Riverside and Redlands areas)	NA	multiplex	P	S	ELISA, PCR	Wong et al., 2004
Oleaceae	*Olea europea*	Olive	Italy	Salento peninsula (Apulia, southern Italy, Lecce province)	pauca	pauca	P	S	Symptoms, ELISA, PCR, culture	Cariddi et al., 2014
Oleaceae	*Olea europea*	Olive	Italy	Salento peninsula (Apulia, southern Italy, Lecce province)	pauca	pauca	P	S	Symptoms, ELISA, PCR	Loconsole et al., 2014
Oleaceae	*Olea europea*	Olive	USA	Temecula, CA	NA	NA	P	S	ELISA	Costa et al., 2004

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Oleaceae	*Olea europea*	Olive	USA	Los Angeles Co., CA	multiplex	multiplex	P	NA	NA	Nunney et al., 2013
Oleaceae	*Olea europea*	Olive	USA	CA	NA	NA	P	NA	NA	Nunney et al., 2013
Oleaceae	*Olea europea*	Olive	Italy	Salento peninsula (Apulia, southern Italy)	NA	pauca	P	S	DAS-ELISA, PCR	Saponari et al., 2013
Oleaceae	*Olea europea*	Olive	USA	Riverside Co., CA	multiplex	multiplex	P	NA	NA	Nunney et al.,. 2013 supplementary data
Oleaceae	*Olea europea*	Olive	USA	CA (Riverside and Redlands areas)	multiplex	multiplex	P	S	Symptoms, ELISA, PCR, culture	Wong's report: http://celosangeles.ucanr.edu/newsletters/Fall_200534798.pdf; Wong et al., 2004
Oleaceae	*Syringa vulgaris*	Lilac	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Oleaceae	*Syringa vulgaris*	Lilac	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Oleaceae	*Syringa vulgaris*	Lilac	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Onagraceae	*Epilobium californicum*	Willow herb	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Onagraceae	*Epilobium californicum*	Willow herb	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Onagraceae	*Epilobium californicum*	Willow herb	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Onagraceae	*Epilobium paniculatum*	Panicled willow herb	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Onagraceae	*Epilobium paniculatum*	Panicled willow herb	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Onagraceae	*Epilobium paniculatum*	Panicled willow herb	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Onagraceae	*Fuchsia magellanica*	Fuchsia	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Onagraceae	*Fuchsia magellanica*	Fuchsia	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Onagraceae	*Fuchsia magellanica*	Fuchsia	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951

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Onagraceae	*Godetia grandiflora*	Godetia	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Onagraceae	*Godetia grandiflora*	Godetia	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Onagraceae	*Godetia grandiflora*	Godetia	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Onagraceae	*Ludwigia grandiflora*	Water primrose	USA	Weedy alfalfa fields near USDA-ARS research centre in Parlier, CA	NA	NA	NA	S	ELISA	Krugner et al., 2012
Onagraceae	*Oenothera hookeri*	Evening primrose	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Onagraceae	*Oenothera hookeri*	Evening primrose	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Onagraceae	*Oenothera hookeri*	Evening primrose	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Pinaceae	*Pinus taeda*		USA	Gulf Coast, TX	NA	NA	NA	?	ELISA, PCR	McGaha et al., 2007
Pittosporuceae	*Pittosporum crassifolium*	Karo	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Pittosporuceae	*Pittosporum crassifolium*	Karo	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Pittosporuceae	*Pittosporum crassifolium*	Karo	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Plantaginaceae	*Plantago lanceolata*	Ribwort plantain	USA	Weedy alfalfa fields near USDA-ARS research centre in Parlier, CA	NA	NA	NA	S	ELISA	Krugner et al., 2012
Plantaginaceae	*Veronica* sp.	Speedwell	USA	CA's Central Valley	NA	multiplex	P	S	Immunocapture DNA separation and PCR	Shapland et al., 2006
Platanaceae	*Platanus* sp.	Sycamore	USA	16 Kentucky cities	NA	multiplex	H	S	Symptoms, ELISA, electron microscopy	Hartman et al., 1995
Platanaceae	*Platanus* sp.	Sycamore	USA	Rockport, IN	NA	multiplex	H	S	Symptoms, ELISA, electron microscopy	Hartman et al., 1995
Platanaceae	*Platanus* sp.	Sycamore	USA	Knoxville, TN	NA	multiplex	H	S	Symptoms, ELISA, electron microscopy	Hartman et al., 1995
Platanaceae	*Platanus* sp.	Sycamore	North America	NA	multiplex	multiplex	P	NA	NA	Nunney et al., 2010
Platanaceae	*Platanus* sp.	Sycamore	USA	NA	NA	multiplex	H	E	Culturing, phase contrast microscopy	Sherald et al., 1985

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Platanaceae	*Platanus occidentalis*	American sycamore	USA	Leesburg, FL (wild plant species within 50 miles of the Central Florida Research and Education Centre)	NA	multiplex	H	E	ELISA, phase contrast microscopy, symptoms	Sherald, 1993
Platanaceae	*Platanus occidentalis*	American sycamore	USA	Washington, DC	NA	multiplex	H	S	Symptoms, TEM	Hearon et al., 1980
Platanaceae	*Platanus occidentalis*	American sycamore	USA	Washington, DC	NA	multiplex	H	S	Symptoms, TEM	Hearon et al., 1980
Platanaceae	*Platanus occidentalis*	American sycamore	USA	Not specified	NA	multiplex	H	E	Phase contrast microscopy, culture	Sherald et al., 1985
Platanaceae	*Platanus occidentalis*	American sycamore	USA	National Mall in Washington DC	NA	multiplex	H	E	ELISA	Sherald and Lei, 1991
Platanaceae	*Platanus occidentalis*	Sycamore	USA	SC	NA	NA	NA	S	ELISA, symptoms	Blake, 1993
Platanaceae	*Platanus occidentalis*	American sycamore	USA	American hybrid vineyard in the Texas Gulf Coast (Austin County Vineyards, a 4.5-acre vineyard located in Cat Spring, TX, 70 miles west of Houston)	NA	NA	NA	S	ELISA, PCR	Buzombo et al., 2006
Platanaceae	*Platanus occidentalis*	American sycamore	USA	Washington, DC	multiplex	multiplex	P	S	ELISA, symptoms, PCR	Di Bello et al., 2012
Platanaceae	*Platanus occidentalis*	American sycamore	USA	DC	multiplex	multiplex	P	S	ELISA:PCR	Harris et al., 2014
Platanaceae	*Platanus occidentalis*	Sycamore	USA	Clemson,SC	NA	NA	H	S and E	Symptoms and ELISA	Haygood and Witcher, 1988
Platanaceae	*Platanus occidentalis*	Sycamore	USA	Raleigh, NC	NA	NA	H	S and E	Symptoms and ELISA	Haygood and Witcher, 1988
Platanaceae	*Platanus occidentalis*	American sycamore	USA	Leesburg, FL (wild plant species within 50 miles of the Central Florida Research and Education Centre)	NA	fastidiosa	H	E	ELISA, fluorescence microscopy	Hopkins and Adlerz, 1988
Platanaceae	*Platanus occidentalis*	American sycamore	USA	Not specified	NA	NA	NA	E	not described	Leininger et al., 2001

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Platanaceae	*Platanus occidentalis*	American sycamore	USA	Shreveport, LA	NA	NA	P	NA	NA	Melanson et al., 2012
Platanaceae	*Platanus occidentalis*	American sycamore	USA	Washington, DC	multiplex	multiplex	P	NA	NA	Nunney et al., 2013
Platanaceae	*Platanus occidentalis*	American sycamore	USA	Fayette Co., KY	multiplex	multiplex	P	NA	NA	Nunney et al., 2013
Platanaceae	*Platanus occidentalis*	American sycamore	USA	Collin Co., TX	multiplex	multiplex	P	NA	NA	Nunney et al., 2013
Platanaceae	*Platanus occidentalis*	American sycamore	USA	Uvalde Co., TX	multiplex	multiplex	P	NA	NA	Nunney et al., 2013
Platanaceae	*Platanus occidentalis*	American sycamore	USA	Not specified	NA	multiplex	H	E	Phase contrast microscopy, culture	Sherald et al., 1985
Platanaceae	*Platanus occidentalis*	American sycamore	USA	Washington, DC, Richardson, TX and New Orleans, LA	NA	fastidiosa	H	S and E	Incubating woodchip samples in a liquid medium similar to that used for culture of the periwinkle wilt agent, phase contrast microscopy and electron microscopy, indirect IFAS	Sherald et al., 1985
Platanaceae	*Platanus occidentalis*	American sycamore	USA	Alachua Co., FL	multiplex	multiplex	P	NA	NA	Nunney et al., 2013 supplementary data
Platanaceae	*Platanus occidentalis*	Sycamore	USA	NA	NA	multiplex	H	NA	Primary isolations obtained from contributors	Wells et al., 1987
Platanaceae	*Platanus racemosa*	Sycamore	USA	Greenhouse, Temecula, CA	NA	fastidiosa	P	E	ELISA	Costa et al., 2004
Poaceae	*Agrostis gigantea*	Redtop	USA	Weedy alfalfa fields near USDA-ARS research centre in Parlier, CA	NA	NA	NA	S	ELISA	Krugner et al., 2012
Poaceae	*Avena fatua*	Wild oat	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Poaceae	*Avena fatua*	Wild oat	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Poaceae	*Avena fatua*	Wild oat	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951

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Poaceae	*Avena fatua*	Wild oat	USA	Weedy alfalfa fields near USDA-ARS research centre in Parlier, CA	NA	NA	NA	S	ELISA	Krugner et al., 2012
Poaceae	*Brachiaria decumberis*	Capim braquiaria	Brazil	Boa Esperanca and San José farm	NA	pauca	P	S and E	PCR	Lopes et al., 2003
Poaceae	*Brachiaria plantaginea*	Capim marmelada	Brazil	San José farm	NA	pauca	P	S and E	PCR	Lopes et al., 2003
Poaceae	*Bromus* sp.	Russian brome grass	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Poaceae	*Bromus* sp.	Russian brome grass	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Poaceae	*Bromus* sp.	Russian brome grass	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Poaceae	*Bromus catharticus*	Rasque grass	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Poaceae	*Bromus catharticus*	Rasque grass	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Poaceae	*Bromus catharticus*	Rasque grass	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Poaceae	*Bromus diandrus*	Great brome	USA	Weedy alfalfa fields near USDA-ARS research centre in Parlier, CA	NA	NA	NA	S	ELISA	Krugner et al., 2012
Poaceae	*Bromus rigidus*	Ripgut grass	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Poaceae	*Bromus rigidus*	Ripgut grass	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Poaceae	*Bromus rigidus*	Ripgut grass	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Poaceae	*Cenchrus echinatus*	Capim carrapicho	Brazil	Boa Esperanca and San José farm	NA	pauca	P	S and E	PCR	Lopes et al., 2003
Poaceae	*Coelorachis cylindrical*		USA	Gulf Coast, TX	NA	?	?	?	ELISA, PCR	McGaha et al., 2007
Poaceae	*Cynodon dactylon*	Bermuda grass	USA	CA (Berkley, Los Angeles and Napa Valley	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Poaceae	*Cynodon dactylon*	Grama seda	Brazil	Boa Esperanca and San José farm	NA	pauca	P	S and E	PCR	Lopes et al., 2003
Poaceae	*Cynodon dactylon*	Bermuda grass	USA	CA	NA	fastidiosa	H	E	ELISA, culturing	Hill and Purcell, 1997

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Poaceae	*Cynodon dactylon*	Bermuda grass	USA	CA	NA	fastidiosa	H	E	ELISA	Hill and Purcell, 1995
Poaceae	*Cynodon dactylon*	Bermuda grass	USA	Weedy alfalfa fields near USDA-ARS research centre in Parlier, CA	NA	NA	NA	S	ELISA	Krugner et al., 2012
Poaceae	*Digitaria horizontalis*	Jamaican crabgrass (Capim colchao)	Brazil	Boa Esperanca and San José farm	NA	pauca	P	S and E	PCR	Lopes et al., 2003
Poaceae	*Digitaria insularis*	Capim amargoso	Brazil	Boa Esperanca and San José farm	NA	pauca	P	S and E	PCR	Lopes et al., 2003
Poaceae	*Digitaria sanguinalis*	Hairy crabgrass	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Poaceae	*Digitaria sanguinalis*	Hairy crabgrass	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Poaceae	*Digitaria sanguinalis*	Hairy crabgrass	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Poaceae	*Echinochloa crusgalli*	Barnyard grass	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Poaceae	*Echinochloa crusgalli*	Barnyard grass	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Poaceae	*Echinochloa crusgalli*	Barnyard grass	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Poaceae	*Echinochloa crusgalli*	Watergrass	USA	CA	NA	fastidiosa	H	E	ELISA, culturing	Hill and Purcell, 1997
Poaceae	*Echinochloa crusgalli*	Barnyard grass	USA	CA	NA	fastidiosa	H	E	ELISA	Hill and Purcell, 1995
Poaceae	*Echinochloa crusgalli*	Watergrass	USA	Weedy alfalfa fields near USDA-ARS research centre in Parlier, CA	NA	NA	NA	S	ELISA	Krugner et al., 2012
Poaceae	*Echinochloa crusgalli*	Barnyard grass	Brazil	Cajobi	NA	pauca	P	S and E	PCR	Lopes et al., 2003
Poaceae	*Echinochloa crusgalli*	Barnyard grass	Brazil	Luis Antonio, SP	NA	pauca	P	S and E	PCR	Lopes et al., 2003
Poaceae	*Echinochloa crusgalli*	Barnyard grass	USA	San Joaquin Valley, CA	NA	fastidiosa	L	E	Vectors	Wistrom and Purcell, 2005
Poaceae	*Eragrostis diffusa*	Diffuse love grass	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Poaceae	*Eragrostis diffusa*	Diffuse love grass	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951

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Poaceae	*Eragrostis diffusa*	Diffuse love grass	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Poaceae	*Eriochloa contracta*	Prairie cupgrass	USA	Weedy alfalfa fields near USDA-ARS research centre in Parlier, CA	NA	NA	NA	S	ELISA	Krugner et al., 2012
Poaceae	*Eriochola gracilis*	Southwestern cupgrass	USA	San Joaquin Valley, CA	NA	fastidiosa	L	E	Vectors	Wistrom and Purcell, 2005
Poaceae	*Festuca megalura*	Foxtail feseue	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Poaceae	*Festuca megalura*	Foxtail feseue	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Poaceae	*Festuca megalura*	Foxtail feseue	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Poaceae	*Holous halepensis*	Johnson grass	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Poaceae	*Holous halepensis*	Johnson grass	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Poaceae	*Holous halepensis*	Johnson grass	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Poaceae	*Holous sudanensis*	Sudan grass	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Poaceae	*Holous sudanensis*	Sudan grass	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Poaceae	*Holous sudanensis*	Sudan grass	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Poaceae	*Hordeum murinum*	Common foxtail	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Poaceae	*Hordeum murinum*	Common foxtail	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Poaceae	*Hordeum murinum*	Common foxtail	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Poaceae	*Hordeum murinum* subsp. *murinum*	Common foxtail	USA	Weedy alfalfa fields near USDA-ARS research centre in Parlier, CA	NA	NA	NA	S	ELISA	Krugner et al., 2012
Poaceae	*Hordeum vulgare*	Barley	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Poaceae	*Hordeum vulgare*	Barley	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Poaceae	*Hordeum vulgare*	Barley	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951

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Poaceae	*Lolium perenne*	Perennial ryegrass	USA	Weedy alfalfa fields near USDA-ARS research centre in Parlier, CA	NA	NA	NA	S	ELISA	Krugner et al., 2012
Poaceae	*Lolium mulliflorum*	Italian ryegrass	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Poaceae	*Lolium mulliflorum*	Italian ryegrass	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Poaceae	*Lolium mulliflorum*	Italian ryegrass	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Poaceae	*Lolium temulentum*	Darnol	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Poaceae	*Lolium temulentum*	Darnol	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Poaceae	*Lolium temulentum*	Darnol	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Poaceae	*Panicum maximum*	Coloniao	Brazil	Boa Esperanca and San José farm	NA	pauca	P	S and E	PCR	Lopes et al., 2003
Poaceae	*Paspalum dilatatum*	Dallisgrass	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Poaceae	*Paspalum dilatatum*	Dallisgrass	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Poaceae	*Paspalum dilatatum*	Dallisgrass	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Poaceae	*Paspalum dilatatum*	Dallisgrass	USA	Vineyards in Napa River, CA	NA	fastidiosa	L	S	ELISA, electron microscopy and light microscopy	Raju et al., 1980
Poaceae	*Pennisetum clandestimum*	Kikuyu grass	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Poaceae	*Pennisetum clandestimum*	Kikuyu grass	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Poaceae	*Pennisetum clandestimum*	Kikuyu grass	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Poaceae	*Phalaris minor*	Mediterranean canary grass	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Poaceae	*Phalaris minor*	Mediterranean canary grass	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Poaceae	*Phalaris minor*	Mediterranean canary grass	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Poaceae	*Phalaris paradoxa*	Gnawed canary grass	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951

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Poaceae	*Phalaris paradoxa*	Gnawed canary grass	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Poaceae	*Phalaris paradoxa*	Gnawed canary grass	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Poaceae	*Phleum pratense*	Timothy	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Poaceae	*Phleum pratense*	Timothy	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Poaceae	*Phleum pratense*	Timothy	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Poaceae	*Poa annua*	Annual bluegrass	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Poaceae	*Poa annua*	Annual bluegrass	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Poaceae	*Poa annua*	Annual bluegrass	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Poaceae	*Poa annua*	Annual bluegrass	USA	Weedy alfalfa fields near USDA-ARS research centre in Parlier, CA	NA	NA	NA	S	ELISA	Krugner et al., 2014
Poaceae	*Poa annua*	Annual bluegrass	USA	CA's Central Valley	NA	multiplex	P	S	Immunocapture DNA separation and PCR	Shapland et al., 2006
Poaceae	*Setaria lutescens*	Yellow bristlegrass	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Poaceae	*Setaria lutescens*	Yellow bristlegrass	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Poaceae	*Setaria lutescens*	Yellow bristlegrass	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Poaceae	*Setaria magna*		USA	Gulf Coast, TX	NA	?	?	?	ELISA, PCR	McGaha et al., 2007
Poaceae	*Sorghum halepense*	Johnsongrass	USA	GA	NA	multiplex?	H	S	Immunofluorescent reaction IMF; microscopy	Wells et al., 1980
Poaceae	*Sorghum halepense*	Johnsongrass	USA	San Joaquin Valley, CA	NA	fastidiosa	L	E	Vectors	Wistrom and Purcell, 2005
Poaceae	*Erodium* spp.	Filaree	USA	California's central valley	NA	multiplex	P	S	Immunocapture DNA separation and PCR	Shapland et al., 2006
Poaceae	*Erodium cicutarium*	Redstem filaree	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Poaceae	*Erodium cicutarium*	Redstem filaree	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951

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Poaceae	*Erodium cicutarium*	Redstem filaree	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Poaceae	*Erodium moscatum*	Whitestem filaree	USA	San Joaquin Valley, CA	NA	fastidiosa	L	E	Vectors	Wistrom and Purcell, 2005
Poaceae	*Pelargonium hortorum*	Fish geranium	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Poaceae	*Pelargonium hortorum*	Fish geranium	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Poaceae	*Pelargonium hortorum*	Fish geranium	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Polygalaceae	*Polygala myrtifolia*	Myrtile-leaf milkwort	Italy	Salento area (Apulia)	pauca	pauca	P	S	Symptoms, ELISA and PCR	Saponari et al., 2014
Polygonaceae	*Persicaria maculosa*	Lady's thumb	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Polygonaceae	*Persicaria maculosa*	Lady's thumb	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Polygonaceae	*Persicaria maculosa*	Lady's thumb	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Polygonaceae	*Polygonum convolvulis*	Black bindweed	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Polygonaceae	*Polygonum convolvulis*	Black bindweed	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Polygonaceae	*Polygonum convolvulis*	Black bindweed	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Polygonaceae	*Polygonum lapathifolium*	Pale persicaria	USA	Weedy alfalfa fields near USDA-ARS research centre in Parlier, CA	NA	NA	NA	S	ELISA	Krugner et al., 2012
Polygonaceae	*Polygonum arenastrum*	Common knotweed	USA	Weedy alfalfa fields near USDA-ARS research centre in Parlier, CA	NA	NA	NA	S	ELISA	Krugner et al.,2012
Polygonaceae	*Rheum rhaponticum*	Rhubarb	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Polygonaceae	*Rheum rhaponticum*	Rhubarb	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Polygonaceae	*Rheum rhaponticum*	Rhubarb	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Polygonaceae	*Rumex crispus*	Curly dock	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Polygonaceae	*Rumex crispus*	Curly dock	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951

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Polygonaceae	*Rumex crispus*	Curly dock	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Polygonaceae	*Rumex crispus*	Curly dock	USA	Weedy alfalfa fields near USDA-ARS research centre in Parlier, CA	NA	NA	NA	S	ELISA	Krugner et al., 2012
Polygonaceae	*Rumex crispus*	Curly dock	USA	San Joaquin Valley, CA	NA	fastidiosa	L	E	Vectors	Wistrom and Purcell, 2005
Portulaceae	*Montia linearis*	Narrowleaf miner's lettuce	USA	Napa County, CA	NA	fastidiosa	H	E	ELISA	Raju et al., 1980
Portulaceae	*Portulaca oleraceae*	Common purslane	Brazil	Boa Esperanca and San José farm	NA	pauca	P	S and E	PCR	Lopes et al., 2003
Portulaceae	*Portulaca oleraceae*	Common purslane	USA	Weedy alfalfa fields near USDA-ARS research centre in Parlier, CA	NA	NA	NA	S	ELISA	Krugner et al., 2012
Portulaceae	*Portulaca oleraceae*	Common purslane	USA	San Joaquin Valley, CA	NA	fastidiosa	L	E	Vectors	Wistrom and Purcell, 2005
Ranunculaceae	*Ranunculus repens*	Creeping buttercup	USA	Weedy alfalfa fields near USDA-ARS research centre in Parlier, CA	NA	NA	NA	S	ELISA	Krugner et al., 2012
Resedaceae	*Reseda odorata*	Common mignonetta	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Resedaceae	*Reseda odorata*	Common mignonetta	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Resedaceae	*Reseda odorata*	Common mignonetta	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Rhamnaceae	*Rhamnus californica*	Coffeeberry	USA	Napa Valley, CA	NA	fastidiosa	L	E	PCR and culturing assays	Purcell and Saunders, 1999b
Rosaceae	*Cotoneaster rotundifolia*	Cotoneastor	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Rosaceae	*Cotoneaster rotundifolia*	Cotoneastor	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Rosaceae	*Cotoneaster rotundifolia*	Cotoneastor	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Rosaceae	*Fragaria vesca* var. *californica*	California strawberry	USA	Napa County, CA	NA	fastidiosa	H	E	ELISA	Raju et al., 1983
Rosaceae	*Heteromeles arbutifolia*	Toyon or Christmas berry	USA	Temecula, CA	NA	NA	P	S	ELISA	Costa et al., 2004

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Rosaceae	*Photinia arbutifolia*	Toyon or Christmas berry	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Rosaceae	*Photinia arbutifolia*	Toyon or Christmas berry	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Rosaceae	*Photinia arbutifolia*	Toyon or Christmas berry	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Rosaceae	*Prunus* sp.	Almond	USA	Temecula, CA	NA	NA	P	S	ELISA, PCR, culture	Costa et al., 2004
Rosaceae	*Prunus* sp.	Plum tree	USA	NA	NA	fastidiosa	P	S?	PCR, culture	da Costa et al., 2000
Rosaceae	*Prunus* sp.	Plum tree	Brazil	Parana	NA	multiplex	P	S?	PCR, culture	da Costa et al., 2000
Rosaceae	*Prunus* sp.	Almond	USA	USDA-ARS research centre in Parlier, CA	multiplex	multiplex	P	E	PCR, culturing	Krugner et al., 2012
Rosaceae	*Prunus* sp.	Almond	USA	San Joaquin, CA	multiplex	multiplex	P	S	NA	Lopes et al., 2009
Rosaceae	*Prunus* sp.	Almond	USA	Butte, CA	multiplex	multiplex	P	S	NA	Lopes et al., 2009
Rosaceae	*Prunus* sp.	Almond	USA	Solano, CA	multiplex	multiplex	P	S	NA	Lopes et al., 2009
Rosaceae	*Prunus* sp.	Almond	USA	Glenn, CA	multiplex	multiplex	P	S	NA	Lopes et al., 2009
Rosaceae	*Prunus* sp.	Almond	Iran	Chahar Mahal-va-Bakhtiari (orchard)	NA	NA	NA	S	DAS-ELISA, PCR, culture	Amanifar et al., 2014
Rosaceae	*Prunus* sp.	Almond	Iran	West Azerbaijan (orchard)	NA	NA	NA	S	DAS-ELISA, PCR, culture	Amanifar et al., 2014
Rosaceae	*Prunus* sp.	Almond	Iran	Semnan provinces (orchard)	NA	NA	NA	S	DAS-ELISA, PCR, culture	Amanifar et al., 2014
Rosaceae	*Prunus* sp.	Plum	Brazil	Cajobi	NA	pauca	P	S and E	PCR	Lopes et al., 2003
Rosaceae	*Prunus* sp.	Plum	Brazil	Luis Antonio, SP	NA	pauca	P	S and E	PCR	Lopes et al., 2003.
Rosaceae	*Prunus* sp.	Decorative prunus	USA	Riverside Co., CA	multiplex	multiplex	P	NA	NA	Nunney et al., 2013.
Rosaceae	*Prunus* sp.	Decorative prunus	USA	Riverside Co., CA	multiplex	multiplex	P	NA	NA	Nunney et al., 2013.

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Rosaceae	*Prunus* sp.	Plum	USA	Napa Valley, CA	NA	fastidiosa	L	E	PCR and culturing assays	Purcell and Saunders, 1999b
Rosaceae	*Prunus* sp.	Hybrid plum	USA	GA	multiplex	multiplex	P	NA	NA	Nunney et al.,. 2013 supplementary data
Rosaceae	*Prunus* sp.	Peach (nemagard rootstock)	USA	Greenhouse, Temecula, CA	NA	fastidiosa	P	E	ELISA	Costa et al., 2004
Rosaceae	*Prunus* sp.	Almond	USA	Fresno County, CA	NA	fastidiosa	P	S	Symptoms, array-PCR, culturing	Livingston et al., 2010
Rosaceae	*Prunus* sp.	Plum	USA	GA	multiplex	multiplex	P	NA	NA	Schuenzel et al., 2005
Rosaceae	*Prunus americana*	Plum (native)	USA	Greenhouse, Temecula, CA	NA	fastidiosa	P	E	ELISA	Costa et al., 2004
Rosaceae	*Prunus amygdalus*	Almond	USA	Fresno	NA	fastidiosa	P	NA	NA	Almeida and Purcell, 2003
Rosaceae	*Prunus amygdalus*	Almond	USA	Stanislaus	NA	fastidiosa	P	NA	NA	,Almeida and Purcell, 2003
Rosaceae	*Prunus amygdalus*	Almond	USA	Tulare	NA	fastidiosa	P	NA	NA	Almeida and Purcell, 2003
Rosaceae	*Prunus amygdalus*	Almond	USA	San Joaquin	NA	multiplex	P	NA	NA	Almeida and Purcell, 2003
Rosaceae	*Prunus amygdalus*	Almond	USA	Butte	NA	multiplex	P	NA	NA	Almeida and Purcell, 2003
Rosaceae	*Prunus amygdalus*	Almond	USA	Solano	NA	multiplex	P	NA	NA	Almeida and Purcell, 2003
Rosaceae	*Prunus amygdalus*	Almond	USA	Glenn	NA	multiplex	P	NA	NA	Almeida and Purcell, 2003
Rosaceae	*Prunus amygdalus*	Almond	USA	Contra Costa	NA	multiplex	P	NA	NA	Almeida and Purcell, 2003
Rosaceae	*Prunus amygdalus*	Almond	India	Almond Experimental Orchards of the University of Horticulture and Forestry, Solan	NA	NA	NA	S	Peach chemical test (Mircetich et al.,. 1976), symptoms	Jindal and Sharma, 1987
Rosaceae	*Prunus amygdalus*	Almond	USA	Georgia, Manassas (VA)	NA	multiplex	H	E?	SEM, culturing	Marques et al., 2002
Rosaceae	*Prunus amygdalus*	Almond	Brazil	Georgia	NA	multiplex	H	E?	SEM, culturing	Marques et al., 2002

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Rosaceae	*Prunus amygdalus*	Almond	USA	Tulare (Southern CA)	fastidiosa	fastidiosa	P	NA	NA	Schuenzel et al., 2005
Rosaceae	*Prunus amygdalus*	Almond	USA	Solano (Northern CA)	multiplex	multiplex	P	NA	NA	Schuenzel et al., 2005
Rosaceae	*Prunus amygdalus*	Almond	USA	San Joaquin (Northern CA)	multiplex	multiplex	P	NA	NA	Schuenzel et al., 2005
Rosaceae	*Prunus amygdalus*	Almond	USA	Temecula (Southern CA)	multiplex	multiplex	P	NA	NA	Schuenzel et al., 2005
Rosaceae	*Prunus amygdalus*	Almond	USA	NA	NA	NA	H	?	Primary isolations obtained from contributors	Wells et al., 1987
Rosaceae	*Prunus amygdalus*	Almond	USA	US Davis campus	NA	fastidiosa	H	NA	NA	Chatelet et al., 2011
Rosaceae	*Prunus amygdalus*	Almond	Turkey	Sanliurfa (southern Turkey)	NA	NA	NA	S	DAS-ELISA, microscopy	Guldur et al., 2005
Rosaceae	*Prunus amygdalus*	Almond	USA	CA	NA	NA	NA	NA	NA	Montero-Astúa et al., 2007
Rosaceae	*Prunus amygdalus*	Almond	USA	CA	NA	NA	H	S	PCR, cultures	Rodrigues et al., 2003
Rosaceae	*Prunus amygdalus*	Almond	USA	CA	NA	NA	H	S	Electron microscopy	Mircetich et al., 1976
Rosaceae	*Prunus angustifolia*	Wild plum	USA	GA	NA	multiplex?	H	S	Immunofluorescent reaction IMF, microscopy	Wells et al., 1980
Rosaceae	*Prunus angustifolia*	Florida sand plum	USA	Fort Valley, GA	NA	multiplex	H	E	Symptom observations	Hutchins and Rue, 1949
Rosaceae	*Prunus armeniaca*	Apricot	USA	Riverside Co., CA	multiplex	multiplex	P	NA	NA	Nunney et al., 2013
Rosaceae	*Prunus armeniaca*	Siberian apricot	USA	Fort Valley, GA	NA	multiplex	H	E	Symptom observations	Hutchins and Rue, 1949
Rosaceae	*Prunus avium*	Mazzard cherry	USA	GA	NA	multiplex?	H	S	Immunofluorescent reaction IMF, microscopy	Wells et al., 1980
Rosaceae	*Prunus avium*	Cherry	USA	CA	fastidiosa	fastidiosa	P	NA	NA	Nunney et al., 2013
Rosaceae	*Prunus avium*	Cherry	USA	San Bernardino Co., CA	fastidiosa	fastidiosa	P	NA	NA	Yuan et al., 2010
Rosaceae	*Prunus avium*	Cherry	Italy	Salento area (Apulia)	pauca	pauca	P	S	Symptoms, ELISA and PCR	Saponari et al., 2014
Rosaceae	*Prunus cerasifera*	Purple leaf plum	USA	CA	multiplex	multiplex	P	NA	NA	Nunney et al., 2013

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Rosaceae	*Prunus cerasifera*	Purple leaf plum	USA	Riverside Co., CA	multiplex	multiplex	P	NA	NA	Nunney et al., 2013.
Rosaceae	*Prunus cerasifera*	Cherry plum	USA	Riverside Co., CA	multiplex	multiplex	P	NA	NA	Nunney et al., 2010
Rosaceae	*Prunus cerasifera*	Purple leaf plum	USA	Riverside Co., CA	multiplex	multiplex	P	NA	NA	Nunney et al.,. 2013 supplementary data
Rosaceae	*Prunus cerasifera*	Myra plum	USA	GA	NA	multiplex?	H	S	Immunofluorescent reaction IMF, microscopy	Wells et al., 1980
Rosaceae	*Prunus cerasifera*	Plum	USA	Riverside Co., CA	multiplex	multiplex	P	NA	NA	Yuan et al., 2010
Rosaceae	*Prunus cerasifera*	Purple-leafed plum	USA	CA (Riverside and Redlands areas)	multiplex	multiplex	P	S	Symptoms, ELISA, PCR	Wong et al., 2004
Rosaceae	*Prunus cerasifera* "Myrobalan"	Plum	USA	FL	NA	NA	NA	E	Direct immunofluorescence, ELISA, cultures, electron microscopy, re-isolation	Timmer et al., 1983
Rosaceae	*Prunus cerasus* "Montmorency"	Montmorency cherry	USA	GA	NA	multiplex?	H	S	Immunofluorescent reaction IMF, microscopy	Wells et al., 1980
Rosaceae	*Prunus cerasus* "Shirofugen"	Shirofugen cherry	USA	GA	NA	multiplex?	H	S	Immunofluorescent reaction IMF, microscopy	Wells et al., 1980
Rosaceae	*Prunus davidiana*		USA	GA	NA	multiplex?	H	S	Immunofluorescent reaction IMF, microscopy	Wells et al., 1980
Rosaceae	*Prunus domestica*	Plum	USA	GA	multiplex	multiplex	P	NA	NA	Nunney et al.,. 2013 Supplementary data
Rosaceae	*Prunus domestica*	Plum	USA	GA	multiplex	multiplex	P	NA	NA	Nunney et al.,. 2013 Supplementary data
Rosaceae	*Prunus domestica*	Domestic plum	USA	GA	NA	multiplex?	H	S	Immunofluorescent reaction IMF, microscopy	Wells et al., 1980

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Rosaceae	*Prunus domestica*	Plum	Paraguay	Centro Regional de Investigacion Agricola, Capitán, Miranda, Itapúa, Paraguay	NA	multiplex?	H	S	Phase contrast microscopy in unstained wet mounts, electron microscopy	French and Kitajima, 1978
Rosaceae	*Prunus domestica*	Plum	USA	Riverside Co., CA	multiplex	multiplex	P	NA	NA	Nunney et al., 2013
Rosaceae	*Prunus domestica*	Plum	Brazil	Unidade de Execucao de Pesquisa de Ambito Estadual de Cascata, Rio Grande do Sul, Brasil	NA	multiplex	H	S	Phase contrast microscopy in unstained wet mounts, electron microscopy,	French. and Kitajima, 1978
Rosaceae	*Prunus dulcis*	Almond (Butte)	USA	Greenhouse, Temecula, CA	NA	fastidiosa	P	E	ELISA, PCR, culture	Costa et al., 2004
Rosaceae	*Prunus dulcis*	Almond	USA	Weedy alfalfa fields near USDA-ARS research centre in Parlier, CA	NA	NA	NA	S	ELISA	Krugner et al., 2012
Rosaceae	*Prunus dulcis*	Almond	USA	CA	NA	NA	H	E?	SEM, culturing	Marques et al., 2002
Rosaceae	*Prunus dulcis*	Almond	USA	CA	fastidiosa	fastidiosa	P	NA	NA	Nunney et al., 2013
Rosaceae	*Prunus dulcis*	Almond	USA	Kern Co., CA	multiplex	multiplex	P	NA	NA	Nunney et al., 2013
Rosaceae	*Prunus dulcis*	Almond	North America	NA	fastidiosa	fastidiosa	P	NA	NA	Nunney et al., 2010
Rosaceae	*Prunus dulcis*	Almond	North America	NA	multiplex	multiplex	P	NA	NA	Nunney et al., 2010
Rosaceae	*Prunus dulcis*	Almond	USA	Kern Co., CA	multiplex	multiplex	P	NA	NA	Nunney et al.,. 2013 supplementary data
Rosaceae	*Prunus dulcis*	Almond	USA	San Joaquin Co., CA	multiplex	multiplex	P	NA	NA	Nunney et al., 2013 supplementary data
Rosaceae	*Prunus dulcis*	Almond	USA	Solano Co., CA	multiplex	multiplex	P	NA	NA	Nunney et al.,. 2013 supplementary data

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Rosaceae	*Prunus dulcis*	Almond	USA	Riverside Co., CA	multiplex	multiplex	P	NA	NA	Nunney et al., 2013 supplementary data
Rosaceae	*Prunus dulcis*	Almond	USA	San Bernardino Co., CA	fastidiosa	fastidiosa	P	NA	NA	Yuan et al., 2010
Rosaceae	*Prunus dulcis*	Almond	USA	San Joaquin Co., CA	fastidiosa	fastidiosa	P	NA	NA	Yuan et al., 2010
Rosaceae	*Prunus dulcis*	Almond	USA	Stanislaus Co., CA	fastidiosa	fastidiosa	P	NA	NA	Yuan et al., 2010
Rosaceae	*Prunus dulcis*	Almond	USA	Fresno Co., CA	fastidiosa	fastidiosa	P	NA	NA	Yuan et al., 2010
Rosaceae	*Prunus dulcis*	Almond	USA	Kern Co., CA	fastidiosa	fastidiosa	P	NA	NA	Yuan et al., 2010
Rosaceae	*Prunus dulcis*	Almond	USA	CA (Riverside and Redlands areas)	NA	fastidiosa	P	S	Symptoms, ELISA, PCR, culturing	Wong et al., 2004
Rosaceae	*Prunus dulcis*	Almond	USA	CA (Riverside and Redlands areas)	NA	multiplex	P	S	Symptoms, ELISA, PCR, culturing	Wong et al., 2004
Rosaceae	*Prunus dulcis*	Almond	USA	California's central valley almond orchards in: Butte, Glenn, Stanislaus,= and Kern counties	NA	multiplex	P	S	Immunocapture DNA separation and PCR	Shapland et al., 2006
Rosaceae	*Prunus dulcis*	Almond	USA	Tulare Co., CA	fastidiosa	fastidiosa	P	NA	NA	Yuan et al., 2010
Rosaceae	*Prunus dulcis*	Almond	USA	Riverside Co., CA	fastidiosa	fastidiosa	P	NA	NA	Yuan et al., 2010
Rosaceae	*Prunus dulcis*	Almond	USA	CA	fastidiosa	fastidiosa	P	NA	NA	Yuan et al., 2010
Rosaceae	*Prunus dulcis*	Almond	USA	Solano Co., CA	multiplex	multiplex	P	NA	NA	Yuan et al., 2010
Rosaceae	*Prunus dulcis*	Almond	USA	Kern Co., CA	multiplex	multiplex	P	NA	NA	Yuan et al., 2010
Rosaceae	*Prunus dulcis* var. Sonora-Hansen	Almond	USA	CA	fastidiosa	fastidiosa	P	E	Cultures	Lopes et al., 2009
Rosaceae	*Prunus dulcis* var. Sonora-Hansen	Almond	USA	CA	multiplex	multiplex	P	E	Cultures	Lopes et al., 2009
Rosaceae	*Prunus dulcis* "Peerless"	Almond	USA	San Joaquin Valley Agricultural Centre (USDA, Parlier, CA)	NA	fastidiosa	L	E	PCR, culturing	Wistrom et al., 2010

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Rosaceae	*Prunus hortulana*	Hortulan plum	USA	Fort Valley, GA	NA	multiplex	H	E	Symptom observations	Hutchins and Rue, 1949
Rosaceae	*Prunus mahaleb*	Mahaleb cherry	USA	GA	NA	multiplex?	H	S	Immunofluorescent reaction IMF, microscopy	Wells et al., 1980
Rosaceae	*Prunus mexicana*	Mexican plum	USA	Fort Valley, GA	NA	multiplex	H	E	Symptom observations	Hutchins and Rue, 1949
Rosaceae	*Prunus mume*	Japanese apricot	USA	Fort Valley, GA	NA	multiplex	H	E	Symptom observations	Hutchins and Rue, 1949
Rosaceae	*Prunus persica*	Peach	USA	Greenhouse in Davis and various localities in CA	NA	NA	NA	S	Peach roots, tissue observations(gummed areas in xylem)	Esau, 1948
Rosaceae	*Prunus persica*	Peach	USA	Orange Co., CA	multiplex	multiplex	P	NA	NA	Nunney et al., 2013
Rosaceae	*Prunus persica*	Peach	USA	Riverside Co.., CA	multiplex	multiplex	P	NA	NA	Nunney et al., 2013
Rosaceae	*Prunus persica*	Peach ("Maygold" and "Junegold")	USA	Leesburg, FL	NA	multiplex	H	S	electron microscopy	Hopkins et al., 1973
Rosaceae	*Prunus persica*	Peach	USA	Leesburg, FL	NA	multiplex	H	S	Electron microscopy	Hopkins et al.,1973
Rosaceae	*Prunus persica*	Peach	USA	Fort Valley, GA	NA	multiplex	H	E	Symptom observations	Hutchins et al., 1953
Rosaceae	*Prunus persica*	Peach	?	NA	NA	multiplex	H	E	Not mentioned	Hutchins, 1939
Rosaceae	*Prunus persica*	Peach	USA	GA	fastidiosa	fastidiosa	P	NA	NA	Nunney et al., 2010
Rosaceae	*Prunus persica*	Peach	North America	NA	multiplex	multiplex	P	NA	NA	Nunney et al., 2010
Rosaceae	*Prunus persica*	Peach	USA	South-eastern Fruit and Tree Nut Research Station, Bron, GA	NA	multiplex?	H	S	Electron microscopy	Nyland et al., 1973
Rosaceae	*Prunus persica*	Peach	USA	Chattanooga, Fort Valley, GA	NA	multiplex	H	S and E	Symptoms	Turner, 1949
Rosaceae	*Prunus persica*	Peach	USA	NA	NA	multiplex	H	E	Not described	Turner and Pollard, 1955
Rosaceae	*Prunus persica*	Peach	USA	NA	NA	multiplex	H	NA	Primary isolations obtained from contributors	Wells et al., 1987

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Rosaceae	*Prunus persica*	Peach	USA	Houston County, GA	NA	multiplex?	H	S	Immunofluorescent reaction IMF, microscopy	Wells et al., 1980
Rosaceae	*Prunus persica*	Peach	USA	GA	multiplex	multiplex	P	NA	NA	Schuenzel et al., 2005
Rosaceae	*Prunus persica*	Peach	USA	GA	multiplex	multiplex	P	NA	NA	Nunney et al.,. 2013 supplementary data
Rosaceae	*Prunus persica*	Peach	USA	FL	multiplex	multiplex	P	NA	NA	Nunney et al.,. 2013 supplementary data
Rosaceae	*Prunus persica*	Peach	USA	CA	NA	multiplex	H	E and S	ELISA, microscope	Wells et al., 1981
Rosaceae	*Prunus persica*	Peach	USA	Peach County, GA	NA	multiplex?	H	S	Immunofluorescent reaction IMF, microscopy	Wells et al., 1980
Rosaceae	*Prunus persica*	Peach	USA	CA (Riverside and Redlands areas)	fastidiosa	fastidiosa	P	S	Symptoms, ELISA, PCR, direct culturing	Wong's report: http://celosangeles.ucanr.edu/newsletters/Fall_200534798.pdf; Wong et al., 2004
Rosaceae	*Prunus persica*	Peach	USA	GA	multiplex	multiplex	P	NA	NA	Yuan et al., 2010
Rosaceae	*Prunus persica*	Peach	USA	Leesburg, FL (wild plant species within 50 miles of the Central Florida Research and Education Centre)	NA	fastidiosa	H	E	ELISA, fluorescence microscopy	Hopkins and Adlerz, 1988
Rosaceae	*Prunus salicina*	Plum	USA	GA	NA	NA	NA	NA	NA	Montero-Astúa et al., 2007
Rosaceae	*Prunus salicina*	Japanese plum	Brazil	Unidade de Execucao de Pesquisa de Ambito Estadual de Cascata, Rio Grande do Sul, Brasil	NA	multiplex	H	S	Phase contrast microscopy in unstained wet mounts, electron microscopy	French and Kitajima, 1978

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Rosaceae	*Prunus salicina*	Japanese plum	Paraguay	Centro Regional de Investigacion Agricola, Capitán, Miranda, Itapúa, Paraguay	NA	multiplex?	H	S	Phase contrast microscopy in unstained wet mounts, electron microscopy	French and Kitajima, 1978
Rosaceae	*Prunus salicina*	Japanese plum	Argentina	Delta of the Parana River	NA	multiplex	H	E	Electron microscopy	Kitajima et al., 1975
Rosaceae	*Prunus salicina*	Plum	Brazil	Parana	NA	multiplex	H	S	PCR, cultures	Rodrigues et al., 2003
Rosaceae	*Prunus saliciana*	Japanese plum	USA	NA	NA	multiplex	H	?	Primary isolations obtained from contributors	Wells et al., 1987
Rosaceae	*Prunus salicina*	Plum	USA	GA	NA	multiplex	H	S	PCR, cultures	Rodrigues et al., 2003
Rosaceae	*Prunus salicina*	Japanese plum	USA	CA	NA	multiplex	L	E and S	ELISA, microscope	Wells et al.,1981
Rosaceae	*Prunus serotina*	Wild black cherry	USA	GA	NA	multiplex?	H	S	Immunofluorescent reaction IMF, microscopy	Wells et al., 1980
Rosaceae	*Prunus* interspecific *Prunus* hybrid: *P. simonii* × *P. solicina* × *P. cerasifera* × *P. munsoniana*)	Shiro plum	USA	GA	NA	multiplex?	H	S	Immunofluorescent reaction IMF, microscopy	Wells et al., 1980
Rosaceae	*Pyrus pyrifolia*	Asian pear	Taiwan	Taichung, Chiayi and Lisan areas	NA	NA	NA	S	Electron microscopy(TEM), culturing	Leu and Su, 1993
Rosaceae	*Rosa californica*	California wild Rose	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Rosaceae	*Rosa californica*	California wild Rose	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Rosaceae	*Rosa californica*	California wild Rose	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Rosaceae	*Rosa californica*	California wild rose	USA	Napa Valley, CA	NA	fastidiosa	L	E	PCR and culturing assays	Purcell and Saunders, 1999a

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Rosaceae	*Rubus* sp.	NA	USA	Leesburg, FL (wild plant species within 50 miles of the Central Florida Research and Education Centre)	NA	fastidiosa	H	E	ELISA, fluorescence microscopy	Hopkins and Adlerz, 1988
Rosaceae	*Rubus* sp.	Blackberry	USA	NC	multiplex	multiplex	P	E	NA	Nunney et al., 2014
Rosaceae	*Rubus* sp.	Blackberry	USA	FL	multiplex	multiplex	P	E	NA	Nunney et al., 2014
Rosaceae	*Rubus discolor*	Himalayan blackberry	USA	Hopland (Mendocino County), CA	NA	fastidiosa	L	E	Real-time PCR, culturing	Baumgartner and Warren, 2005
Rosaceae	*Rubus discolor*	Himalayan blackberry	USA	Oakville (Napa County), CA	NA	fastidiosa	L	E	Real-time PCR, culturing	Baumgartner and Warren, 2005
Rosaceae	*Rubus discolor*	Himalayan blackberry	USA	CA	NA	fastidiosa	H	E	ELISA, culturing	Hill and Purcell, 1997
Rosaceae	*Rubus discolor*	Himalayan Blackberry	USA	CA	NA	fastidiosa	H	E	ELISA	Hill and Purcell, 1995
Rosaceae	*Rubus procerus*	Himalayan giant blackberry	USA	Napa County, CA	NA	fastidiosa	H	E	ELISA	Raju et al., 1983
Rosaceae	*Rubus trivialis*	Southern dewberry	USA	American hybrid vineyard in the Texas Gulf Coast (Austin County Vineyards, a 4.5-acre vineyard located in Cat Spring, TX, 70 miles west of Houston)	NA	NA	NA	S	ELISA, PCR	Buzombo et al., 2006
Rosaceae	*Rubus ursinus*	California blackberry	USA	Oakville (Napa County), CA	NA	fastidiosa	L	E	Real-time PCR, culturing	Baumgartner and Warren, 2005
Rosaceae	*Rubus ursinus*	California blackberry	USA	Hopland (Mendocino County), CA	NA	fastidiosa	L	E	Real-time PCR, culturing	Baumgartner and Warren, 2005
Rosaceae	*Rubus ursinus*	California blackberry	USA	Oakville (Napa County), CA	NA	fastidiosa	L	E	Real-time PCR, culturing	Baumgartner and Warren, 2005

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Rosaceae	*Rubus ursinus*	California blackberry	USA	Napa Valley, CA	NA	fastidiosa	L	E	PCR and culturing assays	Purcell and Saunders, 1999b
Rosaceae	*Rubus vitifolius*	California blackberry	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Rosaceae	*Rubus vitifolius*	California blackberry	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Rosaceae	*Rubus vitifolius*	California blackberry	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Rubiaceae	*Coffea* sp.	Coffee	Brazil	Many locations	NA	pauca	P	NA	NA	Almeida et al., 2007
Rubiaceae	*Coffea* sp.	Coffee	Brazil	Garca, SP	NA	pauca	P	NA	Cultures	Almeida et al., 2008
Rubiaceae	*Coffea* sp.	Coffee	Brazil	Lavras, MG	NA	pauca	P	NA	Cultures	Almeida et al., 2008
Rubiaceae	*Coffea* sp.	Coffee	Brazil	Ribeirao Preto, SP	NA	pauca	P	NA	Cultures	Almeidaet al., 2008.
Rubiaceae	*Coffea* sp.	Coffee	Brazil	Matao, SP	NA	pauca	P	NA	Cultures	Almeida et al., 2008
Rubiaceae	*Coffea* sp.	Coffee	Brazil	Cravinhos, SP	NA	pauca	P	NA	Cultures	Almeida et al., 2008
Rubiaceae	*Coffea* sp.	Coffee	Brazil	Planaltina, DF	NA	pauca	P	NA	Cultures	Almeida et al., 2008
Rubiaceae	*Coffea* sp.	Coffee	Brazil	Sao Gotardo, DF	NA	pauca	P	NA	Cultures	Almeida et al., 2008
Rubiaceae	*Coffea* sp.	Coffee	Brazil	Muritinga Sul, SP	NA	pauca	P	NA	Cultures	Almeida et al., 2008
Rubiaceae	*Coffea* sp.	Coffee	Brazil	Pedregulho, SP	NA	pauca	P	NA	Cultures	Almeida et al., 2008
Rubiaceae	*Coffea* sp.	Coffee	Brazil	Varginha, MG	NA	pauca	P	NA	Cultures	Almeida et al., 2008
Rubiaceae	*Coffea* sp.	Coffee	Brazil	São Paulo	NA	pauca	P	S?	PCR, culture	Beretta et al., 1996
Rubiaceae	*Coffea* sp.	Coffee	Brazil	São Paulo	NA	NA	NA	NA	NA	Montero-Astúa et al., 2007
Rubiaceae	*Coffea* sp.	Coffee	Brazil	Casa Branca	NA	NA	NA	NA	NA	Montero-Astúa et al., 2007
Rubiaceae	*Coffea* sp.	Coffee	Costa Rica	Not mentioned	NA	fastidiosa	P	NA	NA	Nunney et al., 2010
Rubiaceae	*Coffea* sp.	Coffee	South America	NA	pauca	pauca	P	NA	NA	Nunney et al., 2010

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Rubiaceae	*Coffea* sp.	Coffee	Brazil	São Paulo	pauca	pauca	P	E	NA	Nunney et al., 2012a
Rubiaceae	*Coffea* sp.	Coffee	Costa Rica	Desamparados (South region of San José)	NA	NA	L	S	DAS-ELISA	Villalobos et al., 2006
Rubiaceae	*Coffea* sp.	Coffee	Brazil	São Paulo	pauca	pauca	P	NA	NA	Yuan et al., 2010
Rubiaceae	*Coffea* sp.	Coffee	Costa Rica	NA	NA	NA	NA	NA	Culturing	Montero-Astúa et al., 2008c
Rubiaceae	*Coffea* sp.	Coffee	Costa Rica	Central Valley	NA	fastidiosa	P	S	DAS-ELISA (symptomatic and non-symptomatic plants), PCR, RFLP analysis	Montero-Astúa et al., 2008c
Rubiaceae	*Coffea* sp.	Coffee	Costa Rica	Central Valley	NA	NA	NA	S	ELISA, TEM, cultures, PCR, symptoms	Montero-Astúa et al., 2008c
Rubiaceae	*Coffea arabica* cv. Catuai vermelho/clone 99	Coffee	Brazil	Greenhouse at ESALQ, University of São Paulo, Piracicaba	NA	pauca	P	E	Culturing methods	Almeida et al., 2008
Rubiaceae	*Coffea arabica* cv. Mundo Novo	Coffee	Brazil	NA	NA	pauca	L	S	Immunobinding and Western blotting, culturing, PCR, symptoms	Beretta et al., 1996
Rubiaceae	*Coffea arabica*	Coffee	Brazil	Casa Branca, SP	NA	pauca	P/H/L	E	Light microscopy, SEM, dot immunobinding assays, ELISA, PCR	deLima et al., 1998
Rubiaceae	*Coffea arabica* "Mundo Novo"	Coffee	Brazil	Matao, SP	NA	pauca	P	E	ELISA, PCR, microscopy	Li et al., 2001
Rubiaceae	*Coffea arabica*	Coffee	Brazil	Cajobi	NA	pauca	P	S and E	PCR	Lopes et al., 2003
Rubiaceae	*Coffea arabica*	Coffee	Brazil	Luis Antonio, SP	NA	pauca	P	S and E	PCR	Lopes et al., 2003
Rubiaceae	*Coffea arabica*	Coffee	Brazil	São Paulo	NA	pauca	H	E?	SEM, culturing	Marques et al., 2002
Rubiaceae	*Coffea arabica*	Coffee	Costa Rica	Curridabat, San José Province, CR	fastidiosa	fastidiosa	P	NA	NA	Nunney et al., 2010
Rubiaceae	*Coffea arabica*	Coffee	Costa Rica	Orosi, Cartago Province, CR	fastidiosa	fastidiosa	P	NA	NA	Nunney et al., 2010
Rubiaceae	*Coffea arabica*	Coffee	Costa Rica	Grecia, Alajuela Province, CR	fastidiosa	fastidiosa	P	NA	NA	Nunney et al., 2010

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Rubiaceae	*Coffea arabica*	Coffee	Costa Rica	Santo Domingo, Heredia, CR	fastidiosa	fastidiosa	P	NA	NA	Nunney et al., 2010
Rubiaceae	*Coffea arabica*	Coffee	Brazil	São Paulo	NA	pauca	H	S	PCR, cultures	Rodrigues et al., 2003
Rubiaceae	*Coffea arabica*	Coffee	Costa Rica	Desamparados	NA	NA	NA	NA	NA	Montero-Astúa et al., 2007
Rubiaceae	*Coffea arabica*	Coffee	Costa Rica	Grecia	NA	NA	NA	NA	NA	Montero-Astúa et al., 2007
Rubiaceae	*Coffea arabica*	Coffee	Costa Rica	Curridabat	NA	NA	NA	NA	NA	Montero-Astúa et al., 2007
Rubiaceae	*Coffea arabica*	Coffee	Costa Rica	Orosi	NA	NA	NA	NA	NA	Montero-Astúa et al., 2007
Rubiaceae	*Coffea arabica*	Coffee	Costa Rica	Desamparados, San José Province, CR	fastidiosa	fastidiosa	P	NA	NA	Nunney et al., 2010
Rubiaceae	*Coffea arabica* cv. Catuai vermelho/clone 99	Coffee	Brazil	São Paulo	NA	pauca	H	E	Culturing	Prado et al., 2008
Rubiaceae	*Coffea canephora* var. *robusta* "Apuatao 2258"	Coffee	Brazil	NA	NA	pauca	P	E	ELISA, PCR, microscopy	Li et al., 2001
Rubiaceae	*Coprosma baueri*	Coastal coprosoma	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Rubiaceae	*Coprosma baueri*	Coastal coprosoma	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Rubiaceae	*Coprosma baueri*	Coastal coprosoma	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Rubiaceae	*Coprosma repens*	Mirror plant	USA	Greenhouse, Temecula, CA	NA	fastidiosa	P	E	ELISA, PCR	Costa et al., 2004
Rubiaceae	*Richardia brasiliensis*	Poaia branca	Brazil	Boa Esperanca	NA	pauca	P	S and E	PCR	Lopes et al., 2003
Rubiaceae	*Spermacoce latifolia*	Erva-quente	Brazil	Boa Esperanca and San José farm	NA	pauca	P	S and E	PCR	Lopes et al., 2003
Rutaceae	*Citrus* sp.	Citrus	Brazil	Many locations	NA	pauca	P	NA	NA	Almeida et al., 2007
Rutaceae	*Citrus* sp.	Citrus	Brazil	Pedregulho, SP	NA	pauca	P	NA	Cultures	Almeida et al., 2008
Rutaceae	*Citrus* sp.	Citrus	Brazil	Araras, SP	NA	pauca	P	NA	Cultures	Almeida et al., 2008
Rutaceae	*Citrus* sp.	Citrus	Brazil	Com. Gomes, SP	NA	pauca	P	NA	Cultures	Almeida et al., 2008

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Rutaceae	*Citrus* sp.	Citrus	Brazil	Matao, SP	NA	pauca	P	NA	Cultures	Almeida et al., 2008
Rutaceae	*Citrus* sp.	Citrus	Brazil	Taquaritinga, SP	NA	pauca	P	NA	Cultures	Almeida et al., 2008
Rutaceae	*Citrus* sp.	Citrus	Brazil	Ubirajara, SP	NA	pauca	P	NA	Cultures	Almeida et al., 2008
Rutaceae	*Citrus* sp.	Citrus	Brazil	Gaviao Peixoto, SP	NA	pauca	P	NA	Cultures	Almeida et al., 2008
Rutaceae	*Citrus* sp.	Citrus	Brazil	Frutal, SP	NA	pauca	P	NA	Cultures	Almeida et al., 2008
Rutaceae	*Citrus* sp.	Citrus	Brazil	Rio Real, BA	NA	pauca	P	NA	Cultures	Almeida et al., 2008
Rutaceae	*Citrus* sp.	Citrus	Brazil	Itapirucu, BA	NA	pauca	P	NA	Cultures	Almeida et al., 2008
Rutaceae	*Citrus* sp.	Citrus	Brazil	Botucatu, SP	NA	pauca	P	NA	Cultures	Almeida et al., 2008
Rutaceae	*Citrus* sp.	Citrus	Brazil	Itaju, SP	NA	pauca	P	NA	Cultures	Almeida et al., 2008
Rutaceae	*Citrus* sp.	Citrus	Brazil	Neves Paulista, SP	NA	pauca	P	NA	Cultures	Almeida et al., 2008
Rutaceae	*Citrus* sp.	Citrus	Brazil	Sao Carlos, SP	NA	pauca	P	NA	Cultures	Almeida et al., 2008
Rutaceae	*Citrus* sp.	Citrus	Brazil	Cafelandia, SP	NA	pauca	P	NA	Cultures	Almeida et al., 2008
Rutaceae	*Citrus* sp.	Citrus	Brazil	Macaubal, SP	NA	pauca	P	NA	Cultures	Almeida et al., 2008
Rutaceae	*Citrus* spp.	Citrus	USA	Temecula, CA	NA	NA	P	S	ELISA	Costa et al., 2004
Rutaceae	*Citrus* sp.	Citrus	Brazil	São Paulo	NA	pauca	P	S?	PCR, culture	da Costa et al., 2000
Rutaceae	*Citrus* sp.	Citrus	Brazil	NA	NA	pauca	H	E?	SEM, culturing	Marques et al., 2002
Rutaceae	*Citrus* sp.	Citrus	USA	NA	NA	NA	NA	NA	Culturing	Montero-Astúa et al., 2006
Rutaceae	*Citrus* sp.	Citrus	Costa Rica	NA	NA	NA	NA	NA	Culturing	Montero-Astúa et al., 2006.
Rutaceae	*Citrus* sp.	Citrus	Brazil	São Paulo	multiplex	multiplex	P	NA	NA	Schuenzel et al., 2005
Rutaceae	*Citrus* sp.	Citrus	South America	NA	pauca	pauca	P	NA	NA	Nunney et al., 2010
Rutaceae	*Citrus* sp.	Citrus	Brazil	São Paulo	pauca	pauca	P	E	NA	Nunney et al., 2012

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Rutaceae	*Citrus benghalensis*	NA	Brazil	Boa Esperanca and San José farm	NA	pauca	P	S and E	PCR	Lopes et al., 2003
Rutaceae	*Citrus echinatus*	NA	Brazil	Boa Esperanca and San José farm	NA	pauca	P	S and E	PCR	Lopes et al., 2003
Rutaceae	*Citrus grandis* "Periforme pummelo"		Brazil	NA	NA	pauca	H	NA	Symptoms, serological DIBA, immunoblotting with specific antiserum for CVC, PCR	Laranjeira et al., 1998
Rutaceae	*Citrus limon*	Lemon (frost eureka)	USA	Greenhouse, Temecula, CA	NA	fastidiosa	P	E	ELISA	Costa et al., 2004
Rutaceae	*Citrus limon* "Camargo"	Lemon	Brazil	NA	NA	pauca	H	NA	Symptoms, serological DIBA, Immunoblotting with specific antiserum for CVC, PCR	Laranjeira et al., 1998
Rutaceae	*Citrus limon* "Sanguino"	Lemon	Brazil	NA	NA	pauca	H	NA	Symptoms, serological DIBA, Immunoblotting with specific antiserum for CVC, PCR	Laranjeira et al., 1998
Rutaceae	*Citrus limon* "Amber"	Lemon	Brazil	NA	NA	pauca	H	NA	Symptoms, serological DIBA, Immunoblotting with specific antiserum for CVC, PCR	Laranjeira et al., 1998
Rutaceae	*Citrus medica* "Comprida citron"		Brazil	NA	NA	pauca	H	NA	Symptoms, serological DIBA, Immunoblotting with specific antiserum for CVC, PCR	Laranjeira et al., 1998
Rutaceae	*Citrus paradisi*	Pomelo	Brazil	NA	NA	pauca	H	NA	Symptoms, serological DIBA, Immunoblotting with specific antiserum for CVC, PCR	Laranjeira et al., 1998
Rutaceae	*Citrus sinensis*	Citrus	Brazil	Greenhouse at ESALQ, University of São Paulo, Piracicaba	NA	pauca	P	E	Culturing methods	Almeida et al., 2008
Rutaceae	*Citrus sinensis* var. Pera	Sweet orange	Brazil	Alfenas, MG	NA	pauca	H	S	Electron microscopy, symptoms	Chagas et al., 1992

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Rutaceae	*Citrus sinensis* var. Pera	Sweet orange	Brazil	Prata, MG	NA	pauca	H	S	Electron microscopy, symptoms	Chagas et al., 1992
Rutaceae	*Citrus sinensis* var. Pera	Sweet orange	Brazil	Colina, SP	NA	pauca	H	S	Electron microscopy, symptoms	Chagas et al., 1992
Rutaceae	*Citrus sinensis* var. Pera	Sweet orange	Brazil	Catigua, SP	NA	pauca	H	S	Electron microscopy, symptoms	Chagas et al., 1992
Rutaceae	*Citrus sinensis* var. Natal	Sweet orange	Brazil	Alfenas, MG	NA	pauca	H	S	Electron microscopy, symptoms	Chagas et al., 1992
Rutaceae	*Citrus sinensis* var. Valencia	Sweet orange	Brazil	Conchal, SP	NA	pauca	H	S	Electron microscopy, symptoms	Chagas et al., 1992
Rutaceae	*Citrus sinensis* var. Pera	Sweet orange	Brazil	São Paulo City	NA	pauca	H	S	Electron microscopy, symptoms	Chagas et al., 1992
Rutaceae	*Citrus sinensis*	Citrus	Brazil	Macaubal, SP	pauca	pauca	H	E	DAS-ELISA, Culture and Serological detection	Chang et al., 1993
Rutaceae	*Citrus sinensis*	Citrus	Costa Rica	NA	NA	fastidiosa	L	S	DAS-ELISA, microscopy, SEM and TEM	Aguilar et al., 2005
Rutaceae	*Citrus sinensis*	Citrus	Brazil	Colina, SP	NA	pauca	H	E	DAS-ELISA, culture and serological detection	Chang et al., 1993
Rutaceae	*Citrus sinensis*	Citrus	Brazil	Barretos	NA	pauca	H	E	DAS-ELISA, culture and Serological detection	Chang et al., 1993
Rutaceae	*Citrus sinensis*	Citrus	Brazil	Cocal	NA	pauca	H	E	DAS-ELISA, culture and serological detection	Chang et al., 1993
Rutaceae	*Citrus sinensis*	Citrus	Brazil	Taquaritinga	NA	pauca	H	E	DAS-ELISA, culture and serological detection	Chang et al., 1993
Rutaceae	*Citrus sinensis*	Citrus	Brazil	Catigua	NA	pauca	H	E	DAS-ELISA, culture and serological detection	Chang et al., 1993
Rutaceae	*Citrus sinensis*	Citrus	Argentina	Tabay	NA	pauca	H	E	DAS-ELISA, culture and serological detection	Chang et al., 1993
Rutaceae	*Citrus sinensis*	Citrus	Argentina	Corrientes	NA	pauca	H	E	DAS-ELISA, culture and serological detection	Chang et al., 1993
Rutaceae	*Citrus sinensis* (rootstock: *Citrus sunki*)	Sunkat mandarin	Brazil	São Paulo	NA	pauca	P	E	DAS-ELISA, PCR, light microscopy	He et al., 2000

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Rutaceae	*Citrus sinensis* (rootstock: *Citrus reticulata*)	Wiking mandarin	Brazil	São Paulo	NA	pauca	P	E	DAS-ELISA, PCR, light microscopy	He et al., 2000
Rutaceae	*Citrus sinensis* (rootstock: *C. reticulata* × *C. paradisi*)	Orlando tangelo	Brazil	São Paulo	NA	pauca	P	E	DAS-ELISA, PCR, light microscopy	He et al., 2000
Rutaceae	*Citrus sinensis (rootstock: C. paradisi* × *P. trifoliata)*	Swingle citrumelo	Brazil	São Paulo	NA	pauca	P	E	DAS-ELISA, PCR, light microscopy	He et al., 2000
Rutaceae	*Citrus sinensis (rootstock: C. sinensis* × *P. trifoliata)*	Troyer citrange	Brazil	São Paulo	NA	pauca	P	E	DAS-ELISA, PCR, light microscopy	He et al., 2000
Rutaceae	*Citrus sinensis (rootstock: Citrus reticulata)*	Batangas mandarin	Brazil	São Paulo	NA	pauca	P	E	DAS-ELISA, PCR, light microscopy	He et al., 2000
Rutaceae	*Citrus sinensis* (rootstock: *C. reticulata* × *C. paradisi*)	Thornton tangelo	Brazil	São Paulo	NA	pauca	P	E	DAS-ELISA, PCR, light microscopy	He et al., 2000
Rutaceae	*Citrus sinensis*	Caipira sweet orange	Brazil	São Paulo	NA	pauca	P	E	DAS-ELISA, PCR, light microscopy	He et al., 2000
Rutaceae	*Citrus sinensis* (rootstock: *P. trifoliata)*	Trifoliate orange	Brazil	São Paulo	NA	pauca	P	E	DAS-ELISA, PCR, light microscopy	He et al., 2000
Rutaceae	*Citrus sinensis* var. Natal		Brazil	NA	NA	pauca	H	NA	PCR, culture	Lacava et al., 2007
Rutaceae	*Citrus sinensis* cv. Pera	Laranja doce	Brazil	San José Farm	NA	pauca	P	S and E	PCR	Lopes et al., 2003
Rutaceae	*Citrus sinensis* cv. Caipira	Laranja Caipira	Brazil	Cajobi	NA	pauca	P	S and E	PCR	Lopes et al., 2003
Rutaceae	*Citrus sinensis*	Citrus	Costa Rica	Santa Elena	NA	NA	NA	NA	NA	Montero-Astúa et al., 2007
Rutaceae	*Citrus sinensis*	Citrus	Brazil	Rio Grande do Sul	NA	pauca	H	S	PCR, cultures	Rodrigues et al., 2003
Rutaceae	*Citrus sinensis*	Valencia sweet orange	Brazil	Macaubal, SP	pauca	pauca	H	E?	Not described	Simpson et al., 2000

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Rutaceae	*Citrus sinensis*	Citrus	USA	Polk Co., FL	fastidiosa	fastidiosa	P	NA	NA	Yuan et al., 2010
Rutaceae	*Citrus sinensis*	Citrus	Brazil	São Paulo	pauca	pauca	P	NA	NA	Yuan et al., 2010
Rutaceae	*Citrus sinensis* "Madame Vinous"	Sweet orange	USA	Central FL	NA	pauca	H	E	PCR	Brlansky et al., 2002
Rutaceae	*Citrus sinensis*	Citrus	USA	US Davis campus	NA	fastidiosa	H	NA	NA	Chatelet et al., 2011
Rutaceae	*Citrus sinensis*	Sweet orange	Brazil	NA	NA	pauca	H	NA	Symptoms, serological DIBA, Immunoblotting with specific antiserum for CVC, PCR	Laranjeira et al., 1998
Rutaceae	*Citrus sinensis* "Pera" sweet orange	Citrus	Brazil	Taquaritinga, SP	NA	pauca	P	E	ELISA, PCR, microscopy	Li et al., 2001
Rutaceae	*Citrus sinensis* cv. Hamlim	Laranja doce	Brazil	Boa Esperanca	NA	pauca	P	S and E	PCR	Lopes et al., 2003
Rutaceae	*Citrus sinensis* cv. Caipira	Laranja Caipira	Brazil	Luis Antonio, SP	NA	pauca	P	S and E	PCR	Lopes et al., 2003
Rutaceae	*Citrus sinensis*	Sweet orange	Brazil	São Paulo	NA	NA	NA	NA	NA	Montero-Astúa et al., 2007
Rutaceae	*Citrus sinensis*	Sweet orange	Brazil	Taquaritinga	NA	NA	NA	NA	NA	Montero-Astúa et al., 2007
Rutaceae	*Citrus sinensis*	Sweet orange "pera"	Brazil	Bebedouro, SP	NA	fastidiosa	P	S?	PCR	Pooler and Hartung, 1995
Rutaceae	*Citrus sinensis* cv. Caipira	Citrus	Brazil	São Paulo	NA	pauca	H	E	Culturing	Prado et al., 2008
Rutaceae	*Citrus sinensis*	Citrus	Brazil	São Paulo	NA	pauca	H	S	PCR, cultures	Rodrigues et al., 2003
Rutaceae	*Citrus sinensis*	Citrus	Brazil	Minas Gerais	NA	pauca	H	S	PCR, cultures	Rodrigues et al., 2003
Rutaceae	*Citrus sinensis*	Citrus	Brazil	Parana	NA	pauca	H	S	PCR, cultures	Rodrigues et al., 2003
Rutaceae	*Citrus sinensis*	Citrus	Brazil	Luis Antonio, SP	NA	pauca	P	S and E	PCR	Lopes et al., 2003
Rutaceae	*Citrus sinensis*	Citrus	Brazil	Cajobi	NA	pauca	P	S and E	PCR	Lopes et al., 2003
Salicaceae	*Populus fremontii*	Fremont cottonwood	USA	Napa Valley, CA	NA	fastidiosa	L	E	PCR and culturing assays	Purcell and Saunders, 1999

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Salicaceae	*Salix* spp.	Willow	USA	Temecula, CA	NA	NA	P	S	ELISA	Costa et al., 2004
Salicaceae	*Salix* sp.	Willow	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Salicaceae	*Salix* sp.	Willow	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Salicaceae	*Salix* sp.	Willow	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Salicaceae	*Salix laevigata*	Red willow	USA	Napa Valley, CA	NA	fastidiosa	L	E	PCR and culturing assays	Purcell and Saunders, 1999
Salicaceae	*Salix lasiolepis*	Arroyo willow	USA	Napa Valley, CA	NA	fastidiosa	L	E	PCR and culturing assays	Purcell and Saunders, 1999
Sapindaceae	*Acer* spp.	Maple	USA	SC	NA	NA	NA	S	ELISA, symptoms	Blake, 1993
Sapindaceae	*Acer* sp.	Maple	North America	NA	multiplex	multiplex	P	NA	NA	Nunney et al., 2010
Sapindaceae	*Acer* sp.	Maple	USA	Alameda Co., CA	fastidiosa	fastidiosa	P	NA	NA	Yuan et al., 2010
Sapindaceae	*Acer griseum*	Paperbark maple	USA	Fayette Co., KY	multiplex	multiplex	P	NA	NA	Nunney et al.,
Sapindaceae	*Acer macrophylum*	Big leaf maple	USA	Napa Valley, CA	NA	fastidiosa	L	E	PCR and culturing assays	Purcell and Saunders, 1999
Sapindaceae	*Acer macrophylum*	Big leaf maple	Canada	Goldstream (British Columbia)	NA	NA	NA	S	Symptoms, ELISA	FIDS 1992, page 28–29
Sapindaceae	*Acer macrophylum*	Big leaf maple	Canada	Greater Victoria on the island (British Columbia)	NA	NA	NA	S	Symptoms, ELISA	FIDS 1992, page 28–29
Sapindaceae	*Acer macrophylum*	Big leaf maple	Canada	Gates Lake (British Columbia)	NA	NA	NA	S	Symptoms, ELISA	FIDS 1992, page 28–29
Sapindaceae	*Acer macrophylum*	Big leaf maple	Canada	Powell River (British Columbia)	NA	NA	NA	S	Symptoms, ELISA	FIDS 1992, page 28–29
Sapindaceae	*Acer macrophylum*	Big leaf maple	Canada	Stanley Park, Vancouver (British Columbia)	NA	NA	NA	S	Symptoms, ELISA	FIDS 1992, page 28–29
Sapindaceae	*Acer negundo*	Box elder	USA	National park Service Daingerfield Island Nursery in Alexandria, VA	NA	MULTIPL	L	S	PCR	McElrone et al., 1999
Sapindaceae	*Acer negundo*	Box elder	USA	National parks in Washington DC	NA	multiplex	L	S	PCR	McElrone et al., 1999
Sapindaceae	*Acer negundo*	Box elder	USA	Napa Valley, CA	NA	fastidiosa	L	E	PCR and culturing assays	Purcell and Saunders, 1999

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Sapindaceae	*Acer platanoides*	Norway maple	USA	DC	NA	NA	NA	S	ELISA:PCR	Harris et al., 2014
Sapindaceae	*Acer platanoides*	Norway maple	USA	Washington, DC	multiplex	multiplex	P	S	ELISA, symptoms, PCR	Di Bello et al., 2012
Sapindaceae	*Acer rubrum*	Red maple	USA	16 Kentucky cities	NA	multiplex	H	S	Symptoms, ELISA, electron microscopy	Hartman et al. 1995
Sapindaceae	*Acer rubrum*	Red maple	USA	Rockport, IN	NA	multiplex	H	S	Symptoms, ELISA, electron microscopy	Hartman et al. 1995
Sapindaceae	*Acer rubrum*	Red maple	USA	Knoxville, TN	NA	multiplex	H	S	Symptoms, ELISA, electron microscopy	Hartman et al. 1995
Sapindaceae	*Acer rubrum*	Red maple	USA	Alexandria, VA	NA	multiplex	H	S	Symptoms, ELISA, electron microscopy, culture	Sherald et al., 1987
Sapindaceae	*Acer rubrum*	Red maple	USA	Fayette Co., KY	multiplex	multiplex	P	NA	NA	Nunney et al., 2013
Sapindaceae	*Acer rubrum*	Red maple	USA	National Mall in Washington DC	NA	multiplex	H	NA	ELISA	Sherald and Lei, 1991
Sapindaceae	*Acer rubrum*	Red maple	USA	NA	NA	multiplex	H	NA	Primary isolations obtained from contributors	Wells et al., 1987
Sapindaceae	*Acer saccharum*	Sugar maple	USA	Oldham County, KY	NA	NA	H	S	ELISA, symptoms, electron microscopy	Hartman et al., 1996
Sapindaceae	*Aesculus californica*	California buckeye	USA	Napa Valley, CA	NA	fastidiosa	L	E	PCR and culturing assays	Purcell and Saunders, 1999
Sapindaceae	*Aesculus* × *hybrid*	Buckeye	USA	National park Service Daingerfield Island Nursery in Alexandria, VA	NA	multiplex	L	S	PCR	McElrone et al., 1999
Sapindaceae	*Aesculus* × *hybrid*	Buckeye	USA	National parks in Washington DC	NA	multiplex	L	S	PCR	McElrone et al., 1999
Sapindaceae	*Koelreuteria bipinnata*	Goldenrain tree	USA	Riverside Co., CA	multiplex	multiplex	P	NA	NA	Nunney et al., 2013
Sapindaceae	*Sapindus saponaria*	Western soapberry	USA	Uvalde Co., TX	multiplex	multiplex	P	NA	NA	Nunney et al., 2013
Scrophulariaceae	*Veronica* sp.	Speedwell	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Scrophulariaceae	*Veronica* sp.	Speedwell	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Scrophulariaceae	*Veronica* sp.	Speedwell	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Simmondsiadaceae	*Simmondsia chinensis*	Jojoba	USA	San Joaquin Valley, CA	NA	fastidiosa	L	E	Vectors	Wistrom and Purcell, 2005

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Solanaceae	*Datura meteloides*		USA	Lake Valley Seed, Boulder, CO, and Botanical Interests Inc., Broomfield, CO	NA	fastidiosa	H	NA	NA	Chatelet et al., 2011
Solanaceae	*Datura wrightii*	Sacred datura	USA	Weedy alfalfa fields near USDA-ARS research centre in Parlier, CA	NA	NA	NA	S	ELISA	Krugner et al., 2012
Solanaceae	*Lycopersicon esculentum* cv. Ace	Tomato	USA	San Joaquin Valley, CA	NA	fastidiosa	L	E	Vectors	Wistrom and Purcell, 2005
Solanaceae	*Nicotiana glauca*	Tree tobacco	USA	San Joaquin Valley, CA	NA	fastidiosa	L	E	Vectors	Wistrom and Purcell, 2005
Solanaceae	*Nicotiana × sanderae*		USA	US Davis campus	NA	fastidiosa	H	NA	NA	Chatelet et al., 2011
Solanaceae	*Nicotiana tabacum*	Tobacco	Brazil	Sao José farm Taquaritinga	NA	pauca	H	E	PCR, phase contrast microscopy, scanning electron microscopy of stems and petioles, DAS-ELISA	Lopes et al., 2000
Solanaceae	*Solanum americanum*	American nightshade	Brazil	Cajobi	NA	pauca	P	S and E	PCR	Lopes et al., 2003
Solanaceae	*Solanum americanum*	American nightshade	Brazil	Luis Antonio, SP	NA	pauca	P	S and E	PCR	Lopes et al., 2003
Solanaceae	*Solanum elaeagnifolium*	Silverleaf nightshade	USA	Temecula, CA	NA	NA	P	S	ELISA	Costa et al., 2004
Solanaceae	*Solanum melongea* cv. Violeta lunga	Aubergine	USA	San Joaquin Valley, CA	NA	fastidiosa	L	E	Vectors	Wistrom and Purcell, 2005
Ulmaceae	*Celtis occidentalis*	Hackberry	USA	Fayette Co., KY	multiplex	multiplex	P	NA	NA	Nunney et al., 2013
Ulmaceae	*Ulmus* sp.	Elm	USA	Washington DC	NA	multiplex	H	E?	SEM, culturing	Marques et al., 2002
Ulmaceae	*Ulmus americana*	American elm	Canada	Southern Ontario, Niagara Peninsula (locations: Fort Erie, Niagara-on-the-Lake, Virgil)	NA	NA	NA	S	Symptoms, DNA extraction and PCR	Goodwin and Zhang, 1997
Ulmaceae	*Ulmus americana*	American elm	Canada	Alberta	NA	NA	NA	NA	NA	Holley, 1993
Ulmaceae	*Ulmus americana*	American elm	Canada	Saskatchewan	NA	NA	NA	S	Symptoms	Northover et al., 2012

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Ulmaceae	*Ulmus americana*	American elm	USA	DC	multiplex	multiplex	P	S	ELISA:PCR	Harris et al., 2014
Ulmaceae	*Ulmus americana*	American elm	USA	Washington, DC	NA	multiplex	H	S	Symptoms, TEM	Hearon et al., 1980
Ulmaceae	*Ulmus americana*	American elm	USA	Washington, DC	NA	multiplex	H	S	Symptoms, TEM	Hearon et al., 1980
Ulmaceae	*Ulmus americana*	American elm	USA	Washington DC area	NA	multiplex	H	S	Comparison of physiology of affected and non-affected trees	Kostka and Tattar, 1986a
Ulmaceae	*Ulmus americana*	American elm	USA	Washington DC	NA	multiplex	P	S	PCR (detection from insects) from plants not mention	Pooler et al., 1997
Ulmaceae	*Ulmus americana*	American elm	USA	Washington, DC	NA	multiplex	H	S	PCR, cultures	Rodrigues et al., 2003
Ulmaceae	*Ulmus americana*	American elm	USA	Leesburg, FL (wild plant species within 50 miles of the Central Florida Research and Education Centre)	NA	multiplex	H	E	ELISA, phase contrast microscopy, symptoms	Sherald, 1993
Ulmaceae	*Ulmus americana*	American elm	USA	National Mall in Washington DC	NA	multiplex	H	S and E	ELISA	Sherald and Lei, 1991
Ulmaceae	*Ulmus americana*	American elm	USA	Washington, DC	multiplex	multiplex	P	NA	NA	Nunney et al., 2013 supplementary data
Ulmaceae	*Ulmus americana*	American elm	USA	NA	NA	multiplex	H	?	Primary isolations obtained from contributors	Wells et al., 1987
Ulmaceae	*Ulmus americana*	American elm	USA	Washington, DC	multiplex	multiplex	P	S	ELISA, symptoms, PCR	Di Bello et al., 2012
Ulmaceae	*Ulmus americana*	American elm	USA	Washington, DC	NA	multiplex	H	S	Symptoms, TEM	Hearon et al., 1980

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Ulmaceae	*Ulmus americana*	American elm	USA	Washington DC area	NA	multiplex	H	E	Isolations made from all trees by aseptically incubating excised wood chips in a modified PW broth (Sherald et al., 1983) or by vacuum extracting bacteria from stem segments and confirming their presence using phase contrast microscopy (French et al., 1977, Hearon et al., 1980 Sherald, 1993)	Kostka et al., 1985a
Ulmaceae	*Ulmus americana*	American elm	USA	Washington DC	NA	NA	NA	NA	NA	Montero-Astúa et al., 2007
Ulmaceae	*Ulmus americana*	American elm	USA	Washington, DC	multiplex	multiplex	P	NA	NA	Nunney et al., 2013
Ulmaceae	*Ulmus americana*	American elm	USA	Washington DC	NA	multiplex	H	E and S	Symptoms and cultures	Wester and Jylkka, 1959
Ulmaceae	*Ulmus crassifolia*	Cedar elm	USA	Uvalde Co., TX	multiplex	multiplex	P	NA	NA	Nunneyet al., 2013.
Urticaceae	*Urtica dioica*	Stinging nettle	USA	Napa Valley, CA	NA	fastidiosa	L	E	PCR and culturing assays	Purcell and Saunders, 1999
Urticaceae	*Urtica gracilis* var. *holosericea*	Greek netila	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Urticaceae	*Urtica gracilis* var. *holosericea*	Greek netila	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Urticaceae	*Urtica gracilis* var. *holosericea*	Greek netila	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Urticaceae	*Urtica urens*	Burning nettle	USA	California's central valley	NA	multiplex	P	S	Immunocapture DNA separation and PCR	Shapland et al., 2006
Verbenaceae	*Callicarpa americana*		USA	Gulf Coast, TX	NA	NA	NA	NA	ELISA, PCR	McGaha et al., 2007
Verbenaceae	*Duranta repens*	Pigeon-berry	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Verbenaceae	*Duranta repens*	Pigeon-berry	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Verbenaceae	*Duranta repens*	Pigeon-berry	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Verbenaceae	*Lantana* sp.	Shrub verbena	USA	Central FL	NA	pauca	H	S	MEIF	Brlansky et al., 2002

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Verbenaceae	*Lantana camara*	Cambara	Brazil	Boa Esperanca	NA	pauca	P	S and E	PCR	Lopes et al., 2003
Verbenaceae	*Lippia nodiflora*	Frogfruit	USA	American hybrid vineyard in the Texas Gulf Coast (Austin County Vineyards, a 4.5-acre vineyard located in Cat Spring, TX, 70 miles west of Houston)	NA	NA	NA	S	ELISA, PCR	Buzombo et al., 2006
Verbenaceae	*Verbena litoralis*	Seashore vervain	USA	Weedy alfalfa fields near USDA-ARS research centre in Parlier, CA	NA	NA	NA	S	ELISA	Krugner et al., 2012
Vitaceae	*Ampelopsis arborea*	Pepper vine	USA	Leesburg, FL (wild plant species within 50 miles of the Central Florida Research and Education Centre)	NA	fastidiosa	H	E	ELISA, fluorescence microscopy	Hopkins and Adlerz, 1988
Vitaceae	*Ampelopsis arborea*	Pepper vine	USA	Gulf Coast, TX	NA	NA	NA	NA	ELISA, PCR	McGaha et al., 2007
Vitaceae	*Ampelopsis cordata*	Heartleaf pe	USA	Llano Co., TX	multiplex	multiplex	P	NA	NA	Nunney et al., 2013
Vitaceae	*Parthenocissus iricuspidata*	Boston ivy	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Vitaceae	*Parthenocissus iricuspidata*	Boston ivy	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Vitaceae	*Parthenocissus iricuspidata*	Boston ivy	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Vitaceae	*Parthenocissus quinquefolia*	Virginia creeper	USA	Leesburg, FL (wild plant species within 50 miles of the Central Florida Research and Education Centre)	NA	fastidiosa	H	E	ELISA, fluorescence microscopy	Hopkins and Adlerz, 1988
Vitaceae	*Parthenocissus quinquefolia*	Virginia creeper	USA	PD strains from Leesburg, FL	NA	fastidiosa	H	E	Immunomagnetic capture and nested PCR, culturing	McElrone et al., 2001
Vitaceae	*Vitis* sp.	Grapevine	Yugoslavia	Cermjan (Kosova)	NA	NA	NA	S	Electron microscopy, ELISA, PCR	Berisha et al., 1998

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Vitaceae	*Vitis* sp.	Grapevine	Iran	Chahar Mahal-va-Bakhtiari (vineyard)	NA	NA	NA	S	DAS-ELISA, PCR, culture	Amanifar et al., 2014
Vitaceae	*Vitis* sp.	Grapevine	Iran	Fars (vineyard)	NA	NA	NA	S	DAS-ELISA, PCR, culture	Amanifar et al., 2014
Vitaceae	*Vitis* sp.	Grapevine	Iran	Qazvin (vineyard)	NA	NA	NA	S	DAS-ELISA, PCR, culture	Amanifar et al., 2014
Vitaceae	*Vitis* sp.	Grapevine	Iran	Hamedan (vineyard)	NA	NA	NA	S	DAS-ELISA, PCR, culture	Amanifar et al., 2014
Vitaceae	*Vitis* sp.	Grapevine	Iran	Khorasan Razavi (vineyard)	NA	NA	NA	S	DAS-ELISA, PCR, culture	Amanifar et al., 2014
Vitaceae	*Vitis* sp.	Grapevine	Iran	Alborz (vineyard)	NA	NA	NA	S	DAS-ELISA, PCR, culture	Amanifar et al., 2014
Vitaceae	*Vitis* sp.	Grapevine	Iran	Isfahan provinces (vineyard)	NA	NA	NA	S	DAS-ELISA, PCR, culture	Amanifar et al., 2014
Vitaceae	*Vitis* sp.	Black Spanish	USA	American hybrid vineyard in the Texas Gulf Coast (Austin County Vineyards, a 4.5-acre vineyard located in Cat Spring, TX, 70 miles west of Houston)	NA	NA	NA	S	ELISA, PCR	Buzombo et al., 2006
Vitaceae	*Vitis* sp.	Blanc du Bois	USA	American hybrid vineyard in the Texas Gulf Coast (Austin County Vineyards, a 4.5-acre vineyard located in Cat Spring, TX, 70 miles west of Houston)	NA	NA	NA	S	ELISA, PCR	Buzombo et al., 2006

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Vitaceae	*Vitis* sp.	Cynthiana	USA	American hybrid vineyard in the Texas Gulf Coast (Austin County Vineyards, a 4.5-acre vineyard located in Cat Spring, TX, 70 miles west of Houston)	NA	NA	NA	S	ELISA, PCR	Buzombo et al., 2006
Vitaceae	*Vitis* sp.	Grapevine	USA	NA	NA	fastidiosa	P	S?	PCR, culture	da Costa et al., 2000
Vitaceae	*Vitis* sp.	Grapevine	USA	National park Service Daingerfield Island Nursery in Alexandria, Virginia	NA	multiplex	L	S	PCR	McElrone et al., 1999
Vitaceae	*Vitis* sp.	Grapevine	USA	National parks in Washington DC	NA	multiplex	L	S	PCR	McElrone et al., 1999
Vitaceae	*Vitis* sp.	Grapevine	Costa Rica	Santa Ana	NA	NA	NA	NA	NA	Montero-Astúa et al., 2007
Vitaceae	*Vitis* sp.	Grapevine	Costa Rica	San José	NA	NA	NA	NA	NA	Montero-Astúa et al., 2007
Vitaceae	*Vitis* sp.	Grapevine	USA	CA	NA	NA	NA	NA	NA	Montero-Astúa et al., 2007
Vitaceae	*Vitis* sp.	Grapevine	USA	FL	NA	NA	NA	NA	NA	Montero-Astúa et al., 2007
Vitaceae	*Vitis* spp.	Wild grape	USA	CA	fastidiosa	fastidiosa	P	NA	NA	Nunney et al., 2013
Vitaceae	*Vitis* spp.	Wild grape	USA	NC	fastidiosa	fastidiosa	P	NA	NA	Nunney et al., 2013
Vitaceae	*Vitis* spp.	Wild grape	USA	TX	fastidiosa	fastidiosa	P	NA	NA	Nunney et al., 2013
Vitaceae	*Vitis* sp.	Grapevine	Costa Rica	San José, San José province, CR	fastidiosa	fastidiosa	P	NA	NA	Nunney et al.,2010
Vitaceae	*Vitis* sp.	Grapevine	USA	Tulare (South CA)	fastidiosa	fastidiosa	P	NA	NA	Schuenzel et al.,2005
Vitaceae	*Vitis* sp.	Grapevine	USA	San Luis Obispo (South CA)	fastidiosa	fastidiosa	P	NA	NA	Schuenzel et al., 2005
Vitaceae	*Vitis* sp.	Grapevine	USA	Napa (North CA)	fastidiosa	fastidiosa	P	NA	NA	Schuenzel et al., 2005
Vitaceae	*Vitis* sp.	Grapevine	USA	FL	fastidiosa	fastidiosa	P	NA	NA	Schuenzel et al., 2005

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Vitaceae	*Vitis* sp.	Common grapevine	USA	Napa Valley, CA	NA	fastidiosa	H	S	NA	Winkler et al., 1949
Vitaceae	*Vitis* sp.	Grapevine	USA	Napa Valley, CA	NA	fastidiosa	P	E	Culturing, symptoms	Almeida and Purcell, 2006
Vitaceae	*Vitis* sp.	Grapevine	USA	NA	NA	NA	NA	NA	ELISA, PCR	Bextine and Miller, 2004
Vitaceae	*Vitis* sp.	Common grapevine	USA	FL	NA	fastidiosa	H	E	Symptoms	Hopkins and Mortensen, 1971
Vitaceae	*Vitis* sp.	Grapevine	USA	Weedy alfalfa fields near USDA-ARS research centre in Parlier, CA	NA	NA	NA	S	ELISA	Krugner et al., 2012
Vitaceae	*Vitis* sp.	Grapevine	USA	Kern (Central Valley) CA	fastidiosa	fastidiosa	P	S	NA	Lopes et al., 2009
Vitaceae	*Vitis* sp.	Grapevine	USA	Tulare (Central Valley of CA)	fastidiosa	fastidiosa	P	S	NA	Lopes et al., 2009
Vitaceae	*Vitis* sp.	Grapevine	USA	South-eastern USA and CA	NA	fastidiosa	H	NA	Symptoms, culture	Lu et al., 2003
Vitaceae	*Vitis* sp.	Common grapevine	USA	FL	NA	fastidiosa	H	E	SEM, culturing	Marques et al., 2002
Vitaceae	*Vitis* sp.	Grapevines	USA	NA	NA	NA	NA	NA	Culturing	Montero-Astúa et al., 2006
Vitaceae	*Vitis* sp.	Grapevines	Costa Rica	NA	NA	NA	NA	NA	Culturing	Montero-Astua et al., 2006
Vitaceae	*Vitis* sp.	Common grapevine	Costa Rica	Not mentioned	NA	fastidiosa	P	NA	NA	Nunney et al., 2010
Vitaceae	*Vitis* sp.	Grapevine	Costa Rica	La Urucaa, San José, CR	fastidiosa	fastidiosa	P	NA	NA	Nunney et al., 2010
Vitaceae	*Vitis* sp.	Grapevine	Costa Rica	La Urucaa, San José, CR	fastidiosa	fastidiosa	P	NA	NA	Nunney et al., 2010
Vitaceae	*Vitis* sp.	Grapevine	North America	NA	fastidiosa	fastidiosa	P	NA	NA	Nunney et al., 2010
Vitaceae	*Vitis* sp.	Grapevine	USA	San Joaquin Valley Agricultural Centre (USDA, Parlier, CA)	NA	fastidiosa	L	E	PCR, culturing	Wistrom et al., 2010
Vitaceae	*Vitis* sp.	Grapevine	USA	Temecula (South CA)	fastidiosa	fastidiosa	P	NA	NA	Schuenzel et al., 2005
Vitaceae	*Vitis aestivalis*	Wild grape	USA	Val Verde Co., TX	fastidiosa	fastidiosa	P	NA	NA	Yuan et al., 2010

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Vitaceae	*Vitis californica*	California wild grape	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Vitaceae	*Vitis californica*	California wild grape	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Vitaceae	*Vitis californica*	California wild grape	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Vitaceae	*Vitis californica*	California grapevine	USA	Oakville (Napa County), CA	NA	fastidiosa	L	E	real-time PCR, culturing	Baumgartner and Warren, 2005
Vitaceae	*Vitis californica*	California grapevine	USA	Hopland (Mendocino County), CA	NA	fastidiosa	L	E	Real-time PCR, culturing	Baumgartner and Warren, 2005
Vitaceae	*Vitis girdiana*	Desert wild grape	USA	NA	fastidiosa	fastidiosa	P	NA	NA	Nunney et al., 2013
Vitaceae	*Vitis girdiana*	Desert wild grape	USA	Riverside Co., CA	fastidiosa	fastidiosa	P	NA	NA	Yuan et al., 2010
Vitaceae	*Vitis labrusca* (cultivar Schuyler)	Grapevine	USA	Agricultural Research Centre in Leesburg, FL	NA	fastidiosa	H	S	Light microscopy	Hopkins, 1981
Vitaceae	*Vitis labrusca* "Concord"	Grapevine	USA	Canadian County, OK	NA	fastidiosa	H	S	Symptoms, real-time PCR, ELISA	Smith et al., 2009
Vitaceae	*Vitis labrusca* "Concord"	Concord Grape	USA	CA (Riverside and Redlands areas)	NA	fastidiosa	P	S	ELISA, PCR, culture	Wong et al., 2004
Vitaceae	*Vitis mustangensis*	Mustang grape	USA	American hybrid vineyard in the Texas Gulf Coast (Austin County Vineyards, a 4.5-acre vineyard located in Cat Spring, TX, 70 miles west of Houston)	NA	NA	NA	S	ELISA, PCR	Buzombo et al., 2006
Vitaceae	*Vitis mustangensis*	Mustang grape	USA	Gulf Coast, TX	NA	NA	NA	NA	ELISA, PCR	McGaha et al., 2007
Vitaceae	*Vitis rotundifolia*	Muscadine	USA	NC	fastidiosa	fastidiosa	P	NA	NA	Yuan et al., 2010
Vitaceae	*Vitis rotundifolia*	Muscadine	USA	FL	fastidiosa	fastidiosa	P	NA	NA	Yuan et al., 2010
Vitaceae	*Vitis rotundifolia*	Muscadine	USA	Gulf Coast, TX	NA	NA	NA	NA	ELISA, PCR	McGaha et al., 2007
Vitaceae	*Vitis rubestris*	Grape rootstock	USA	Napa Valley, CA	NA	fastidiosa	L	E	PCR and culturing assays	Purcell and Saunders, 1999

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Vitaceae	*Vitis vinifera*	Common grapevine	USA	Temecula, CA	NA	NA	P	S	ELISA, PCR, Culture	Costa et al., 2004
Vitaceae	*Vitis vinifera*	Common grapevine	USA	Napa County, CA	NA	fastidiosa	H	E	serologically and microscope.	Davis et al., 1978
Vitaceae	*Vitis vinifera*	Common grapevine	USA	Berkeley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Vitaceae	*Vitis vinifera*	Common grapevine	USA	Napa Valley, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Vitaceae	*Vitis vinifera*	Common grapevine	USA	Los Angeles, CA	NA	fastidiosa	L	E	Symptoms and infecting with vectors	Freitag, 1951
Vitaceae	*Vitis vinifera*	Common grapevine	USA	Hessmer, LA	NA	fastidiosa	P	NA	NA	Melanson et al., 2012
Vitaceae	*Vitis vinifera*	Common grapevine	USA	CA	fastidiosa	fastidiosa	P	NA	NA	Nunney et al., 2013
Vitaceae	*Vitis vinifera*	Common grapevine	USA	Gillespie Co., TX	fastidiosa	fastidiosa	P	NA	NA	Yuan et al., 2010
Vitaceae	*Vitis vinifera*	Common grapevine	Mexico	Parras	NA	fastidiosa	H	E	Serological studies: relationship between isolates by agar gel double diffusion, ultrastructural studies of bacteria were done according to Davis et al., 1978, electron microscopy	Raju et al., 1980
Vitaceae	*Vitis vinifera*	Common grapevine	USA	CA	fastidiosa	fastidiosa	P	NA	NA	Yuan et al., 2010
Vitaceae	*Vitis vinifera*	Common grapevine	USA	Sonoma Co., CA	fastidiosa	fastidiosa	P	NA	NA	Yuan et al., 2010
Vitaceae	*Vitis vinifera*	Common grapevine	USA	Southern CA, CA	fastidiosa	fastidiosa	P	NA	NA	Yuan et al., 2010
Vitaceae	*Vitis vinifera*	Common grapevine	USA	Ventura Co., CA	fastidiosa	fastidiosa	P	NA	NA	Yuan et al., 2010
Vitaceae	*Vitis vinifera*	Common grapevine	USA	Santa Barbara Co., CA	fastidiosa	fastidiosa	P	NA	NA	Yuan et al., 2010
Vitaceae	*Vitis vinifera*	Common grapevine	USA	Alameda Co., CA	fastidiosa	fastidiosa	P	NA	NA	Yuan et al., 2010
Vitaceae	*Vitis vinifera*	Common grapevine	USA	San Luis Obispo Co., CA	fastidiosa	fastidiosa	P	NA	NA	Yuan et al., 2010
Vitaceae	*Vitis vinifera*	Common grapevine	Mexico	Baja CA, MX	fastidiosa	fastidiosa	P	NA	NA	Yuan et al., 2010

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Vitaceae	*Vitis vinifera*	Common grapevine	USA	Napa Co., CA	fastidiosa	fastidiosa	P	NA	NA	Yuan et al., 2010
Vitaceae	*Vitis vinifera*	Common grapevine	USA	Santa Cruz Co., CA	fastidiosa	fastidiosa	P	NA	NA	Yuan et al., 2010
Vitaceae	*Vitis vinifera*	Common grapevine	Venezuela	State of Zulia (El Patrón),	NA	NA	NA	S	ELISA	Jimenez, 1985
Vitaceae	*Vitis vinifera*	Common grapevine	Venezuela	State of Zulia (Los Pachos)	NA	NA	NA	S	ELISA	Jimenez, 1985
Vitaceae	*Vitis vinifera*	Common grapevine	Venezuela	State of Zulia (Maribelo)	NA	NA	NA	S	ELISA	Jimenez, 1985
Vitaceae	*Vitis vinifera*	Common grapevine	Venezuela	State of Zulia (Tocuyo)	NA	NA	NA	S	ELISA	Jimenez, 1985
Vitaceae	*Vitis vinifera*	Common grapevine	Costa Rica	San José province (Santa Ana and La Uruca)	NA	fastidiosa	L	S	DAS-ELISA using antibodies against Xf, characterisation of the cells of bacteria, DNA of each clone was extracted and used as template in PCR with primers 272–1/272–2 and RST31/RST33, and also TEM used	Aguilar et al., 2008
Vitaceae	*Vitis vinifera*	Common grapevine	Costa Rica	La Garita, Alajuela province	NA	fastidiosa	L	S	DAS-ELISA using antibodies against Xf, characterisation of the cells of bacteria, DNA of each clone was extracted and used as template in PCR, and also TEM used	Aguilar et al., 2008
Vitaceae	*Vitis vinifera*	Common grapevine	Mexico	NA	NA	fastidiosa	P	NA	NA	Almeida and Purcell, 2003
Vitaceae	*Vitis vinifera*	Common grapevine	USA	Kern	NA	fastidiosa	P	NA	NA	Almeida and Purcell, 2003
Vitaceae	*Vitis vinifera*	Common grapevine	USA	Napa	NA	fastidiosa	P	NA	NA	Almeida and Purcell, 2003
Vitaceae	*Vitis vinifera*	Common grapevine	USA	Fresno	NA	fastidiosa	P	NA	NA	Almeida and Purcell, 2003
Vitaceae	*Vitis vinifera*	Common grapevine	USA	Riverside	NA	fastidiosa	P	NA	NA	Almeida and Purcell, 2003
Vitaceae	*Vitis vinifera*	Common grapevine	USA	Tulare	NA	fastidiosa	P	NA	NA	Almeida and Purcell, 2003

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Vitaceae	*Vitis vinifera*	Common grapevine	USA	Los Angeles	NA	fastidiosa	P	NA	NA	Almeida and Purcell, 2003
Vitaceae	*Vitis vinifera*	Common grapevine	USA	Greenhouse in Davis and various localities in CA	NA	fastidiosa	H	E	Symptoms	Esau, 1948
Vitaceae	*Vitis vinifera*	Common grapevine	USA	Davis greenhouse, CA (grape strains from Napa Valley, Temecula, Fresno, Solano County, Contra Costa County and OLS strains from Palm Springs)	NA	fastidiosa	H	E	Culturing	Feil and Purcell, 2001
Vitaceae	*Vitis vinifera*	Common grapevine	NA	NA	NA	fastidiosa	H	NA	Not described in the article (short note)	Frazier, 1944
Vitaceae	*Vitis vinifera*	Common grapevine	USA	Berkeley	NA	fastidiosa	H	E	Not described in the article	Frazier and Freitag, 1946
Vitaceae	*Vitis vinifera*	Common grapevine	USA	Napa Valley, CA	NA	fastidiosa	H	E	Electron microscopy	Goheen et al., 1973
Vitaceae	*Vitis vinifera*	Common grapevine	?	NA	NA	fastidiosa	L	E	NA	Hewitt et al., 1942
Vitaceae	*Vitis vinifera*	Common grapevine	USA	CA	NA	fastidiosa	H	E	ELISA, sympotoms, culturing	Hill and Purcell, 1997
Vitaceae	*Vitis vinifera*	Common grapevine	USA	CA	NA	fastidiosa	H	E	ELISA	Hill and Purcell, 1995
Vitaceae	*Vitis vinifera*	Common grapevine	USA	CA	NA	fastidiosa	H	NA	NA	Matthews et al., 2008
Vitaceae	*Vitis vinifera*	Common grapevine	USA	FL	fastidiosa	fastidiosa	P	NA	NA	Nunney et al., 2013
Vitaceae	*Vitis vinifera*	Common grapevine	USA	GA	fastidiosa	fastidiosa	P	NA	NA	Nunney et al., 2013
Vitaceae	*Vitis vinifera*	Common grapevine	USA	KY	fastidiosa	fastidiosa	P	NA	NA	Nunney et al., 2013
Vitaceae	*Vitis vinifera*	Common grapevine	USA	TX	fastidiosa	fastidiosa	P	NA	NA	Nunney et al., 2013
Vitaceae	*Vitis vinifera*	Common grapevine	USA	Vineyards in Napa River, CA	NA	fastidiosa	L	S	ELISA, electron microscopy and light microscopy	Raju et al., 1980
Vitaceae	*Vitis vinifera*	Common grapevine	USA	CA	NA	fastidiosa	H	S	PCR, cultures	Rodrigues et al., 2003
Vitaceae	*Vitis vinifera*	Common grapevine	USA	FL	NA	fastidiosa	H	S	PCR, cultures	Rodrigues et al., 2003

Plant family	Plant species	Plant common name	Country of detection/ experimentation	Location of detection/ experimentation	*X.fastidiosa* subspecies mentioned in the paper	*X. fastidiosa* putative subspecies	Justification for putative subspecies	Method by which infection determined	Detection protocol	Citation
Vitaceae	*Vitis vinifera*	Common grapevine	USA	Riverside Co., CA	fastidiosa	fastidiosa	P	NA	NA	Yuan et al., 2010
Vitaceae	*Vitis vinifera*	Common grapevine	USA	Napa Co., CA	fastidiosa	fastidiosa	P	NA	NA	Yuan et al., 2010
Vitaceae	*Vitis vinifera*	Common grapevine	USA	Mendocino Co., CA	fastidiosa	fastidiosa	P	NA	NA	Yuan et al., 2010
Vitaceae	*Vitis vinifera*	Common grapevine	USA	Blanco Co., TX	fastidiosa	fastidiosa	P	NA	NA	Yuan et al., 2010
Vitaceae	*Vitis vinifera*	Common grapevine	USA	Travis Co., TX	fastidiosa	fastidiosa	P	NA	NA	Yuan et al., 2010
Vitaceae	*Vitis vinifera*	Common grapevine	USA	San Joaquin Co., CA	fastidiosa	fastidiosa	P	NA	NA	Yuan et al., 2010
Vitaceae	*Vitis vinifera*	Common grapevine	USA	GA	fastidiosa	fastidiosa	P	NA	NA	Yuan et al., 2010
Vitaceae	*Vitis vinifera*	Common grapevine	USA	FL	fastidiosa	fastidiosa	P	NA	NA	Yuan et al., 2010
Vitaceae	*Vitis vinifera*	Common grapevine	USA	Fayette Co., KY	fastidiosa	fastidiosa	P	NA	NA	Yuan et al., 2010
Vitaceae	*Vitis vinifera*	Common grapevine	USA	Napa County, CA	NA	fastidiosa	H	E	ELISA	Raju et al., 1983
Vitaceae	*Vitis vinifera*	Common grapevine	Taiwan	Taichung city	NA	NA	NA	S	PCR	Su et al., 2013
Vitaceae	*Vitis vinifera*	Common grapevine	Taiwan	Nantou County	NA	NA	NA	S	PCR	Su et al., 2013
Vitaceae	*Vitis vinifera*	Common grapevine	Taiwan	Maoli County	NA	NA	NA	S	PCR	Su et al., 2013
Vitaceae	*Vitis vinifera*	Common grapevine	Taiwan	NA	NA	NA	NA	E	PCR	Su et al., 2013
Vitaceae	*Vitis vinifera* var. Beni Taka	Common grapevine	Brazil	Araraquara, SP	NA	pauca	P	E	Symptoms, ELISA, PCR	Li et al., 2002
Vitaceae	*Vitis* sp. Cultivar Blue Vernon Seeedless	Common grapevine	Yugoslavia	Cermjan (Kosova)	NA	NA	NA	E	electron microscopy, ELISA, PCR, culture	Berisha et al., 1998
Vitaceae	*Vitis vinifera* var. Cabernet	Common grapevine	USA	greenhouse University of California, Berkeley	NA	fastidiosa	H	E	Symptoms, cultures, confocal laser-scanning microscopy	Newman et al., 2003
Vitaceae	*Vitis vinifera* var. Cabernet sauvignon	Common grapevine	USA	University of California, Berkeley	NA	fastidiosa	H	E	Cultures, PCR	Newman et al., 2004

Plant family	Plant species	Plant common name	Country of detection/ experimentation	Location of detection/ experimentation	*X.fastidiosa* subspecies mentioned in the paper	*X. fastidiosa* putative subspecies	Justification for putative subspecies	Method by which infection determined	Detection protocol	Citation
Vitaceae	*Vitis vinifera* Cabernet Sauvignon	Common grapevine	USA	US Davis campus	NA	fastidiosa	H	NA	NA	Chatelet et al., 2011
Vitaceae	*Vitis vinifera* var. Cabernet Sauvignon	Common grapevine	USA	CA	fastidiosa	fastidiosa	P	E	Cultures	Lopes et al., 2009
Vitaceae	*Vitis vinifera* cv. Chardonnay	Common grapevine	USA	Temecula, CA	NA	fastidiosa	P	S	ELISA, PCR	Bextine and Miller, 2004
Vitaceae	*Vitis vinifera* cv. Chardonnay	Common grapevine	USA	Greenhouse (State University?), NC	NA	fastidiosa	H	E	DAS-ELISA, PCR	Myers et al., 2007
Vitaceae	*Vitis vinifera* Chardonnay	Common grapevine	USA	US Davis campus	NA	fastidiosa	H	NA	NA	Chatelet et al., 2011
Vitaceae	*Vitis vinifera* cv. Chardonnay	Common grapevine	USA	University of California, Riverside, CA	NA	fastidiosa	P	S	ELISA, PCR	Bextine and Miller, 2004
Vitaceae	*Vitis vinifera* cv. Chardonnay	Common grapevine	USA	Department of Viticulture and Enology, University of California, Davis, CA	NA	fastidiosa	H	E	DAS-ELISA	Buzkan and Walker, 2004
Vitaceae	*Vitis vinifera* var. Chardonnay	Grapevine	USA	CA	NA	pauca	P	E	Symptoms	Li et al., 2002
Vitaceae	*Vitis vinifera* cv. Chardonnay	Common grapevine	USA	Davis, CA	NA	fastidiosa	H	E	qPCR	Gambetta et al., 2007
Vitaceae	*Vitis vinifera* (Emperor variety)	Common grapevine	USA	NA	NA	fastidiosa	H	E	Symptoms	Houston and Esau, 1947
Vitaceae	*Vitis vinifera* var. Italia	Common grapevine	Brazil	Araraquara, SP	NA	pauca	P	E	Symptoms, ELISA, PCR	Li et al., 2002
Vitaceae	*Vitis vinifera* var. Niagara	Common grapevine	Brazil	Araraquara, SP	NA	pauca	P	E	Symptoms, ELISA, PCR	Li et al., 2002
Vitaceae	*Vitis vinifera* Pinot Noir	Common grapevine	USA	US Davis campus	NA	fastidiosa	H	NA	NA	Chatelet et al., 2011
Vitaceae	*Vitis vinifera* var. Rubi	Common grapevine	Brazil	Araraquara, SP	NA	pauca	P	E	Symptoms, ELISA, PCR	Li et al., 2002
Vitaceae	*Vitis vinifera* Sylvaner	Common grapevine	USA	US Davis campus	NA	fastidiosa	H	NA	NA	Chatelet et al., 2011
Vitaceae	*Vitis vinifera* "Thompson Seedless"	Thompson seedless grape	USA	NA	NA	fastidiosa	H	NA	Primary isolations obtained from contributors	Wells et al., 1987
Vitaceae	*Vitis vinifera* "Red Flame"	Red flame grape	USA	CA (Riverside and Redlands areas)	NA	fastidiosa	P	S	ELISA, PCR, culture	Wong et al., 2004

Plant family	Plant species	Plant common name	Country of detection/ experimentation	Location of detection/ experimentation	*X.fastidiosa* subspecies mentioned in the paper	*X. fastidiosa* putative subspecies	Justification for putative subspecies	Method by which infection determined	Detection protocol	Citation
Vitaceae	*Vitis vinifera* "Thompson Seedless"	Thompson seedless grape	USA	CA (Riverside and Redlands areas)	NA	fastidiosa	P	S	ELISA, PCR, culture	Wong et al., 2004
Vitaceae	*Vitis vinifera* "Thompson Seedless"	Thompson seedless grape	USA	FL	NA	fastidiosa	H	S	Electron microscopy	Mollenhauer and Hopkins, 1974
Vitaceae	*Vitis* sp. (Thompson seedless grape)	Thompson seedless grape	USA	Agricultural Research Centre in Leesburg, FL	NA	fastidiosa	H	S	Electron microscopy, symptoms	Hopkins et al., 1973
Xanthorrhoeaceae	*Hemerocallis* sp.	Day lily	USA	CA (Riverside and Redlands areas)	sandyi	sandyi	P	S	Symptoms, ELISA, PCR, culturing	Wong's report: http://celosangeles.ucanr.edu/newsletters/Fall_200534798.pdf; Wong et al., 2004
Xanthorrhoeaceae	*Hemerocallis* sp.	Day lily	USA	Riverside Co., CA	sandyi	sandyi	P	NA	NA	Yuan et al., 2010

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Appendix C. European putative vectors of *Xylella fastidiosa*

Xylem-sap feeders Taxonomy	Species	Distribution	Host plant	Life cycle	Potential role as vector	Potential role as vector: criteria	Citation
Sharpshooter Cicadellinae Cicadellini	*Cicadella lasiocarpae* Ossiannilsson 1981	Belarus, Britain, Danish mainland, Finland, Germany, Ireland, Russia North, Sweden, East Palaearctic	*Carex* sp., *Carex lasiocarpa*, *Carex nigra*, *Carex vesicaria* and others	Univoltine	Low	Host range restricted to *Carex* spp.	Ossiannilsson, 1981; Nickel and Remane, 2002; Nickel, 2003; Soderman, 2007; Kunz et al., 2011; Malenovsky, 2013
	Cicadella viridis (Linnaeus 1758)	Albania, Austria, Belgium, Britain, Bulgaria, Croatia, Czech Republic, Danish mainland, Estonia, Finland, France, Germany, Greek mainland, Hungary, Ireland, Italy (also Sardinia and Sicily), Latvia, Lithuania, Moldavia, Norwegian mainland, PL, Romania, Russia (North, South, Central), Slovakia, Slovenia, Spain (mainland), Sweden (incl. Gotland), Switzerland, The Netherlands, Ukraine, Serbia, Kosovo, Montenegro and present also in East Palaearctic, Near east and Nearctic region and oriental region	Grasses, willow stand, lowland bog and transitional bog; Juncaceae and Cyperaceae, *Juncus* and *Carex* and others	Univoltine or bivoltine	Moderate to High	Very common, wide host range but hygrophilous	Anufriev and Smirnova, 2009; Sára and Riedle-Bauer, 2009; Kunz et al., 2010; Malenovsky, 2013;
	Graphocephala fennahi Young 1977	Britain, Germany, Italian mainland, Switzerland, The Netherlands and Nearctic region	*Rhododendron* spp. and woody plants	Univoltine	Low	Host range restricted to *Rhododendron* spp.	Sergel, 1987; Nikusch, 1992; Łabanowski and Soika, 1997; Nickel and Remane, 2002
Sharpshooter Cicadellidae Evacanthini	*Evacanthus acuminatus* (Fabricius 1794)	Albania, Austria, Belgium, Britain, Bulgaria, Croatia, Czech republic, Danish mainland, Estonia, Finland, France, Germany, Greek	Grasses, oak forest, humid shady habitats, *Lamiaceae* and others	Univoltine	Low	Uncommon, restricted to grasses	Nickel and Remane, 2002; Anufriev, 2006; Anufriev and Smirnova, 2009

		mainland, Hungary, Ireland, Italy (also Sicily), Latvia, Lithuania, Moldavia, Norwegian mainland, PL, Romania, Russia (Central, North and South), Slovakia, Slovenia, Spain mainland, Sweden, Switzerland, The Netherlands, Ukraine, Serbia, Kosovo, Montenegro and worldwide East Palaearctic, Near east and Nearctic region					
	Evacanthus interruptus (Linnaeus 1758)	Albania, Austria, Belgium, Britain, Bulgaria, Croatia, Danish mainland, Estonia, Finland, Germany, Greek mainland, Hungary, Ireland, Italian mainland and Sicily, Moldavia, Norwegian mainland, Poland, Portuguese mainland, Romania, Russia (Central, North, South), Slovakia, Slovenia, Spain, Sweden, Switzerland, The Netherlands, Ukraine, Serbia, Kosovo	In forest with high grasses, forest edges and ruderal areas from perennials and herbs, *Asteraceae*, *Urtica*, *Epilobium* and others	Univoltine	Low	Uncommon, restricted to grasses	Nickel and Remane, 2002; Anufriev, 2006; Orosz, 2008; Sára and Riedle-Bauer, 2009
	Evacanthus rostagnoi (Picco 1921)	Italian mainland and the rest—no data			Low	Very restricted area of distribution, uncommon	
Sharpshooter Cicadellinae Anoterostemmatini	*Anoterostemma ivanoffi* (Lethierry 1876)	Italian mainland, Moldavia, Romania, Russia South, Ukraine, Serbia, Kosovo and East Palaearctic and Near East	*Juncus* sp.		Low	Host range restricted to *Juncus* spp.	Lodos and Kalkandelen, 1983; Gnezdilov, 2000
Sharpshooter Cicadellinae Errhomenini	*Errhomenus brachypterus* Fieber	Austria, Belgium, Czech Republic, French mainland, Germany, Hungary, Italian mainland, Poland, Romania, Slovakia, Switzerland, The Netherlands, Ukraine, Serbia, Kosovo, Montenegro	Roots?	Univoltine or bivoltine	Low	Uncommon, unknown biology and ecology	Nickel and Remane, 2002
Spittlebugs	*Aphrophora alni*	Albania, Austria, Belgium,	Forest with *Alnus glutinosa* and *Acer*	Univoltine	Moderate	Common, wide	Fahringer, 1922, cited

Aphrophoridae	(Fallen 1805)	Bosnia and Herzegovina, Britain, Bulgaria, Greece (mainland and Crete, Cyclades), Croatia, Czech republic, Danish mainland, Estonia, Finland, French mainland, Germany, Hungary, Ireland, Italian mainland (Sardinia and Sicily - present,), Latvia, Lithuania, Macedonia, Malta, Moldavia, Norwegian mainland, Poland, Portuguese mainland, Romania, Russia (Central, North, South), Slovakia, Slovenia, Spanish mainland, Sweden, Switzerland, The Netherlands, Ukraine, Serbia, Kosovo, Montenegro and East Palaearctic, Near East, North Africa	*pseudoplatanus*, meadow with *Salix viminalis*, *Oryza sativa*, *Pisum sativum*, *Vitis vinifera*, *Corylus avellana*, *Cornus mas*, *Rubus fructicosus*, *Crataegus*, *Amygdalus communis*, *Juglans regia*, *Prunus domestica*, *P. avium*, *P. cerasus*, *Rosa* sp., *Cynodon vulgaris*, *Mespilus germanica*, *Salix*, *Populus*, *Alnus*, *Fagus silvatica*, *Ulmus*, *Urtica* sp., *Verbascum*, *Alnus incana* and *A. orientalis*—nymphs live on low vegetation —*Trifolium*, *Hypericum*, *Erigeron*, *Hieracium*, *Taraxacum*, and adults on forests and shrubs *Corylus avellana*, spruce forest, oak forest and willow stand, diverse deciduous trees (*Alnus*, *Betula*, *Salix*); woody plants, nymphal stages on dicotyledonous herbs		to high	host range	by Lodos and Kalkandelen, 1981; Dlabola, 1961, cited by Lodos and Kalkandelen, 1981; Ural et al., 1973, cited by Lodos and Kalkandelen, 1981; Nickel and Remane, 2002; Orosz 2008; Anufriev and Smirnova, 2009; Świerczewski and Blaszczyk, 2010
	Aphrophora corticea (Germar 1821)	Albania, Austria, Belgium, Czech Republic, Danish mainland, French mainland, Germany, Greek mainland, Italian mainland, Norwegian mainland, Poland, Portuguese mainland, Slovakia, Slovenia, Spanish mainland, Sweden, Switzerland, Ukraine, Serbia, Kosovo, Montenegro	*Pinus*, *Cupressus*, *Quercus*, *Pyrus communis* and *Verbascum*; *Pinus sylvestris* and nymphs on dwarf shrubs	Univoltine	Low to moderate	Wide host range but rather uncommon	Lodos and Kalkandelen, 1981; Nickel and Remane, 2002
	Aphrophora major Uhler 1896	Austria, Britain, Czech Republic, French mainland, Germany, Ireland, Italian mainland, Poland, Russia (Central, North,), Switzerland, The Netherlands, Ukraine, Serbia, Kosovo, Montenegro and East Palaearctic	*Salix*, *Betula* Nymphs mainly on dicotyledonous herbs	Univoltine	Low	Wide area of distribution but uncommon	Nickel and Remane, 2002
	Aphrophora pectoralis Matsumura 1903	Austria, Belgium, Britain, Bulgaria, Czech Republic, Estonia, Finland, French mainland, Germany, Greek mainland, Italian mainland,	*Salix caprea*, *Salix purpurea* and others	Univoltine	Low	Host range restricted to *Salix* spp.	Nickel and Remane, 2002

	Latvia, Lithuania, Norwegian mainland, Poland, Romania, Russia north, Sweden, The Netherlands, Serbia, Kosovo, Montenegro, East Palaearctic					
Aphrophora salicina (Goeze 1778)	Albania, Austria, Belgium, Britain, Bulgaria, Croatia, Czech Republic, Danish mainland, Estonia, French mainland, Germany, Greek mainland, Hungary, Ireland, Italian mainland (Sardinia also), Latvia, Lithuania, Moldavia, Norwegian mainland, Poland, Portuguese mainland, Romania, Russia (Central and North, South), Slovakia, Slovenia, Spanish mainland, Sweden, Switzerland, The Netherlands, Ukraine, Vatican City, Serbia, Kosovo, Montenegro and East Palaearctic and Near East	*Salix, Robinia pseudacacia, Rubus fructicosus- Populus* and *Fraxinus;* various species of *Populus, Salix alba, Salix purpurea* and others	Univoltine	Moderate	Wide area of distribution, common, oligophagous	Müller, 1957, cited by Ai-Ping Liang, 2006; Dlabola, 1961, cited by Lodos and Kalkandelen, 1981; Ossiannilsson, 1978, cited by Ai-Ping Liang, 2006; Nickel and Remane, 2002; Ai-Ping Liang, 2006; Orosz, 2008
Aphrophora similis Lethierry 1888	Poland	Peatbogs and marshes		Low	Very restricted area of distribution, limited to marshes and peatbogs	Świerczewski and Gebicki, 2002, 2003
Aphrophora willemsi Lallemand 1946, synonymous of A. salicina?	Belgium			Low	Very restricted area of distribution, unknown biology and ecology	Ai-Ping Liang, 2006
Lepyronia coleoptrata (Linnaeus 1758)	Albania, Austria, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, Danish mainland, Estonia, European Turkey, Finland, French mainland, Germany, Greek mainland, Hungary, Italian mainland	*Poa annua, Trifolium repens*, plants up to 10 cm high; mainly *Poaceae*, dicotyledonous herbs and others	Univoltine	Low to moderate	Restricted to grasses	Nickel and Remane, 2002; Tishechkin, 2011

	(Sardinia and Sicily), Latvia, Lithuania, Macedonia, Moldavia, Norwegian mainland, Poland, Portuguese mainland, Romania, Russia (Central, North, South), Slovakia, Slovenia, Spanish mainland, Sweden, Switzerland, The Netherlands, Ukraine, Serbia, Kosovo, Montenegro and East Palaearctic, Near East and North Africa					
Neophilaenus albipennis (Fabricius 1798)	Austria, Bulgaria, Czech Republic, Estonia, French mainland, Germany, Greek mainland, Hungary, Italian mainland (also Sardinia), Poland, Romania, Slovakia, Switzerland, Ukraine, Serbia, Kosovo, Montenegro, and East Palaearctic, and North Africa	*Brachypodium pinnatum*; weeds	Univoltine	Low	Uncommon, narrow host range	Lodos and Kalkandelen, 1981; Nickel and Remane, 2002; Biedermann, 2004
Neophilaenus campestris (Fallen 1805)	Albania, Austria, Belgium, Britain, Bulgaria, Cyprus, Czech Republic, Danish mainland, Estonia, French mainland, Germany, Greek mainland, Hungary, Ireland, Italian mainland (Sardinia and Sicily), Latvia, Lithuania, Norwegian mainland, Poland, Portuguese mainland, Romania, Russia (Central, North, South), Slovakia, Slovenia, Spain (Spanish mainland, Balearic Is.), Sweden, Switzerland, The Netherlands, Ukraine, Serbia, Kosovo, Montenegro and also East Palaearctic, Near East and North Africa	Dry grasslands; *Poaceae*	Univoltine	Low	Restricted to grasses in dry ecosystems	Morris, 1981; Nickel and Remane, 2002; Orosz, 2008
Neophilaenus exclamationis (Thunberg 1784)	Albania, Austria, Belgium, Britain, Bulgaria, Croatia, Czech Republic, Danish	Pine forest and *Festuca ovina*, *Deschampsia flexuosa*; *Festuca ovina*, *Deschampsia flexuosa*?	Univoltine	Low	Restricted to gramineous grasses and	Nickel and Remane, 2002; Świerczewski and Blaszczyk, 2010

	mainland, Estonia, Finland, French mainland, Germany, Greek mainland, Hungary, Italian mainland, Latvia, Lithuania, Norwegian mainland, Poland, Russia (Central, North), Slovakia, Slovenia, Sweden, Switzerland, Ukraine, Serbia, Kosovo, Montenegro and East Palaearctic, Near East, North Africa)				pine forests	
Neophilaenus infumatus (Haupt 1917)	Albania, Austria, Bulgaria, Czech Republic, French mainland, Germany, Hungary, Italian mainland (Sicily), Poland, Romania, Slovakia, Switzerland, Serbia, Kosovo, Montenegro and East Palaearctic, Near East,	*Festuca ovina* (and others?)	Univoltine	Low	Very uncommon, restricted to grasses	Nickel and Remane, 2002
Neophilaenus limpidus (Wagner 1935)	Italian mainland, Slovenia			Low	Very limited area of distribution, unknown biology and ecology	
Neophilaenus lineatus (Linnaeus 1758)	Albania, Austria, Belgium, Britain, Bulgaria, Czech Republic, Danish mainland, Estonia, Finland, French mainland, Germany, Greece (Greek mainland, Dodecanese Is.), Hungary, Ireland, Italian mainland (also Sardinia and Sicily), Latvia, Lithuania, Macedonia, Moldavia, Norwegian mainland, Poland, Portuguese mainland, Romania, Russia (Central, North), Slovakia, Slovenia, Spain (Spanish mainland, Balearic Is.), Sweden, Switzerland, The Netherlands, Ukraine, Serbia,	*Juncus squarrosus*; meadow and *Poaceae* weeds, *Phragmites*, *Thuja* sp., forest meadow, especially on *Trifolium armenicum*. It also lives on steppe vegetation besides moist meadow, upland bog, hygrophilous species, feeding on various grasses, on *Cyperaceae, Juncaceae*; *Poaceae*	Univoltine	Low	Limited to forest meadow ecosystem	Fahringer, 1922, cited by Lodos and Kalkandelen, 1981; 1981; Lodos and Kalkandelen, 1981; Brooks and Whittaker, 1999; Nickel and Remane, 2002; Orosz, 2008; Anufriev and Smirnova, 2009

	Kosovo, Montenegro and East Palaearctic, Near East, Nearctic region, North Africa					
Neophilaenus longiceps (Puton 1895)	Britain, French mainland, Portuguese mainland, Spanish mainland and North Africa			Low	Limited area of distribution, unknown biology and ecology	
Neophilaenus minor (Kirschbaum 1868)	Albania, Austria, Belgium, Bulgaria, Czech Republic, Finland, French mainland, Germany, Greek mainland, Hungary, Italian mainland, Latvia, Lithuania, Poland, Portuguese mainland, Slovakia, The Netherlands, Ukraine, Serbia, Kosovo, Montenegro and East Palaearctic and Near East	*Festuca ovina*, *Corynephorus canescens*, pine forests, mixed forests, steppe biotype, *Stipa* sp.; *Festuca ovina*, *Coryneophorus* and others	Univoltine	Low	Restricted to gramineous grasses, uncommon	Emelyanov 1964, cited by Lodos and Kalkandelen 1981; Lodos and Kalkandelen 1981; Nickel and Remane, 2002; Świerczewski and Blaszczyk, 2010
Neophilaenus modestus (Haupt 1922)	Austria, Hungary, Romania, Serbia (Voivodina), Kosovo, Montenegro			Low	Limited area of distribution, unknown biology and ecology	
Neophilaenus pallidus (Haupt 1917)	Danish mainland, Germany, Lithuania, The Netherlands			Low	Limited area of distribution, unknown biology and ecology	
Paraphilaenus notatus (Mulsant & Rey 1855)	French mainland, Russia (South), Ukraine and East Palaearctic, Near East	*Poaceae*		Low	Limited area of distribution, restricted to Poaceae	Kolova, 2011
Peuceptyelus coriaceus (Fallen 1826)	Belarus, Estonia, Finland, Latvia, Lithuania, Poland, Russia (North) and East Palaearctic			Low	Limited area of distribution, unknown biology and ecology	
Philaenus italosignus Drosopoilos & Remane 2000	Italian mainland (Sardinia; absent; Sicily: present)	Asphodel growing under or between trees and shrubs. D'Urso (personal communication) has collected this species in Sicily after July exclusively on oaks		Low	Very limited area of distribution, uncommon	Drosopoulos, 2003

Philaenus lukasi Drosopoulos & Asche 1991	Greek mainland			Low	Very limited area of distribution, unknown biology and ecology	
Philaenus maghresignus Drosopoulos & Remane 2000	Portuguese mainland, Spanish mainland and North Africa	*Asphodelus* growing under and between oaks "exclusively on oaks"		Low	Very limited area of distribution, restricted to oak woodlands	Drosopoulos, 2003
Philaenus signatus Melichar 1896	Albania, Greece (Greek mainland, Crete, Cyclades, Dodecanese Is., North Aegean Is.), Croatia, Cyprus and Near East	Nymphs: lily *Asphodelus microcarpus* and later on shrubs and trees like *Quercus* and *Castanea sativa*	Univoltine	Low	Limited area of distribution, restricted to oak and chestnut woodlands	Drosopoulos, 2003
Philaenus spumarius (L.)	Albania, Austria, Belgium, Bosnia and Herzegovina, Britain (Channel Is., Gibraltar), Bulgaria, Croatia, Cyprus, Czech Republic, Danish mainland, Estonia, European Turkey, Finland, France (French mainland, Corsica), Germany, Greece (Greek mainland, Crete, Cyclades, Dodecanese Is., North Aegean Is.), Hungary, Ireland, Italian mainland (also Sardinia and Sicily), Latvia, Lithuania, Macedonia, Malta, Moldavia, Norwegian mainland, Poland, Portugal (Portuguese mainland, Azores), Romania, Russia (Central, North, South), Slovakia, Slovenia, Spain (Spanish mainland, Balearic Is., Canary Is.), Sweden, Switzerland, The Netherlands, Ukraine, Serbia, Kosovo, Montenegro and also worldwide: Afro -tropical	Generally on *Poaceae* and other herbs, on shrubs and trees; willow stand and *Alnus* forest; mainly dicotyledonous herbs	Univoltine	High	Very common and abundant in diverse ecosystems	Purcell, 1980; Lodos and Kalkandelen, 1981; Nickel and Remane, 2002; Orosz, 2008; Anufriev and Smirnova, 2009; Kunz et al., 2010; Saponari et al., 2014

		regions, Australian region, East Palaearctic, Near east, Nearctic region, Neotropical region, North Africa and oriental region					
	Philaenus tarifa Remane & Drosopoulos 2001	Spanish mainland	Herbs and shrubs and on oaks during the dry season and this species aestivates on trees and shrubs		Low	Very limited area of distribution, uncommon	Drosopoulos, 2003.
	Philaenus tesselatus Melichar 1899	Spanish mainland and North Africa	On various herbaceous plants, trees and shrubs		Low	Very limited area of distribution, uncommon	Drosopoulos, 2003.
pittlebugs Cercopidae	*Cercopis arcuata* Fieber 1844	Austria, Bulgaria, Czech Republic, French mainland, Germany, Greek mainland, Hungary, Italian mainland (Sicily - present and absent in Sardinia, Romania, Russia (Central), Slovakia, Serbia, Kosovo, Montenegro	Mainly dicotyledonous herbs?	Univoltine	Low	Very rare, extinct?	Nickel and Remane, 2002
	Cercopis intermedia Kirschbaum 1868	Albania, Bulgaria, French mainland, Germany (doubtful), Greek mainland, Italian mainland, Portuguese mainland, Russia South, Spanish mainland, Switzerland (doubtful), Serbia, Kosovo, Montenegro and also Near east and North Africa	Herbaceous plants and weeds, *Astragalus*, *Onopordon*, *Verbascum*, *Medicago sativa* and some trees *Pistacia vera*, *prunus domestica*, *Acacia*, *Salix*, *Alnus*		Low	Uncommon, unknown biology and ecology	Lodos and Kalkandelen 1981
	Cercopis sabaudiana Lallemand 1949	French mainland, Italian mainland (doubtful)			Low	Limited area of distribution, uncommon, unknown biology and ecology	
	Cercopis sanguinolenta (Scopoli 1763)	Albania, Austria, Belgium, Bulgaria, Croatia, Czech Republic, French mainland, Germany, Greek mainland, Hungary, Italian mainland	*Cytisus scoparius*; weeds *Medicago sativa*, *Rubus fructicosus*, *Pyrus communis*, *Pyrus malus*, *Castanea vesca*); "feeding on various herbs" mainly dicotyledonous herbs	Univoltine	Low	Wide area of distribution, but uncommon	Lodos and Kalkandelen 1981; Nickel and Remane, 2002; Orosz, 2008

		(Sicily: present; Sardinia: absent), Moldavia, Poland, Portuguese mainland, Romania, Russia South, Slovakia, Slovenia, Spanish mainland, Switzerland, Ukraine, Serbia, Kosovo, Montenegro					
	Cercopis vulnerata Rossi 1807	Albania, Austria, Belgium, Britain, Bulgaria, Croatia, Czech Republic, French mainland, Germany, Greek mainland, Hungary, Italian mainland (Sardinia and Sicily: absent), Moldavia, Norwegian mainland, Poland, Romania, Russia (Central, South), Slovakia, Slovenia, Spanish mainland, Switzerland, the Netherlands, Serbia, Kosovo, Montenegro	*Rubus fructicosus, Crataegus* sp., *Prunus* sp., *Ulmus, Quercus, Linum usitatissimum*; mainly dicotyledonous herbs	Univoltine	Moderate	Wide area of distribution, many host plants but mainly associated with herbaceous plants	Lodos and Kalkandelen 1981; Nickel and Remane, 2002; Kunz et al., 2010
	Haematoloma dorsata (Ahrens 1812)	Austria, Belgium, French mainland, Germany, Greek mainland, Italian mainland (Sardinia - absent, Sicily - present), Portuguese mainland, Spanish mainland, Switzerland, The Netherlands, Serbia, Kosovo, Montenegro and Near East	Eggs laid on grasses, mostly *Poaceae.* Adults feeds on needles of *Pinaceae* and *Cupressaceae*, *Pinus sylvestris*, various weeds, Leguminosae, *Linum usitatissimum, Quercus, Prunus, Populus, Crataegus*, *Rosa* sp.		Low to moderate	Limited to ecosystems of Pinaceae and Cupressaceae with gramineous plants	Lodos and Kalkandelen, 1981; Roversi and Baccetti, 1994; Moraal, 1996
	Triecphorella geniculata (Horvath 1881)	Croatia, European Turkey, Greek mainland, Serbia, Kosovo, Montenegro and Near East			Low	Very restricted area of distribution, uncommon	
Cicadas Cicadidae	*Cicada barbara lusitanica* Boulard	Portugal	Habitat: garrigue, open woods, usually singing on *Eucalyptus globulus, Oleae europea, Ceratonia siliqua, Pinus pinaster, Pistacia lentiscus etc.* (Sueur et al., 2004)	Emergence time: from end of June until September			Sueur et al., 2004
	Cicada barbara (Stal)	Spain					
	Cicada mordoganensis	North Aegean Is.					

	Boulard				
	Cicada orni Linnaeus	Albania, Austria, Bulgaria, Crete, Croatia, Cyprus, Czech Republic, France (including Corsica), Germany, Greece (including Crete,, Dodecanese Is., North Aegean Is.), Hungary, Italy (including Sardinia, Sicily), Slovakia, Slovenia, Spain, Serbia Kosovo, Montenegro	Generally found in open woodlands. Males calling on trees such as Cupressus spp., Eucalyptus globulus, Olea europea, Pinus pinaster, Pinus alpensis, Quercus spp.; found on fruit and some garden trees (Sueur et al., 2004)	Time of emergence: from June until October	Sueur et al., 2004
	Cicadatra alhageos (Kolenati)	Greek mainland			
	Cicadatra atra (Olivier)	Albania, Bulgaria, Corsica, Cyprus, Dodecanese Is, French mainland, Greek mainland, Italian mainland, Romania, Sicily, Spanish mainland, Switzerland, Serbia, Kosovo, Montenegro			
	Cicadatra hyalina (Fabricius)	Greek mainland, Serbia, Kosovo, Montenegro			
	Cicadatra hyalinata (Brullé)	Greek mainland			
	Cicadatra persica Kirkaldy	Monaco			
	Lyristes plebejus (Scopoli)	Albania, Austria, Bulgaria, Cyprus, Czech Republic, France, Germany, Greece, Hungary, Italy (including Sardinia, Sicily), Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Switzerland, Serbia, Kosovo, Montenegro	Mainly in open woods (Sueur et al., 2004)	Time of emergence: from late June until August	Sueur et al., 2004
Cicadas Tibicinidae	*Cicadetta albipennis* Fieber	Greek mainland, Sicily			
	Cicadetta	Croatia			

concinna (Germar)	
Cicadetta dubia (Rambur)	Spain
Cicadetta fangoana Boulard	France
Cicadetta flaveola (Brullé)	Greek mainland, Sicily
Cicadetta hageni Fieber	Cyprus, Greek mainland
Cicadetta mediterranea Fieber	Bulgaria, Croatia, Italy (including Sicily), Serbia, Kosovo, Montenegro
Cicadetta montana macedonica Schedl	Monaco
Cicadetta montana (Scopoli)	Albania, Austria, Belgium, Britain I., Bulgaria, Croatia, Czech Republic, Denmark,
Cicadetta petryi Schumacher	Finland, France (including Corsica), Germany, Greece, Hungary, Italy (including Sicily), Norway, Poland, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland
Cicadetta podolica (Eichwald)	France, Germany
Cicadetta undulata (Waltl)	Croatia, Poland, Romania, Spain
Cicadivetta tibialis (Panzer)	Albania, Austria, Bulgaria, Crete, Croatia, Czech Republic, France, Germany, Greece, Hungary, Italy (including Sicily), Slovakia, Slovenia, Spain, Serbia, Kosovo, Montenegro
Hilaphura varipes (Waltl)	Spain

Pagiphora annulata (Brullé)	Albania, Bulgaria, Czech Republic, Greece, Macedonia, Slovakia, Serbia, Kosovo, Montenegro			
Pagiphora aschei Kartal	Crete			
Tettigetta aneabi Boulard	Spain			
Tettigetta argentata (Olivier)	France, Italy (including Sicily), Portugal, Slovenia, Spain	Habitat: garrigue and open woods, singing on *Arbutus unedo*, *Cistus ladanifer*, *Eucalyptus globulus*, *Olea europea*, *Pinus* sp. and *Quercus* sp.	Time of emergence: from late June until July	Sueur et al., 2004
Tettigetta atra (Gómez-Menor Ortega)	Portugal, Spain			
Tettigetta baenai Boulard	Spain			
Tettigetta brullei Fieber	Albania, Croatia, France, Greece, Italy, Slovenia, Spain			
Tettigetta carayoni Boulard	Crete			
Tettigetta dimissa (Hagen)	Albania, Greece (including Crete), Italy (including Sicily), Slovenia, Serbia, Kosovo, Montenegro			
Tettigetta estrellae Boulard	Portugal	Woods dominated by *Pinus pinaster* and *Eucalyptus globulus*	Time of emergence: from June to August, 2004	Sueur et al., 2004
Tettigetta josei Boulard	Portugal	Mixed low vegetation with small bushes as *Cistus* spp. and herbaceous plants. Sometimes also on trees	Time of emergence: from June to August	Sueur et al., 2004
Tettigetta leunami Boulard	Spain			
Tettigetta manueli Boulard	Spain			
Tettigetta mariae Quartau & Boulard	Portugal	Near the sea in woods dominated by pinus pinaster and *P. pinea* and singing also on *Cistus ladanifer* and *Olea europea*. Also	Time of emergence: from July to	Sueur et al., 2004

		found in marshes along the sea.	August	
Tettigetta musiva (Germar)	Cyprus			
Tettigetta pygmaea (Olivier)	France, Italy, Spain			
Tibicina cisticola larestifi Boulard	Corsica			
Tibicina cisticola (Hagen)	France, Sardinia			
Tibicina contentei (Boulard)	Portugal			
Tibicina corsica (Rambur)	Corsica, Sardinia	Habitat: open grassland where the main plant species were *Bituminaria bituminosa*, *Foeniculum vulgare* and *Thymus vulgaris*		Sueur and Sanborn, 2003, cited by Sueur et al., 2004
Tibicina fairmairei Boulard	France			
Tibicina garricola Boulard	France	Mainly associated with macchie and garrigue, singing on *Arbutus unedo*, *Cistus* spp., *Olea europea*, *Pistacea lentiscus* and *Quercus coccifera*. Found in closed or semi-closed habitats with percentage of ligneous plants higher than 40, height being not important in habitat occupation	Time of emergence: from the end of June until the beginning of August	Sueur et al., 2004
Tibicina haematodes (Scopoli)	Albania, Austria, Bulgaria, Croatia, Czech Republic, France (including Corsica), Germany, Greece, Hungary, Italy (including Sicily), Macedonia, Portugal, Romania, Slovakia, Slovenia, Spain, Switzerland, Serbia, Kosovo, Montenegro			
Tibicina luctuosa (Costa)	Sardinia			
Tibicina nigronervosa	France, Italy, Spain			

Fieber				
Tibicina picta (Fabricius)	France, Italy (including Sardinia), Spain			
Tibicina quadrisignata (Hagen)	France, Portugal, Spain	Open woods with *Cistus* spp. singing on *Castanea sativa*, *Cistus ladanifer*, *Oleae europea*, *Pinus pinaster* and *Quercus pyrenaica*	Time of emergence: from end of June until beginning of August	Sueur et al., 2004
Tibicina tomentosa (Olivier)	France, Italy (including Sardinia), Spain	Single calling male observed on *Cistus* sp. (high moor locally associated with an open wood of *Quercus suber*)	Time of emergence: from June until July	Sueur et al., 2004
Tympanistalna distincta (Rambur)	Spain			
Tympanistalna gastrica (Stal)	Bulgaria, Greece, Portugal, Sicily			

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Appendix D. American vectors of *Xylella fastidiosa*

Taxonomy	Species [a]	Country of report [b]	Source/recipient plant	Transmission to indicator plant	Host plant	Role as vector	Role as vector - criteria	Citation
Sharpshooter Cicadellidae Cicadellini	*Amphigonalia severini* (DeLong, 1948)	USA, restricted to Arizona, New Mexico, Texas	Grape/grape		Grape	Low	Not associated with disease epidemics	Severin, 1949; Nielson and Gill, 1984; Menke et al., 1999
	Bucephalogonia xanthophis (Berg, 1879)	New World (Neotropical): Argentina, Bolivia, Brazil, Paraguay	Citrus/citrus		*Citrus sinensis*, *Vernonia condensata*, *Duranta repens*	High	Common, abundant on ornamental plants and nursery stocks	Krügner et al., 2000; Ciapina et al., 2004; Bento et al., 2008; De Miranda et al., 2008, 2013
	Dilobopterus costalimai Young, 1977	Brazil (São Paulo)	Citrus/citrus		*Citrus sinensis*, *Vernonia condensata*, *Aloysia virgata*	High	Common, abundant on ornamental plants	Almeida and Lopes, 1999; Krügner et al., 2000; Milanez et al., 2001; Marucci et al., 2004; http://www.cnr.berkeley.edu/xylella/insectVector/insectVector.html
	Draeculacephala californica Davidson and Fraizer, 1949	Canada, USA (California, Mexico, Honduras, Cuba and Hawaii)		Grape		Low	Not associated with disease epidemics	Davidson and Frazier, 1949; Freitag and Frazier, 1954; Nielson, 1965;

Taxonomy	Species [a]	Country of report [b]	Source/recipient plant	Transmission to indicator plant	Host plant	Role as vector	Role as vector - criteria	Citation
	Draeculacephala crassicornis Van Duzee, 1915	USA (Alaska, British Columbia, Alberta, Manitoba, Washington, Oregon, California, Idaho, Wyoming, Utah, Colorado and Nebraska)		Grape		Low	Not associated with disease epidemics	Young and Davidson, 1959; Freitag and Frazier, 1954
	Draeculacephala minerva Ball, 1927	USA, Mexico, Central America (Guatemala, Belize, Honduras, El Salvador, Costa Rica, Nicaragua)	Grape/almond, grape/alfalfa, almond/almond, almond/grape, grape/grape		*Medicago sativa*, *Oryza sativa*, *Zea mays*, *Juncus* sp., *Medicago sativa*, *Prunus* spp. *Catharanthus roseus*, *Prunus dulcis*; fruit trees and *Vitis*	High	Common in diverse ecosystems	Cabrera-La Rosa et al., 2008; Daane et al., 2011; http://www.q-bank.eu/; http://www.cnr.berkeley.edu/xylella/insectVector/grnshrp.html; Purcell, 1980; http://naturalhistory.museumwales.ac.uk/vectors/browsespecies.php?-recid=678; Severin 1949; http://imperialis.inhs.illinois.edu/dmitriev/taxahelp.asp?key=Proconia&keyN=&lng=En&hc=3010&mat=1
	Draeculacephala noveboracensis (Fitch)	Northern USA, Canada		Grape, alfalfa		Low	Not associated with disease epidemics	
	Ferrariana trivittata (Signoret 1854)	Brazil		Citrus	*Citrus sinensis*	Moderate	Abundant and widespread but limited to grasses	de Miranda et al., 2009; Lopes et al., 2003

Taxonomy	Species [a]	Country of report [b]	Source/recipient plant	Transmission to indicator plant	Host plant	Role as vector	Role as vector - criteria	Citation
	Graphocephala atropunctata (Signoret)	USA (California, British Columbia, Oregon, Washington), Central America	Grape/almond, grape/alfalfa, almond/almond, almond/grape		Grape, blackberry, elderberry, mugwort, stinging nettle, and snowberry and many others	High	Common in diverse ecosystems, associated with ornamental plants	Purcell, 1980; Severin, 1949; http://www.cnr.berkeley.edu/xylella/insectVector/bgss.html
	Graphocephala confluens (Uhler, 1861)	USA		Grape	*Salix* sp., *Chrysothammus* sp., *Fraxinus* sp., *Malus domestica*, *Quercus* sp., *Eucalyptus* sp.	Moderate	Common in diverse ecosystems, not associated with disease epidemics	Freitag and Frazier, 1954; http://imperialis.inhs.illinois.edu/dmitriev/taxahelp.asp?key=Proconia&keyN=&lng=En&hc=3010&mat=1
	Graphocephala cythura (Baker)	Western USA, Canada		Grape, alfalfa	*Vitis californica*, *Geranium* sp.	Low	Not associated with disease epidemics	Freitag et al., 1952
	Graphocephala hieroglyphica	USA, Mexico		Grape, alfalfa				Frazier and Freitag, 1946; Freitag et al., 1952;
	Graphocephala versuta (Say 1830)	USA	Peach/peach		*Ulmus Americana*, peach? Plum?	Moderate		Turner and Pollard, 1959; Pooler et al., 1997; Myers et al., 2007; Overall, 2013
	Helochara delta Oman	USA (California)	Grape/grape		Grapevine, weeds	Moderate		Severin, 1949; Freitag and Frazier, 1954; Raju et al., 1983; Yamamoto and Gravena, 2000; http://imperialis.inhs.illinois.edu/dmitriev/
	Macugonalia lecomelas (Walker)	Bolivia, Paraguay, Brazil, Argentina		Citrus	*Waltheria indica*, *Malpighiaceae*	High	Common in diverse ecosystems. Associated with ornamental plants and nursery trees	Young, 1977; Paiva et al., 1996; Fundecitrus, 1999

Taxonomy	Species [a]	Country of report [b]	Source/recipient plant	Transmission to indicator plant	Host plant	Role as vector	Role as vector - criteria	Citation
	Paragonia confusa Oman	USA (California, Nevada)	Grape/grape			Low	Not associated with disease epidemics	Frazier and Freitag, 1946; DeLong and Severin, 1949; Severin, 1949
	Paragonia furcata Oman			Grape, alfalfa		Low	Not associated with disease epidemics	Frazier and Freitag, 1946
	Paragonia tredecimpunctata Ball	USA (California)		Alfalfa		Low	Not associated with disease epidemics	Frazier and Freitag, 1946
	Paragonia triundata Ball	USA (California)		Grape, alfalfa		Low	Not associated with disease epidemics	Frazier and Freitag, 1946; DeLong and Severin, 1949; Severin, 1949
	Plesiommata corniculata Young, 1977	Brazil, Mexico, Costa Rica, Panama, Colombia, Trinidad, Grenada, Venezuela, Guyana, Suriname, Bolivia, Paraguay	Citrus/citrus			Moderate	Abundant and widespread but limited to grasses	Yokomi et al., 2000; Krügner et al., 2000; http://naturalhistory.museumwales.ac.uk/sharpshooters/browserecord.php?-recid=1887
	Parathona gratiosa (Blanchard)	Bolivia, Paraguay, Brazil, Argentina		Citrus		Low	Apparently restricted to woody habitats. Low population density	Young, 1977; Fundecitrus, 1999
	Sonesimia grossa (Signoret)	Bolivia, Paraguay, Brazil, Argentina		Citrus	Grasses	Low	Grass-feeding habit limits range expansion	Paiva et al., 1996; Fundecitrus, 1999; Yamamoto and Gravena, 2000
	Xyphon flaviceps (Riley, 1880)		Grape/alfalfa			Moderate		Hewitt et al., 1946; Overall, 2011

Taxonomy	Species [a]	Country of report [b]	Source/recipient plant	Transmission to indicator plant	Host plant	Role as vector	Role as vector - criteria	Citation
	Xyphon fulgida Nottingham, 1932	Mexico, USA (from western Arizona to northern California)	Grape/grape		Alfalfa, *Vitis*, *Cynodon dactylon*, *Chrysothammus* sp.	Moderate	Abundant and widespread but limited to grasses	Daane et al., 2011; http://imperialis.inhs.illinois.edu/dmitriev/search.asp?key=Erythroneura&lng=En; http://www.cnr.berkeley.edu/xylella/insectVector/rhss.html
	Xyphon triguttana Nottingham	USA		Grape	*Medicago* sp. *Bouteloua curtipendula*, *Salsola tragus*, *Cynodon dactylon*, *Lepidium fremontii*, *Atriplex falcata*, *Distichlis spicata*, *Distichlis* sp.	Low	Not associated with disease epidemics	Freitag and Frazier, 1954; Krügner et al., 2000; Catanach et al., 2013; http://imperialis.inhs.illinois.edu/dmitriev/search.asp?key=Erythroneura&lng=En
Sharpshooter Cicadellidae Proconiini Spittlebugs Aphrophoridae	*Acrogonia citrina* Marucci and Cavichioli, 2002	Brazil	Citrus/citrus		*Rutaceae*: *Citrus sinensis*, *Citrus* sp.	High	Common, abundant on ornamental plants and nursery stocks	http://imperialis.inhs.illinois.edu/dmitriev/search.asp?key=Erythroneura&lng=En
	Acrogonia virescens (Metcalf, 1949)	Brazil, Guyana, Paraguay, Peru	Citrus/citrus		Citrus, *Arecaceae*: *Elaeis guineensis* (palm oil tree)	Low	Restricted to woody habitats, low population density	Turner and Pollard, 1959 Krügner et al., 2000; Overall, 2011; http://imperialis.inhs.illinois.edu/dmitriev/search.asp?key=Erythroneura&lng=En
	Cuerna costalis (Fabricius, 1803)	Canada, USA	Peach/peach, pecan/pecan		*Asteraceae*: *Ambrosia artemisiifolia* (ragweed), *Amphiachyris* sp., *Dahlia* sp. (dahlia), *Helianthus petiolaris*, *Helianthus* sp. (sunflower); *Bignoniaceae*: *Campsis radicans* (trumpet creeper); *Brassicaceae*: *Brassica rapa* (turnip); *Chenopodiaceae*: *Beta*	Moderate	Abundant and widespread but limited to herbaceous hosts	http://imperialis.inhs.illinois.edu/dmitriev/taxahelp.asp?hc=1917&key=Proconia&lng=En

Taxonomy	Species [a]	Country of report [b]	Source/recipient plant	Transmission to indicator plant	Host plant	Role as vector	Role as vector - criteria	Citation
					vulgaris (beet); *Fabaceae*: *Albizia julibrissin* (silktree), *Arachis hypogaea* (peanut), *Cassia occidentalis* (coffeeweed), *Cassia tora*, *Cercis* sp. (redbud), *Lespedeza* sp. (lespedeza), *Lupinus angustifolius* (blue lupine), *Pisum sativum* var. (Austrian pea), *Pisum sativum* (garden pea), *Vigna sinensis* (cowpea); *Lythraceae*: *Lagerstroemia indica* (crapemyrtle); *Malvaceae*: *Gossypium herbaceum* (cotton), *Hibiscus esculentus* (okra); *Oleaceae*: *Ligustrum* sp. (privet); *Onagraceae*: *Oenothera biennis* (evening primrose); *Phytolaccaceae*: *Phytolacca americana* (pokeweed); *Poaceae*: *Cynodon dactylon* (Bermuda grass), *Digitaria sanguinalis* (crab grass), *Lolium multiflorum* (rye grass), *Panicum texanum* (Texas millet), *Setaria viridis* (green bristlegrass), *Sorghum halepense* (Johnson grass), *Triticum aestivum* (wheat), *Zea mays* (maize); *Polygonaceae*: *Rumex* sp. (dock); *Rosaceae*: *Fragaria ananassa* (strawberry), *Prunus angustifolia* (chickasaw plum), *Prunus persica* (peach); *Vitaceae*: *Vitis* sp. (grapevine)			

Taxonomy	Species [a]	Country of report [b]	Source/recipient plant	Transmission to indicator plant	Host plant	Role as vector	Role as vector - criteria	Citation
	Cuerna occidentalis Oman and Beamer, 1944	USA (California)		Grape	*Arctostaphylos pungens*, *Symphoricarpos* sp., *Artemisia* sp., *Lotus* sp., *Lupinus* sp. and grasses	Low	Not associated with disease epidemics	Freitag and Frazier, 1954; Nielson, 1965; http://imperialis.inhs.illinois.edu/dmitriev/taxahelp.asp?key=Proconia&keyN=&lng=En&hc=3010&mat=1
	Cuerna yuccae Oman and Beamer	Western USA		Grape	*Yucca brevifolia* (Joshua tree)	Low	Host range limited to one species	Freitag and Frazier, 1954; Nielson, 1965; http://imperialis.inhs.illinois.edu/dmitriev/taxahelp.asp?key=Proconia&keyN=&lng=En&hc=3010&mat=1
	Friscanus friscanus (Ball, 1944)	USA	Grape/grape		*Erigeron glaucus*, grape, *Lupinus arboreus*	Low	Not associated with disease epidemics	Oman, 1938; Frazier and Freitag 1946; Severin, 1949; Freitag and Frazier, 1954; Karban, 1986
	Homalodisca vitripennis (coagulata)(Germar)	USA (southern states), Mexico (northern part), French Polinesia, Easter Island	Grape/grape, peach/peach, pecan/pecan		Grape, citrus, crepe myrtile, avocado and many ornamentals	High	History of range expansion on nursery stock	Adlerz and Hopkins, 1979; Almeida and Purcell, 2003; Sanderlin and Melanson, 2010; Overall, 2011; http://www.cnr.berkeley.edu/xylella/insectVector/oss.html
	Homalodisca ignorata Melichar, 1924	Neotropical (Brazil, Paraguay)	Citrus/citrus		*Citrus sinensis*, *Citrus* sp.	Moderate	Associated with disease epidemics but not abundant	Almeida and Lopes, 1999; http://imperialis.inhs.illinois.edu/dmitriev/taxahelp.asp?key=Proconia&keyN=&lng=En&hc=3010&mat=1

Taxonomy	Species [a]	Country of report [b]	Source/recipient plant	Transmission to indicator plant	Host plant	Role as vector	Role as vector - criteria	Citation
	Homalodisca insolita (Walker, 1858)	Americas: North, South and Central	Peach/peach, pecan/pecan		*Poaceae: Digitaria sanguinalis* (crab grass), *Panicum dichotimoflorum* (fall panicum), *Panicum maximum* (Guinea grass), *Sorghum halepense* (Johnson grass); *Rosaceae: Prunus persica* (peach); *Rutaceae*: *Citrus sinensis* (orange).	Low	Restricted to grasses	Turner and Pollard, 1959; Sanderlin and Melanson, 2010; http://imperialis.inhs.illinois.edu/dmitriev/search.asp?key=Erythroneura&lng=En; http://imperialis.inhs.illinois.edu/dmitriev/taxahelp.asp?key=Proconia&keyN=&lng=En&hc=3010&mat=1
	Homalodisca liturata Ball	South-western USA, Mexico		Grape, alfalfa		Moderate	Possible association with oleander leaf scorch	Freitag et al., 1952; Freitag and Frazier, 1954; Young, 1958; Almeida and Purcell, 2003
	Oncometopia facialis (Signoret)	Brazil, other South American countries	Citrus/citrus		Citrus, insects collected from *Vernonia condensata*, *Aloysia virgata*	High	Wide host range, very common in diverse ecosystems	Almeida and Lopes, 1999; Krügner et al., 2000; Yokomi et al., 2000; Milanez et al., 2001; Marucci et al., 2004; http://imperialis.inhs.illinois.edu/dmitriev/taxahelp.asp?key=Proconia&keyN=&lng=En&hc=3010&mat=1 http://www.cnr.berkeley.edu/xylella/insectVector/insectVector.html
	Oncometopia nigricans (Walker)	USA (Florida)	Peach/peach		Grapes, periwinkle (*Catharanthus roseus*), citrus and many others	High	Associated with disease epidemics, large host range	Turner and Pollard, 1959; Adlerz, 1980; Brlansky et al., 2002; http://imperialis.inhs.illinois.edu/dmitriev/taxahelp.asp?key=Proconia&keyN=&lng=En&hc=3010&mat=1

Taxonomy	Species [a]	Country of report [b]	Source/recipient plant	Transmission to indicator plant	Host plant	Role as vector	Role as vector - criteria	Citation
	Oncometopia orbona (F.)			Peach		Low	Not associated with disease epidemics	Turner and Pollard, 1955, 1959
	Aphrophora angulata Ball	USA (California)	Grape/grape, grape/alfalfa		Grapevine, *Amsinckia intermedia* (*Boraginaceae*), *Achillea millefolium*, *Artemisia vulgaris*, *Cirsium lanceolatum*, *Madia elegans*, *Silybum marianum* (*Compositae*), *Avena fatua* (*Graminaceae*), *Stachys ajugoides. Stachys bullata* (*Labiatae*), *Medicago hispida*, *Melilotus indica*, *Vicia americana* (*Leguminosae*), *Chlorogalum pomeridianum* (*Liliaceae*), *Rumex conglomeratus*, *R.crispus* (*Polygonaceae*), *Montia perfoliata* (*Portulaceae*), *Ranunculus californicus* (*Ranunculaceae*), *Rubus procerus*, *R. vitifolius* (*Rosaceae*),*Galium aparine* (*Rubiaceae*), *Sanicula liberta* - *S. crassicaulis* (*Umbelliferace*), *Pinus halepensis*, *Pinus radiata* (*Pinaceae*), *Anagallis arvensis* (*Primulaceae*), *Urtica californica* (*Urticaceae*)	Low	Not associated with disease epidemics	DeLong and Severin, 1950
	Aphrophora permutata (Uhler)	USA	Grape/grape		Grapevine, lucerne, *Chrysopis villosa*, *Lupinus* sp., *Heracleum lanatum*, Monterey pine	Low	Not associated with disease epidemics	Doering, 1942; DeLong and Severin, 1950; Kelson, 1964;
	Philaenus leucophtalmus (L.)	Throughout the USA	Grape/grape		Grapevine, lucerne and many others	Low to moderate	Large host range and wide distribution, not associated with disease epidemics	DeLong and Severin, 1950

Taxonomy	Species [a]	Country of report [b]	Source/recipient plant	Transmission to indicator plant	Host plant	Role as vector	Role as vector - criteria	Citation
	Philaenus spumarius L.	USA (including Hawaii)	Almond/almond almond/grape		*Erigeron glaucus*, grapevine	Low	Not associated with disease epidemics	Davis and Mitchell, 1946, cited by DeLong and Severin, 1950; Hering, 1966; Purcell, 1980; Karban, 1986; Daane et al., 2011
Cercopidae	*Clastoptera brunnea* Ball 1927	Canada (British Columbia), USA (Colorado, North Dakota, Utah, Oregon, California, Colorado, Nevada, North Dakota, Utah)	Grape/grape		*Artemisia tridentata*, *Chrusothamnus graveolans*, *Hymenoclea salsola*, grapevine	Low	Not associated with disease epidemics	Ball, 1927; Doering, 1942; DeLong and Severin, 1950
	Clastoptera achatina Germar	USA (Michigan)	Pecan/pecan		*Carya* spp. (Juglandaceae)	Low	Host range limited to Carya (Juglandaceae)	Hanna, 1970; Sanderlin and Melanson, 2010
Cicadas Cicadidae	*Dorisiana virides* (Olivier)	Brazil, Argentina, Uruguay		Coffee	*Macadamia integrifolia (*Proteaceae), coffee crops	Low	Not associated with disease epidemics, only reported on coffee crops and *Macadamia integrifolia* in South America, unconfirmed role as a vector	Paiao et al, 2002; Aoki et al., 2010
	Diceroprocta apache Davis	USA (Mexico, Arizona, Utah, Nevada, California)	Grape/grape		*Populus fremontii*, *Salix gooddingii*, *Baccharis* sp., *Prosopis* spp., *Cercidium* sp., *Tamarix* spp., asparagus, sunflower, fruit trees	Low	Not associated with disease epidemics, unconfirmed role as a vector	Ellingson et al., 2002; Krell et al., 2007

(a): Species listed in Redak et al., (2004) except: *Clastoptera achatina* from Sanderlin and Melanson (2010), *Dorisiana virides* from Paiao et al.(2002), *Diceroprocta apache* from Krell et al. (2007).

(b): For many species, data are from http://imperialis.inhs.illinois.edu/dmitriev/index.asp

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http://imperialis.inhs.illinois.edu/dmitriev/

Appendix E. Ratings and descriptors

5. Rating of probability of entry

Rating for entry	Descriptors
Very unlikely	The likelihood of entry would be very low because the pest: • is not, or is only very rarely, associated with the pathway at the origin, • may not survive during transport or storage, • cannot survive the current pest management procedures existing in the risk assessment area, • may not transfer to a suitable host in the risk assessment area.
Unlikely	The likelihood of entry would be low because the pest: • is rarely associated with the pathway at the origin, • survives at a very low rate during transport or storage, • is strongly limited by the current pest management procedures existing in the risk assessment area, • has considerable limitations for transfer to a suitable host in the risk assessment area.
Moderately likely	The likelihood of entry would be moderate because the pest: • is frequently associated with the pathway at the origin, • survives at a low rate during transport or storage, • is affected by the current pest management procedures existing in the risk assessment area, • has some limitations for transfer to a suitable host in the risk assessment area.
Likely	The likelihood of entry would be high because the pest: • is regularly associated with the pathway at the origin, • mostly survives during transport or storage; • is partially affected by the current pest management procedures existing in the risk assessment area, • has very few limitations for transfer to a suitable host in the risk assessment area.
Very likely	The likelihood of entry would be very high because the pest: • is usually associated with the pathway at the origin, • survives during transport or storage; • is not affected by the current pest management procedures existing in the risk assessment area, • has no limitations for transfer to a suitable host in the risk assessment area.

6. Rating of the probability of establishment

Rating for establishment	Descriptors
Very unlikely	The likelihood of establishment would be very low because: • of the absence or very limited availability of host plants; • the unsuitable environmental conditions; • and the occurrence of other considerable obstacles preventing establishment
Unlikely	The likelihood of establishment would be low because: • of the limited availability of host plants; • the unsuitable environmental conditions over the majority of the risk assessment area; • the occurrence of other obstacles preventing establishment
Moderately likely	The likelihood of establishment would be moderate because: • hosts plants are abundant in few areas of the risk assessment area; • environmental conditions are suitable in few areas of the risk assessment area; • no obstacles to establishment occur

Rating for establishment	Descriptors
Likely	The likelihood of establishment would be high becasue: • hosts plants are widely distributed in some areas of the risk assessment area; • environmental conditions are suitable in some areas of the risk assessment area; • no obstacles to establishment occur. • Alternatively, the pest has already established in some areas of the risk assessment area
Very likely	The likelihood of establishment would be very high because: • hosts plants are widely distributed; • environmental conditions are suitable over the majority of the risk assessment area; • no obstacles to establishment occur. • Alternatively, the pest has already established in the risk assessment area

7. Rating of the probability of spread

Rating for spread	Descriptors
Very unlikely	The likelihood of spread would be very low because: • the pest has only one specific way to spread (e.g. a specific vector, specific assisting virus…) which is not present in the risk assessment area; • highly effective barriers to spread exist; • the hosts are not or very rarely present in the area of possible spread
Unlikely	The likelihood of spread would be low because: • the pest has one to few specific ways to spread (e.g. specific vectors, specific assisting virus) and the occurrence of the pest in the risk assessment area is rare; • effective barriers to spread exist; • the hosts are occasionally present
Moderately likely	The likelihood of spread would be moderate because: • the pest has few specific ways to spread (e.g. specific vectors, specific assisting virus) and the occurrence of the pest in the risk assessment area is limited; • partially effective barriers to spread exist; • the hosts are abundant in few parts of the risk assessment area
Likely	The likelihood of spread would be high because: • the pest has some non-specific ways to spread (mechanical transmission…), which occur in the risk assessment area; • no effective barriers to spread exist; • the hosts are widely present in some parts of the risk assessment area
Very likely	• The likelihood of spread would be very high because: • the pest has multiple non-specific ways to spread (mechanical transmission…), which all occur in the risk assessment area; • no effective barriers to spread exist; • the hosts are widely present in the whole risk assessment area

8. Rating of the assessment of consequences

Rating of potential consequences	Descriptors
Minimal	• Differences in crop production (saleable fruits, tubers, plants for planting, seed, etc.) are within normal day-to-day variation; no additional control measures are required
Minor	• Crop production (saleable fruits, tubers, plants for planting, seed, etc.) is rarely reduced or at a limited level; additional control measures are rarely necessary

Rating of potential consequences	Descriptors
Moderate	• Crop production (saleable fruits, tubers, plants for planting, seed, etc.) is occasionally reduced to a limited extent; additional control measures are occasionally necessary
Major	• Crop production (saleable fruits, tubers, plants for planting, seed, etc.) is frequently reduced to a significant extent; additional control measures are frequently necessary
Massive	• Crop production (saleable fruits, tubers, plants for planting, seed, etc.) is always or almost always reduced to a very significant extent (severe crop losses that compromise the harvest); additional control measures are always necessary

9. Rating of the effectiveness of risk reduction options

Rating	Descriptors
Negligible	• The risk reduction option has no practical effect in reducing the probability of entry or establishment or spread, or the potential consequences.
Low	• The risk reduction option reduces, to a limited extent, the probability of entry or establishment or spread, or the potential consequences.
Moderate	• The risk reduction option reduces, to a substantial extent, the probability of entry or establishment or spread, or the potential consequences.
High	• The risk reduction option reduces the probability of entry or establishment or spread, or the potential consequences, by a major extent.
Very high	• The risk reduction option essentially eliminates the probability of entry or establishment or spread, or any potential consequences.

10. Rating of the technical feasibility of risk reduction options

Rating	Descriptors
Negligible	• The risk reduction option is not in use in the risk assessment area, and the many technical difficulties involved (e.g. changing or abandoning the current practices, implement new practices and or measures) make its implementation in practice impossible.
Low	• The risk reduction option is not in use in the risk assessment area, but the many technical difficulties involved (e.g. changing or abandoning the current practices, implement new practices and or measures) make its implementation in practice very difficult or nearly impossible.
Moderate	• The risk reduction option is not in use in the risk assessment area, but it can be implemented (e.g. changing or abandoning the current practices, implement new practices and or measures) with some technical difficulties.
High	• The risk reduction option is not in use in the risk assessment area, but it can be implemented in practice (e.g. changing or abandoning the current practices, implement new practices and or measures) with limited technical difficulties.
Very high	• The risk reduction option is already in use in the risk assessment area or can be easily implemented with no technical difficulties.

11. Ratings used for describing the level of uncertainty

Rating	Descriptors
Low	• No or little information or no or few data are missing, incomplete, inconsistent or conflicting. No subjective judgement is introduced. No unpublished data are used.
Medium	• Some information is missing or some data are missing, incomplete, inconsistent or conflicting. Subjective judgement is introduced with supporting evidence. Unpublished data are sometimes used.
High	• Most information is missing or most data are missing, incomplete, inconsistent or conflicting. Subjective judgement may be introduced without supporting evidence. Unpublished data are frequently used.

Appendix F. Sampling effort—general guidelines

Key to the effectiveness of surveillance measures is the allocation of appropriate sampling resources. The number of sites and sample sizes allocated to a surveillance programme and the frequency of sampling are important. Appropriate sampling efforts should be based on statistical confidence intervals and detection probabilities. In the first instance the binomial distribution can be used to estimate the number of samples required in a one-off sample to detect the disease at low incidence

$$P = 1 - (1 - \theta)^N$$

P is the probability of detecting *X. fastidiosa* at least once given a sample size of n and a true incidence of θ (fraction of an area infected). Initial rates of disease progress within plantings in Brazil have been estimated for citrus variegated chlorosis (Gottwald et al., 1993). Where similar information exists on the likely value of the epidemic growth rate in an area to be sampled, the following rule of thumb can be used to estimate the average incidence at which the disease will be detected, q^* (fraction of the area infected), given a certain sample size n and sampling frequency Δ (days between successive rounds of sampling),

$$q^* = (r\Delta)/n$$

Similarly, the 95 % probability of an epidemic having reached size X^* given a certain surveillance effort can also be calculated using $-\ln(0.95)q^*$.

For the purposes of establishing the probability that an area is free from disease (e.g. pest-free areas; see section 4.1.1.1) the "rule of three" (derived from binomial sampling theory) can be used to approximate the 95 % confidence interval that the true incidence is less than a given threshold given that no disease was found,

$$P = 3/n,$$

For example, based on these assumptions, if 300 samples were taken from an area and no disease was found, then it can be concluded with 95 % confidence that the incidence of the disease is not greater than 1 %.

These methods are provided as general guidelines only and are subject to the assumptions made by the binomial distribution. Where information exists on the level of spatial clustering of *X. fastidiosa* in the area to be sampled, the negative binomial or beta binomial distribution can be used to hone the above calculations (Madden and Hughes, 1999). The sensitivity of the testing scheme will also impact on detection probabilities and, if quantified, can be factored into the analysis (Bell et al., 2014).

Appendix G. Mapping *Xylella fastidiosa* distribution

Reports of Xylella fastidiosa were extracted from literature. Mentioned locations were converted to GIS coordinates by using GOOGLE Maps conversion. The locations were inserted into maps indicating different climatic characterisations:

1. Hardiness zones were taken from NAPPFAST Global Plant Hardiness Maps (Raw data, 2012 maps using CFSR database,data downloaded from http://www.nappfast.org/Plant_hardiness/2012/2012%20ph_index.htm, NAPPFAST (2012))
2. World map of Köppen-Geiger climate classification (Observed climate in 1976-2000, shape format, data downloaded from http://koeppen-geiger.vu-wien.ac.at/shifts.htm, Rubel and Kottek (2010))
3. Temperatures were taken from the WorldClim database (current: ~1950-2000, 30s resolution, version 1.4, rel.3, ESRI format, data downloaded from http://www.worldclim.org/current, Hijmans et al (2005)). Annual minimum temperatures were taken from the BIOCLIM dataset (variable BIO6 = "Minimum temperature of coldest month", http://www.worldclim.org/bioclim).

Annual minimum temperature values were taken from the northern locations in Canada with reports of *Xylella fastidiosa* from Appendix B:

Point	Latitude	Longitude	T min Year
5	54.39736	-102.345	-27.2
4	53.93327	-116.577	-17.8
8	50.4766	-122.627	-8.8
1	42.89902	-78.9755	-8.7
3	43.24727	-79.0704	-8.2
2	43.22772	-79.1227	-8.1
10	49.30166	-123.142	-0.2
6	48.48638	-123.515	0.9
9	49.8412	-124.517	1.1
7	48.42809	-123.358	1.9

To select temperature thresholds to indicate isolines with extreme climatic conditions (to be used in Figure 11 in section 3.3.2.1), these values were rounded to: -28°C, -18°C, -8°C, 2°C

References

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