Netherlands Food and Consumer
Product Safety Authority
Ministry of Economic Affairs

Pest Risk Assessment for *Phytophthora lateralis*

September 2013

Pest Risk Assessment of *Phytophthora lateralis*

Netherlands Food and Consumer Product Safety Authority

Utrecht, the Netherlands

D.J. van der Gaag[1] & J. Meffert[2]

[1] Office for Risk Assessment and Research, Netherlands Food and Consumer Product Safety Authority.
[2] National Reference Laboratory, Division Agriculture & nature. Netherlands Food and Consumer Product Safety Authority.

Acknowledgements: the authors would like to thank Roel Potting and Gerard van Leeuwen for useful comments and suggestions on a draft version of this PRA.

Version: 1.0
Date: September 2013

Summary

Biology
Phytophthora lateralis Tucker & Milbrath is a soil borne pathogen of *Chamaecyparis* spp. and *Taxus brevifolia*. Under humid conditions, aerial infections can also occur. *P. lateralis* causes tree mortality of *Chamaecyparis lawsoniana*. Other *Chamaecyparis* spp. are probably less susceptible. *Taxus brevifolia* is an occasional host plant. Infection of other *Taxus* spp. is not known to date. *Thuja occidentalis* has recently been described as a new host plant species of *P. lateralis.* However, only foliar infection of *Thuja occidentalis* was reported. The potential impact for *Thuja* spp. is uncertain because root infection and plant death of *Thuja* spp. due to attack by *P. late*ralis has thus far not been reported. No disease was observed after planting of *Thuja occidentalis* in infested soil and in the present risk assessment, it is assumed that *P. lateralis* only causes root and stem base infections on *Chamaecyparis* spp. and *Taxus brevifolia* and possibly on other *Taxus* spp. A full datasheet is available from EPPO, the European and Mediterranean Plant Protection Organisation (EPPO, 2009).

Distribution
P. lateralis may originate from Eastern Asia but this is uncertain. The pathogen is known to be present (and under eradication) in the following countries:

Country	Status/region
Belgium	Reported from one nursery in 2013, measures taken for eradication
Canada	Limited distribution (British Columbia)
USA	Limited distribution (California, Oregon, Washington)
France	Western Brittany, hedgerows
Ireland	South-east Ireland, one tree in public area (first detection in 2011)
The Netherlands	Detected at 3 tree nurseries in 2010 and 2011, under eradication
United Kingdom	Found in Scotland for the first time in 2010 and later found at more sites in Scotland, England, Northern Ireland and Wales (in parks, gardens and forests).
Taiwan	Forest (publication from 2010)

Reason for performing the risk assessment
At the end of 2004, an outbreak of *Phytophthora lateralis* was detected at a tree nursery in the Netherlands. At that time, *P. lateralis* was a pathogen that was unknown to occur in the Netherlands. In Europe, it had only been reported from France (two outbreaks from one source) but those outbreaks had been reported to be eradicated. In 2010, a new outbreak was detected in the Netherlands which apparently had no link with the outbreak detected in 2004 nor with import of plants from other countries. The new outbreak raised the question if the pathogen might already be more widespread, also because *P. lateralis* gives similar symptoms as several other *Phytophthora* spp. which are established in the Netherlands. It was decided to make an update of the Pest Risk Assessment for the Netherlands which should especially focus on the impact of *P. lateralis* as compared to other *Phytophthora* species which are already present and fairly widespread and attack the same plant species as *P. lateralis.*

Probability of entry

Probability of entry from third countries: low
Import of the main host plants of *P. lateralis*, *Chamaecyparis* spp., is forbidden under the current EU directive 2000/29/EC. The host plant status of *Taxus* and *Thuja* spp. except

from *Taxus brevifolia*, is uncertain. *P. lateralis* has been reported from foliage of *Thuja occidentalis* but not from roots or stem base. Import volumes of *Taxus* and *Thuja* spp are currently very limited. The pathogen may also be introduced in soil attached to non-host plants from areas where the pest is present. The pathogen can easily remain undetected in plants or soil moving in trade. An important uncertainty is the distribution of *P. lateralis* especially in eastern Asia from which the pathogen is assumed to originate.

Probability of entry from EU-countries: high
There is a large trade volume of plants for planting within the EU and the pathogen can easily remain undetected in plants or soil moving in trade.

Area of potential establishment and endangered area
P. lateralis can very likely establish in the Netherlands. Commercial and non-commercial plantings of *Chamaecyparis lawsoniana* and to a lesser extent also other *Chamaecyparis* spp. are endangered. *Taxus brevifolia* is only incidentally present in the Netherlands. *Taxus baccata* is a common species in gardens and parcs but, thus far, not known as a host plant.

Spread
Under Dutch climatic conditions, human assisted spread is probably the main dispersal mechanism (movement of infested soil and plants). It is uncertain whether aerial infections can occur under Dutch climatic conditions.

Impact
P. lateralis is known as a devastating pest (killing trees and younger plants) in ornamental nurseries and in native *Chamaecyparis lawsoniana* stands in north-western USA.

The potential impact of *P. lateralis* on *Chamaecyparis lawsoniana* grown in commercial fields, in parks, private gardens and hedgerows in the Netherlands is assessed to be MAJOR. However, *P. lateralis* will probably spread slowly and mainly by human assistance. Therefore, impacts are expected to be mainly local (i.e. field or sub-field level). *P. lateralis* is assessed to have a higher impact on *Chamaecyparis lawsoniana* than the *Phytophthora* species that are already present and fairly widespread in the Netherlands.

No control measures are available to control *P. lateralis* in field soil except cultural measures such as good soil drainage systems, use of healthy planting material, removal of diseased plants, precautionary removal of healthy looking plants around diseased plants and hygienic measures to prevent further spread. With the application of such measures, the impact is assessed as generally MODERATE and locally MAJOR.

In container-grown *Chamaecyparis* plants, pesticides are already applied to control *Phytophthora* spp. These pesticide applications will probably also be effective against *P. lateralis*. For container-grown plants, the impact of *P. lateralis* additional to the impact caused by *Phytophthora* pathogens already present is, therefore, assessed to be MINOR to MODERATE.

P. lateralis is assessed to have a MINOR impact on *Taxus* spp in the Netherlands (medium uncertainty), i.e. incidentally plants may become infected (*T. brevifolia* is a host but uncommon in the Netherlands; the commonly planted T. baccata is not known as a host plant).

Although currently not known as a quarantine pest, the presence of the pest on Dutch tree nurseries may lead to requirements by importing countries to guarantee that plants are free of the pathogen.

Uncertainties

A major uncertainty in the PRA is the current distribution of *P. lateralis* in Europe and worldwide. Another uncertainty is whether aerial infections can occur under Dutch climatic conditions. The uncertainty of the impact assessment is medium:

- the ability of *P. lateralis* to spread naturally (aerial dispersal) under Dutch conditons is uncertain; the potential impact would increase if aerial dispersal could occur.
- the pathogenicity on *Taxus spp.* other than *T. brevifolia* is uncertain.

Methodology

Ratings are given according to a 5-point qualitative scale (very low, low, medium, high, very high or minimal, minor, moderate, major, massive) and uncertainty according to a 3-point qualitative scale (low, medium and high) adapted from the PRA-scheme prepared by EPPO, the European and Mediterranean Plant Protection Organisation (http://www.eppo.org/QUARANTINE/Pest_Risk_Analysis/PRA_intro.htm; accessed March 2011). The ratings low, medium and high uncertainty have been adapted from IPCC and are defined as expressing 90, 50 and 35% confidence, respectively, that the score selected is the correct one (Mumford *et al*., 2010).

Pest Risk Assessment

1. Reason and scope

At the end of 2004, an outbreak of *Phytophthora lateralis* Tucker & Milbrath was detected at a tree nursery in the Netherlands. At that time, *P. lateralis* was a pathogen that was unknown to occur in the Netherlands. In Europe, it had only been reported from France (two outbreaks from one source) but those outbreaks had been reported to be eradicated (EPPO, 2006). In 2010, a new outbreak was detected in the Netherlands which apparently had no link with the outbreak detected in 2004 nor with import of plants from other countries. The new outbreak raised the question if the pathogen might already be more widespread than presently known, also because *P. lateralis* gives similar symptoms as several other *Phytophthora* spp. which are established in the Netherlands. Therefore, it was decided to make an update of the Pest Risk Assessment for the Netherlands which should especially focus on the impact of *P. lateralis* as compared to other *Phytophthora* species which are already present and fairly widespread and attack the same plant species as *P. lateralis.*

Damage caused by *P. lateralis* has mainly been reported for *Chamaecyparis lawsoniana* which is also the most common *Chamaecyparis* species grown in the Netherlands (Wijchman, 2005). Presently, the most common *Phytophthora* species on *Chamaecyparis lawsoniana* are probably *P. cinnamomi, P. cryptogea,* and *P. citricola* in the Netherlands and maybe also in the whole of Europe. These species have most frequently been isolated from diseased *Chamaecyparis* plants by the Dutch Plant Protection Service. Therefore, the impact of these three species on *Chamaecyparis* species will be discussed in relation to the potential impact of *P. lateralis*.

Taxus brevifolia has been reported as an occasional host of *P. lateralis* (Jules *et al*., 2002; EPPO, 2006); it is unknown if other *Taxus* spp. are host plants. Because the host plant status of the other *Taxus* spp. is uncertain and *T. brevifolia* is uncommon in the Netherlands, no comparison has been made between the potential damage of *P. lateralis* and other *Phytophthora* spp. for *Taxus* spp. in this pest risk assessment. A full datasheet of *P. lateralis* is available from EPPO, the European and Mediterranean Plant Protection Organisation (EPPO, 2009).

Recently, *P. lateralis* was isolated from foliage of *Thuja occidentalis* nursery stock in Scotland. The plants originated in France (Green, 2011; Schlenzig et al., 2011). This was the first record of *P. lateralis* on a *Thuja* sp. and no information is presently available about the impact of *P. lateralis* on *Thuja* spp. Because of this lack of information, we will only briefly discuss the potential risk of *P. lateralis* for *Thuja* spp. and summarize the results of a small pot experiment with *Chamaecyparis lawsoniana*, *Thuja occidentalis* and *Taxus baccata*.

<u>*Phytophthora ramorum* and *P. kernoviae*</u>

Phytophthora spp. which are presently regulated in the EU or for which Pest Risk Analyses (PRA) has been prepared of are being prepared at the EU- or EPPO-level are *P. ramorum* (Commission Decision 2002/757/EC) and *P. kernoviae* (EPPO-PRA in preparation). *Chamaecyparis lawsoniana* is only known as an experimental host of *P. ramorum* (Sansford *et al*., 2008) and was found resistant against *P. kernoviae* in an experimental test (Sansford, 2008). Several *Taxus* species are known natural hosts of *P. ramorum* (Sansford *et al*., 2008). Less information is available for *P. kernoviae.* In an experiment, *T. baccata* showed a low susceptibility for *P. kernoviae* (Sansford, 2008). Thus, *P. ramorum* and *P. kernoviae* are not known as natural pathogens of *Chamaecyparis* spp. *P. ramorum* is known as a pathogen of *Taxus* spp., but *P. lateralis* is not known as an important pathogen of *Taxus* spp. In conclusion, *P. lateralis* clearly differs in host range and potential damage with *P. ramorum* and *P. kernoviae* and the

potential impact of the latter two species will, therefore, not be discussed in relation to the impact of *P. lateralis* in the present PRA.

2. Scientific names and taxonomy

Class: Oomycota
Order: Pythiales
Family: Phythiaceae
Genus: *Phytophthora*
Species: *Phytophthora lateralis* Tucker & Milbrath

Common names:
Phytophthora root rot; Port-Orford-Cedar root disease (English)
Phytophthora wortel- en voetrot (Dutch)

3. PRA-area

The Netherlands

4. Does a relevant earlier PRA exist?

Yes, a draft pest risk assessment was made by the Dutch Plant Protection Service (PPS) in 2001. Full PRA's (including a risk assessment and identification and evaluation of management options) have been made by the UK and by EPPO in 2006 (CSL, 2006; EPPO, 2006). The EPPO-PRA used information from the Dutch pest risk assessment and the UK PRA. Information from the EPPO-PRA has been used in the present risk assessment. The present risk assessment focuses on the risk for the Netherlands and especially compares the risk of *P. lateralis* with other *Phytophthora species* which can cause similar plant damage and are already established in the Netherlands but also in many other European countries. Such a comparison has not been made in the previous risk assessment and PRA's. A datasheet for *P. lateralis* has been prepared by EPPO (EPPO, 2009).

5. Host plant range (Worldwide)

From the EPPO-PRA (EPPO, 2006):

"The most important hosts of *P. lateralis* are *Chamaecyparis* spp., particularly *C. lawsoniana* (Tucker and Milbrath, 1942). *Taxus brevifolia* is an occasional host (first reported in DeNitto & Kliejunas, 1991)."

"According to Hansen (E. Hansen, Oregon, USA, 2006, personal communication) published reports on hosts other than cedars (*C. lawsoniana* or *Chamaecyparis* spp.) and *T. brevifolia* are considered to be misidentifications."

P. lateralis is known to cause tree mortality of *Chamaecyparis lawsoniana*; other *Chamaecyparis* spp., e.g. the Asiatic species *C. obtusa*, *C. pisifera* and *C. formonsensis* are considered less susceptible (Brasier *et al*., 2010). It is unknown whether *P. lateralis* can infect *Taxus* species other than *T. brevifolia*.

Very recently, *P. lateralis* was isolated from foliage of *Thuja occidentalis* nursery stock in Scotland; the plants originated in France (Green, 2011; Schlenzig et al., 2011). There were no other symptoms apart from those on the foliage and tests on samples of bark, root collar and roots were all negative (Schlenzig et al., 2011). In a small experiment in which plantlets of *Chamaecyparis lawsoniana* cv Alumii, *Thuja occidentalis* cv. Frieslandia and *Taxus baccata* were planted in soil artificially infested with *P. lateralis*, only the plantlets of *C. lawsoniana* developed disease and all plants died within 12 weeks after

planting (NVWA, 2012, unpublished results). *Thuja* spp. have not been reported as host plants from North America where *P. lateralis* has been present for many decades. Thus, available data suggest that *P. lateralis* causes root and stem base infections on *Chamaecyparis* spp. and *Taxus brevifolia*, possibly on other *Taxus* spp. but not on *Thuja* spp.

6. Host plant range (PRA area, including acreage)

Area of commercially grown crops
The area of conifers for ornamental purposes grown in field soil was 3151 ha in 2009 (LEI-CBS, 2010). It is estimated that on about 500 – 1000 ha *Chamaecyparis* and *Taxus* are grown (based on information obtained from Naktuinbouw and DLV, the Netherlands, December 2010). *Chamaecyparis lawsoniana* is the most commonly grown *Chamaecyparis* species on Dutch nurseries (Wijchman, 2005).

The area of container-grown plants in tree nurseries was 768 ha in 2009 (CBS-LEI, 2010) of which about 150 ha are conifers and about 50 ha may be *Chamaecyparis* and *Taxus* (rough estimate based on information from DLV, the Netherlands, December 2010).

Thuja spp. are probably the most commonly grown conifers in the Netherlands. The top 10 of most commonly grown conifers in the Netherlands is approximately (information from Naktuinbouw, the Netherlands, June 2011):

- *Chamaecyparis lawsoniana* "Columnaris "
- *Thuja occidentalis* "Brabant "
- *Taxus baccata*
- *Thuja occidentalis* "Smaragd "
- *Picea glauca* "Conica "
- *Chamaecyparis lawsoniana* "Yvonne"
- *Thuja plicata* "Atrovirens "
- *Juniperus* (x) *pfitzeriana* (=*J.* (x) *media*)
- *Pinus parviflora*
- (x) *Cupressocyparis leylandii*

The "Christmas trees" *Picea abies* and *P. omorika* are also grown at a relatively large scale.

Area of non-commercially grown plants
Chamaecyparis spp. are common plants in private gardens and public parks. They are not present or only to limited extent in nature areas. *Taxus brevifolia* is incidentally grown in gardens and parks (personal communication A. de Haas, NVWA, the Netherlands). *Taxus baccata* is a native *Taxus* species and commonly present in gardens and parks but it is unknown if this species can be affected by *P. lateralis*. *Thuja* spp. are also commonly present but only their foliage may be susceptible for infection (see above).

7. What is the current area of distribution of the pest?

From the EPPO-PRA (EPPO, 2006):
"The pathogen is assumed to have been introduced to North America in 1923 from an unknown origin (Roth *et al*., 1972; as cited by Kliejunas & Adams, 1981 and Erwin & Ribeiro, 1996).

Introduction to France is suspected to have been from North America but this could never be confirmed. *P. lateralis* was isolated and identified from *C. lawsoniana* in 1996 and 1998 in different parts of France (Hansen *et al*., 1999). It was suggested that this probably stemmed from a single original infestation of young, potted, greenhouse-propagated cedars in a commercial nursery. Introduction to The Netherlands was first

noticed in 2004 when a survey was conducted of 350 nurseries with *C. lawsoniana*. *P. lateralis* was isolated from the stem bases of *C. lawsoniana* plants from one isolated nursery but the origin of the pathogen was unknown, especially as there were no associated imports of the affected plant material and propagation material originated from the affected nursery (Meffert, 2005)."

About the origin of *P. lateralis* in North America, Hansen *et al.* (2000) stated that "The nearly complete susceptibility of its primary host marks it as an introduced pathogen." Thus, it is presently unknown what the native area of distribution is and, therefore, the current area of distribution of *P. lateralis* is highly uncertain.

Since the EPPO-PRA from 2006, new findings have been reported (see also Table 1):

Brasier *et al.* (2010) found *P. lateralis* in a forest in Taiwan and suggested that Taiwan may lie within the geographic centre of origin of the pathogen.

In France, the pest was considered to be eradicated, but its presence in Brittany outside tree nurseries was later reported (Robin *et al*., 2010): from 2005 to 2008, the first signs of decline and mortality of *Chamaecyparis* in hedgerows were observed at several sites separated in total by 60 km. The identity of the pathogen was confirmed in 2009. EPPO (2011c) reported that *P. lateralis* had been confirmed at 4 localities in western Brittany but that the pathogen had caused decline and mortality of several thousands of trees over an area of approximately 400 km^2.

In 2010 and 2011, *P. lateralis* was found at several sites in Scotland, England and Northern Ireland and one site in Ireland (Table 1). Two distinct 'lineages' of *P. lateralis* have been found in the UK, one that occurs in the north west of the USA and another that is to date only known from Scotland (http://www.forestry.gov.uk/plateralis; last access August 2013). These different lineages suggest that the pathogen may have been introduced into Europe at more than one occasion.

In the Netherlands, *P. lateralis* was found again in 2010 after the first finding in 2004. In 2011, a survey was performed including 128 commercial tree nurseries and samples were taken from plants with any suspicious looking symptoms. *P. lateralis* was found at two out of the 128 nurseries. Phytosanitary measures were implemented to eradicate the pathogen from the nurseries. In a survey conducted in 2012 (125 nurseries visited) no infestations were found.

The findings/outbreaks in France (1996, 1998 and again in 2009), the Netherlands (2004, 2010 and 2011) and more recently a finding in Belgium (Europhyt, 2013) several findings in the UK and Ireland (2010 and later years) and also the finding on *Thuja* sp. in 2011 (see Question 5) suggest that the pest is already more widespread in Europe than presently known. Symptoms might be attributed to other *Phytophthora species* which are present in many European countries, such as *P. cinnamomi* and *P. cryptogea*.

Table 1. Known distribution of *Phytophthora. lateralis* worldwide

Country	Status/region	Source
Belgium	Reported from one nursery in 2013, measures taken for eradication	Europhyt, 2013
Canada	Limited distribution (British Columbia)	EPPO PQR-database, version 4.6; EPPO, 2001
USA	Limited distribution (California, Oregon, Washington)	EPPO PQR-database, version 4.6; EPPO, 2001
France	Western Brittany, hedgerows	Robin *et al*., 2010; EPPO, 2011c
Ireland	South-east Ireland, one tree in public area (first detection)	EPPO, 2011a
The Netherlands	At 3 tree nurseries detected in 2010 and 2011, under eradication	Netherlands Food and Consumer Product Safety Authority, May 2012
United Kingdom	First finding in Scotland in 2010. Other outbreak sites found in Scotland, England, Northern Ireland and Wales in more recent years (in parks, gardens and forests).	http://www.forestry.gov.uk/ (last access August 2013). EPPO, 2011b
Taiwan	Forest	Brasier *et al*., 2010

8. What is the international phytosanitary status?

P. lateralis is included in the EPPO AI list (http://www.eppo.org/QUARANTINE/listA1.htm) which means that EPPO recommends the EPPO-members to list the pathogen as a quarantine pest.

9. Does it occur in the Netherlands?

Present official status: transient under eradication (see question 7 for details). As stated above, the pathogen may be present at more locations because:

- the source of the outbreaks found at the nurseries was unknown,
- the 2011 and 2012 surveys did not include all nurseries growing *Chamaecyparis lawsoniana,*
- latent infections may have been present, and
- the pathogen may also be present outside nurseries.

10. Probability of entry: preliminary pathway analysis

Note: entry includes here arrival of the pest and subsequent transfer to a host plant

EPPO (2006) considered the following pathways:

1. Plants for planting of *Chamaecyparis* spp. (as cuttings or with growing media attached) from the USA and Canada,
2. Plants for planting of *Taxus brevifolia* (as cuttings or with growing media attached) from the USA and Canada,
3. Plants for planting of non host plants with growing media attached from the USA and Canada
4. Soil from the USA and Canada as a commodity
5. Soil from the USA and Canada as a contaminant on used machinery
6. Soil from the USA and Canada as a contaminant on footwear.

The probability of entry from non-EU countries was assessed as low because import of *Chamaecyparis* spp. is forbidden in the EU. Import of plants for planting of *Taxus* spp. is

presently very limited. During the period 2005-2010, 4 consignments were imported: 3 from Japan (totally 6 plants) and 1 from the Republic of Korea (160 plants); all imported in 2010. No data are available on trade volumes of *Chamaecyparis* and *Taxus* spp. within the EU.

Recently, the presence of *P. lateralis* has been demonstrated in Taiwan and it is assumed that the pathogen originates from Eastern Asia, Taiwan and possibly Japan, since the native *Chamaecyparis* spp. (mainly *C. obtusa*) present in that area are less susceptible than *C. lawsoniana*, the species which is severely affected in North America (Brasier *et al*., 2010). Hence, there are probably more pathways through which the pest could enter the EU, e.g. import of plants for planting from Eastern Asia.

Recently, *P. lateralis* was found in Scotland on diseased plants of *Thuja occidentalis* originating in France (Schlenzig et al., 2011). Thus, import or trade of plants for planting of *Thuja* spp. can also a pathway for *P. lateralis*. The import of *Thuja* spp. is presently very limited. During the period 2006-2011 only one consignment of 1000 *Thuja* plants was imported from India in 2010. No data are available on trade volumes of *Thuja* spp. within the EU. In Scotland, *P. lateralis* could only be isolated from the foliage of *Thuja* plants; roots, root collar and bark did not show any symptoms (Schlenzig et al., 2011). The roots of *Thuja* spp. might be resistant for infection because *P. lateralis* has never been reported before on *Thuja* spp. In a small experiment no disease symptoms were observed when *Thuja occidentalis* plantlets were planted in soil infested with the pathogen (NVWA, 2012; unpublished results; for more details see below question 13). In case *P. lateralis* is only present in the foliage, the probability of transfer will be lower than with root infections because aerial spread may be an uncommon phenomenon under Dutch conditions (see question 12 on spread).

Within the EU, the pest may already be more widespread than presently known (see question 7) and the pest may also enter the Netherlands by EU-internal trade.

P. lateralis may also be introduced with non-host plants with infested soil attached. It has been assumed that *P. lateralis* was introduced into N-W of the USA in such a way (Hansen *et al*., 2000).

Probability of entry from third countries: **low**
Import of the main host plant *Chamaecyparis* spp. is forbidden. Import of *Taxus* and *Thuja* spp is currently very limited. However, the import volumes may increase and, thereby, the probability of entry. The pathogen may also be introduced with non-host plants from areas where the pest is present. The pathogen can easily remain undetected in plants or soil moving in trade.

Uncertainty: **medium**
There is uncertainty about the pest's distribution and import volumes of *Taxus* spp. and non-host plants with soil attached from areas where the pest is present.

Probability of entry from EU-countries: **high**
There is a large trade volume of plants for planting within the EU and the pathogen can easily remain undetected in plants or soil moving in trade.

Uncertainty: **high**
The pest's distribution in the EU is highly uncertain. *P. lateralis* has a limited distribution in the EU but recent outbreaks suggest that it may be present at more locations than presently known. The trade volume of plants for planting of *Chamaecyparis* spp., *Taxus* spp. and *Thuja* spp. from EU-countries to the Netherlands is unknown.

11. Probability of establishment?

Outdoors
The outbreaks found in the Netherlands and the UK show that the pest can establish in the Netherlands. Climatic studies performed in the EPPO-PRA also indicate that the climate in the Netherlands is suitable for establishment.

Probability of establishment: **very high**
Uncertainty: **low**

In protected cultivation
The pest is not known from protected cultivation, probably because its host plants are usually grown outdoors. However, if host plants are grown in soil under protected conditions the pest is expected to be able to establish (when plants are grown in pots on concrete floors the probability of establishment will be lower).

Probability of establishment: **high**
Uncertainty: **low**

12. How likely and how rapid will the pest spread in the PRA-area? (*naturally and by human assistance*)

Natural spread of *Phytophthora* spp. causing stem and root rot usually occurs over short distances only (less than 1 m per year) since the motile spores, the zoospores, only move over very short distances (less than 10 cm) through the soil (Erwin & Ribeiro, 1996). Natural spread over larger distances is possible through water streams (downstream, down slope) and through human assistance (Jules *et al*., 2002).

Aerial spread can also occur. Aerial spread of the pathogen was first reported from the coastal region of Oregon in 1957 and 1959 (Trione & Roth, 1957; Trione, 1959) This method of spread was not reported again until the recent outbreak in western Brittany (Robin *et al*., 2010). Humid conditions are needed for aerial infections (Trione, 1959). The Pacific coast in Oregon has a mild humid climate with an average temperature of 4.4°C in January and 15.6°C in August. These climatic conditions are conducive for aerial infections and aerial spread has not been reported from drier inland forests (Trione & Roth, 1957). Western Brittany has also a mild and humid climate (Annex I).

It is uncertain whether aerial spread as reported from Oregon and western Brittany, can occur under Dutch conditions, and if possible how frequent this could happen. The climate in western Brittany and the Netherlands is largely similar, but in western Brittany the amount of rainfall is higher and the winters are milder; in Oregon aerial infections mainly developed during late winter and early spring (Trione, 1959). Winters in the Netherlands are humid but may be (in part of the country) too cold for aerial infections (Annex I). The climate in the south-west of the Netherlands (e.g. province of Zeeland) may be most conducive for aerial spread. Presently, we do not know if Dutch conditions will allow for aerial infections. At the two outbreak sites in the Netherlands (see question 1), no symptoms were observed which could be related to aerial spread but minor differences in climate may already affect aerial spread (Trione & Roth, 1957).

Spread by water streams (downstream, down slope) will probably play a much smaller role in the Netherlands than in the USA because of the flat landscape. On the other hand, if water in ditches become contaminated and the water is used for irrigation it may lead to rapid spread of the disease at a nursery and other nurseries using the same water source. However, it will probably not lead to rapid spread over larger distances and the main way of long distance spread of *P. lateralis* will probably be through human assistance:

- movement of infected host plants or movement of host and non-host plants with infested soil attached
- movement of infested soil through machinery, cars, shoes etc.

Conclusion
The probability of spread by human assistance is considered high through movement of nursery stock and infested soil. The rate of spread (the rate by which the infested area will increase) is considered low because of the slow natural spread, usually less than 1 m per year. It is expected that under Dutch conditions the main means of movement over longer distances will be by human assistance and not through natural spread. The uncertainty is medium because the pathogen might be spread more rapidly by irrigation practices and it is uncertain if aerial infections can occur under Dutch climatic conditions.

Probability of spread: **high**
Uncertainty: **low**

Rate of spread (increase of infested area): **low**
Uncertainty: **medium**

13. How great an impact is the pest likely to have in the PRA area without any control measures?

Impact in its current area of distribution

USA
Infection by *P. lateralis* will usually lead to death of the trees (Trione, 1959; Hansen *et al*., 2000). Losses of trees in nature areas and on commercial nurseries have been reported from the USA. The following is stated in the EPPO-PRA about the impact in north-western USA:

"For *C. lawsoniana*, the greatest loss in commercial forestry results from the death of young trees at the lower size limits of merchantability. Presently, the disease continues to kill trees in forestry plantations but also hedgerow and landscape trees in the Pacific states of the USA. Trees of *C. lawsoniana* in parks in British Columbia generally experience significant annual losses due to root rot caused by *P. lateralis*, with the cost of replacing them becoming increasingly prohibitive (Utkhede *et al*., 1997). *P. lateralis* is thought to have nearly destroyed the multi-million dollar ornamental cedar (*C. lawsoniana*) industry in northwest Oregon and western Washington (Hansen *et al.*, 2000). The pest has destroyed the nursery trade in western USA (Hansen *et al*.,2000). Affected land cannot be used to produce *Chamaecyparis.* The Panel considered that within its current area of distribution the pest has a massive effect on the yield, quality and control costs for cultivated plants."

In north-western USA, *P. lateralis* has destroyed large areas of *C. lawsoniana* in natural habitats (Brassier, 1999; Hansen *et al*., 2000). Exact figures on losses are limited: Murray & Hansen (1997) found 1.199 dead *C. lawsoniana* (46% mortality) and 86 dead *Taxus brevifolia* (10% mortality) plants along infested streams. Trione (1959) followed the increase in number of diseased trees in a forest area of 4 acres including 952 *C. lawsoniana* trees. The average increase in the number of diseased trees was 7% in undisturbed plots and 13% in disturbed plots. Exact figures on tree losses on nurseries were not found in literature.

France
In Brittany (France), the percentage of declining *Chamaecyparis* trees in hedgerows ranged from 5 to 40% and 10 to 50% at 4 different localities in 2008 and 2009,

respectively (Robin *et al*., 2010). According to EPPO (2011c), several thousands of *Chamaecyparis* trees had declined due to infection with *P. lateralis* in Brittany.

United Kingdom
In a park in Scotland an outbreak of *P. lateralis* was detected in 2010: about 80 *Chamaecyparis* trees were dying or in bad condition and from several of these trees *P. lateralis* was isolated. Plants of *Taxus baccata* were also found in bad condition in the same park. From the soil around two of these plants *P. cinnamomi* was isolated (http://www.forestry.gov.uk/website/forestry.nsf/byunique/infd-8bplhd, accessed 9th December; pers. comm. C. Brasier, February 2011).

Potential impact for nurseries growing *Chamaecyparis* spp. in the Netherlands
In the Netherlands, the pathogen is expected to spread slowly on a natural basis. Nursery fields are mostly flat in the Netherlands, irrigation canals through which the pest may spread are not used and *P. lateralis* is not expected to spread rapidly in a field (see question 12). On the short term, it is, therefore, expected that *P. lateralis* will only locally lead to a major impact (e.g. the first 10 years after its introduction). On the longer term and when no measures are taken to prevent infestation of fields, the pathogen will spread further leading to death of *Chamaecyparis* spp. at a larger scale. Thus, the expected economic impact without any control measures is assessed as low and locally major on the short term. On the longer term, the impact will increase (major impact) through spread of the pathogen. We do not expect a massive impact as in north-western USA because of the presumably slower natural spread in the Netherlands. Also, climatic conditions in the Netherlands seem less favourable for disease development than in Brittany where *P. lateralis* has probably killed many *Chamaecyparis* trees in hedgerows (see above).

Potential impact as compared to *Phytophthora spp.* already present and attacking *Chamaecyparis* spp.
Other *Phytophthora* spp which attack *Chamaecyparis* are already present in the Netherlands and probably widespread on nurseries growing *Chamaecyparis* (information from DLV, the Netherlands, December 2010). *Phytophthora* species that have been isolated from *Chamaecyparis* species by the PPS in the Netherlands are:

- *P. cinnamomi*, a species with a wide host range, mainly woody plants (Erwin & Ribeiro, 1996).
- *P. cryptogea,* a species with a wide host range, distributed among more than 23 plant families (Erwin & Ribeiro, 1996)
- *P. citricola,* a species with a wide host range including trees and shrubs (Erwin & Ribeiro, 1996)
- *P. gonapodyides*, a minor pathogen with only a few hosts (Erwin & Ribeiro, 1996)
- *P. cactorum,* known as pathogen of more than 200 plant species in 150 genera, representing 60 plant families (Erwin & Ribeiro, 1996).

The latter two species *P. gonapodyides* and *P. cactorum* have only occasionally been isolated by the PPS and are considered less important pathogens on *Chamaecyparis* spp. than the first three ones. *P. cinnamomi* and *P. cryptogea* have most frequently been isolated from diseased/dying *Chamaecyparis* spp. However, it is unknown whether these two species are the dominant *Phytophthora* spp. attacking *Chamaecyparis* spp. on Dutch tree nurseries because systematic surveys have not been conducted. In a Polish survey, *P. cinnamomi* and *P. citricola* were the most often isolated *Phytophthora* species from coniferous and ericaceous nursery stock plants with *P. cinnamomi* most often isolated from *C. lawsoniana*. Losses up to 30 and 50% were reported due to *P. cinnamomi* and *P. citricola,* respectively, on different species including *C. lawsoniana* (Orlikowski, 2010). *P. cinnamomi* had also been reported before as the most frequent found species on *C. lawsoniana* in ornamental plant nurseries in Poland (Orlikowski, 2000). Comparable systematic surveys will be needed to determine if *P. cinnamomi* may also be the dominant species in the Netherlands on *Chamaecyparis* spp.

Relevant questions are:

I. Will *P. lateralis* be more pathogenic in the Netherlands than the *Phytophthora* pathogens on *Chamaecyparis* spp. already present and fairly widespread ?
II. Will measures already applied to control other *Phytophthora* pathogens be similar effective against *P. lateralis*?

The first question (I) will be addressed below, the second one (II) later in this PRA under question 15.

Pathogenicity of P. lateralis compared with other Phytophthora spp.

The following information/observations indicate that *P. lateralis* is more pathogenic and/or epidemic on *C. lawsoniana* than other *Phytophthora* species in mild climates such as in the Netherlands:

- *P. lateralis* has been reported as the causal agent of severe losses of *C. lawsoniana* both on nurseries as in forests in Oregon and California while *P. cinnamomi* and *P. cryptogea* are also present in those states (Hansen *et al*., 1989).
- In inoculation tests with seedlings of *C. lawsoniana*, *P. lateralis* killed 100% of all inoculated seedlings, *P. cinnamomi* around 30%, *P. cryptogea* and *P. drechsleri* each killed one out of the 20 seedlings. Results were similar when the experiment was repeated except that *P. cryptogea* did not kill any plantlet (Hansen *et al*., 1989).
- *P. cinnamomi* has never been isolated from forest soil in north-western USA which has been explained by unfavourable environmental conditions in the forests: soils are either too dry or to too cold for disease development. A minimum temperature of about 16°C is needed for *P. cinnamomi* to kill *Pseudotsuga menziesii* seedlings and soil moisture should be near or above field capacity for sporulation (Roth & Kuhlman, 1966; Hansen *et al*., 1989). It is considered that similar conditions will be needed for *P. cinnamomi* to infect *C. lawsoniana.*
- *P. lateralis* was isolated 37 times and *P. cinnamomi* 11 times from diseased *C. lawsoniana* plants originating in nurseries in coastal British Columbia (Atkinson, 1965).
- Aerial infection has not been reported from other *Phytophthora* species attacking *C. lawsoniana*
- In Scotland, *P. lateralis* has been isolated from dying 70-80 years old *Chamaecyparis* trees while *P. cinnamomi* was isolated from soil around two dying *Taxus baccata* plants at the same location (pers. comm. C. Brasier, February 2011).
- The temperature characteristics of the different species (Table 1). *P. lateralis* has the lowest temperature optimum for growth. Outdoor temperatures in the Netherlands with average daily temperatures below 20°C during summer, will generally be more optimal for *P. lateralis* than for the other 3 *Phytophthora* species. In spring and autumn when soil moisture is favourable for disease development, temperatures may be too low for *P. cinnamomi* and *P. citricola* but will allow growth and infection by *P. lateralis* (see Annex I for average temperatures in the Netherlands).

Table 1. Minimum (min), optimum (opt) and maximum (max) temperature (T) for growth and other temperature characteristics of four *Phytophthora* spp.

***Phytophthora* species**	**Temperature (˚C)**				**References**
	min	**opt**	**max**	**other characteristics**	
P. cinnamomi	5-6	24-28	32-34	disease seldom at T<12-15˚C	Erwin & Ribeiro, 1996
P. citricola	3	25-28	31		Erwin & Ribeiro, 1996
P. cryptogea	<1	22-25	<35	in greenhouse most active at 10-25˚C	Erwin & Ribeiro, 1996
P. lateralis	3	20	<26	sporangial production abundant at 10-20˚C, no production at 5 and 25˚C; infection at 3-25˚C	Erwin & Ribeiro, 1996; Trione & Roth, 1957; Trione, 1959

Based on the information presented above, we assess that under Dutch environmental conditions *P. lateralis* can potentially cause more damage to *Chamaecyparis* spp. than *P. cinnamomi* and other *Phytophthora* species which are already present in the Netherlands. *P. cinnamomi* may especially be a problem during summer months but drier soils during that period of the year may limit disease development while *P. lateralis* may also infect plants under cooler conditions in the spring and autumn when soils are usually near or above field capacity.

Potential impact for nurseries growing *Taxus* spp. in the Netherlands

Taxus brevifolia has been reported as an occasional host and was found less susceptible than *C. lawsoniana* in experiments (Murray & Hansen, 1997). At high inoculum densities, *T. brevifolia* plants may, however, become severely infected as Murray & Hansen (1997) found 10% dead *T. brevifolia* plants along infested streams in north-western USA and plant mortality could be attributed to *P. lateralis*. It is unknown if other *Taxus* spp. can become infected. Atkinson (1965) isolated *P. lateralis* much more frequently than *P. cinnamomi* from diseased *C. lawsoniana* plants on nurseries in British Columbia. *P. cinnamomi* was isolated 2 times from diseased *T. baccata* plants whereas *P. lateralis* was only isolated from *C. lawsoniana*. In a small experiment in which plantlets of *Chamaecyparis lawsoniana* cv Alumii, *Thuja occidentalis* cv. Frieslandia and *Taxus baccata* were planted in soil artificially infested with *P. lateralis*, only the plantlets of *C. lawsoniana* developed disease and all plants died within 12 weeks after planting (NVWA, 2012, unpublished results).

These observations and the observation in Scotland (see above) suggest that *Taxus baccata* is not or only a minor host of *P. lateralis*. Based on this information, we assess the impact of *P. lateralis* for *Taxus* in the Netherlands as minor with a medium uncertainty.

Potential impact for municipalities, consumers, landscape etc.

P. lateralis can affect *Chamaecyparis* spp. present in gardens and parks. Its impact will probably be more severe than that of *P. cinnamomi* and other *Phytophthora* species already present for the same reasons as given above for tree nurseries. Planting of a tree infected or contaminated with *P. lateralis* in a park, garden or in a hedgerow may have a higher impact to (other) susceptible trees in the surroundings than for example planting with *P. cinnamomi.* In the case of *P. cinnamomi* infection of other, healthy trees, may be limited by low temperatures in spring and autumn and by dry soils during summer while *P. lateralis* may also infect plants under relatively cool conditions (Hansen *et al*., 1989; see also above).

Potential environmental impact

Not relevant for the Netherlands because *Chamaecyparis* spp. are not present (or only incidentally) in nature areas.

Potential impact on *Thuja* spp.
Until recently, *P. lateralis* was not known as a pest of *Thuja* spp. (Green, 2011). Except from the finding in Scotland on *Thuja occidentalis* plants originating in France, there are no other records on *Thuja* spp. Close to the field plot where *P. lateralis* was found on *C. lawsoniana* in 2010 in the Netherlands, the same grower also had a plot with *Thuja* sp. No symptoms were observed on these *Thuja* plants. In Scotland, *P. lateralis* could only be isolated from the foliage of *Thuja* plants and roots and root collar may be resistant for infection. In the small pot experiment described above, no disease symptoms on *Thuja occidentalis* plants were observed after planting in artificially infested soil and *Thuja* spp. may only become infected through aerial spread of spores or splash dispersal. These spread mechanisms may be uncommon under Dutch conditions and, the potential impact of *P. lateralis* for *Thuja* spp. may, therefore, be minor (medium uncertainty).

It should be noted that other *Phytophthora* species like *P. cinnamomi* and *P. ramorum* have shown an increasing list of natural host plants over time (e.g. Swiecki *et al*., 2003; Webber *et al*., 2010). *P. lateralis* has a much narrower host list and is mainly a pathogen of *Chamaecyparis* spp. but still it cannot be excluded that *P. lateralis* may increase its host range over time and, thereby, its potential impact.

Conclusion
The potential impact of *P. lateralis* on *Chamaecyparis lawsoniana* without the use of control measures against the pathogen or any other *Phytophthora* species is assessed major with a low uncertainty. However, we do not expect a major impact at the national level because of the slow natural spread of the pathogen. The impact for other *Chamaecyparis* species other than *C. lawsoniana* is probably lower. *P. lateralis* is not known as an important pathogen of *Taxus* spp. and the potential impact of *P. lateralis* on *Taxus* spp. is assessed minor with a medium uncertainty due to the limited data available. The potential impact for *Thuja* spp. may be minor because only the foliage may (incidentally) become infected.

Impact level for *Chamaecyparis lawsoniana* without measures both for nurseries and elsewhere (e.g. private gardens, parks etc.): **major**
(on the short term, e.g. first 10 years, only major a the local (field) level because of the slow natural spread; on the longer term major impacts may occur at a larger scale)
Uncertainty: **low**

14.Which control measures are available and how effective are these measures?

Soil fumigants
In the Netherlands, metam-sodium is registered but may only be used once in a period of 5 years (http://www.ctb.agro.nl/; last access 21st August 2013).

Metam-sodium suppresses *Phythopthora* in soil but studies indicate that it does not eradicate the pathogen from soil. Effects have been shown against *P. cactorum* (Utkhede *et al*., 2001; Utkhede & Smith, 2000), *P. cinnamomi* (Pinkerton *et al*., 2000) and *P. capsici* (Hartz *et al*., 1993). A possible reason that it does not eradicate the pathogen, could be that it has no effect on survival of oospores (Erwin & Ribeiro, 1996).

Pesticides
The following pesticides are registered in the Netherlands against *Phytophthora* root- and stem rot (caused by *P. cinnamomi*) for container-grown tree nursery products (http://www.ctb.agro.nl/; last access 21st August 2013).
- Fenamidone, fosethyl-aluminium (Fenomenal)
- etridiazole (AAterra ME)
- metalaxyl-m (Ridomil Gold and Budget Metalaxyl-M SL)

The above mentioned pesticides have a good effect against root- and stem rot diseases caused by *Phytophthora* spp. (e.g. Erwin & Ribeiro, 1996).

In the Netherlands, no pesticides are registered against *Phytophtora* root- and stem rot diseases in field-grown plants.

Biological control
There are no biocontrol agents available against *Phytophthora spp.* in the Netherlands. Results of Dutch experiments with some biocontrol products were not very promising (Breedeveld, 2002).

Physical methods
Steam-heating of soil: usually only applied in glasshouses and not in the open field; relatively expensive.

Cultural methods
Prevention of infestation of a field by using healthy planting material will be the best option to control the disease (Erwin & Ribeiro, 1996).

Rotation: could be used for annual crops but is less suitable for *Chamaecyparis* spp. which are usually grown for several years before being sold. However, growing several crops of *Chamaecyparis* or other host plants on the same plot should be avoided.

Management of soil water: avoidance of wet soils, good soil drainage (Erwin & Ribeiro, 1996).

Once a field is infested, it will be difficult to get rid of the pathogen, especially at nurseries for which *Chamaecyparis* is the main crop. The best option would be to immediately remove diseased plants including healthy looking plants around the diseased plants because these plants may already be infected and/or the soil below these plants could be infested. Hygienic measures would be needed to prevent spread of the pathogen by movement of soil and/or planting material. Cultivation of host plants at such a place should be avoided for several years (see also below: eradication of an outbreak).

Control measures currently applied against other *Phytophthora* spp.
Control measures that are currently applied and/or recommended on commercial nurseries are (information obtained from DLV, The Netherlands, December 2010):

Field-grown plants
- use of healthy planting material
- good soil drainage system en improvement of soil structure to prevent wet soil conditions
- crop rotation

Container-grown plants
- use of healthy planting material
- a well-drained container field
- use of potting mixture with good drainage
- prevention of large fluctuations in moisture content of the pots
- pesticides are applied in a preventive way

Conclusions control measures
Pesticides are available to control *Phytophthora* root and stem rot diseases in container-grown plants but not in field-grown plants. Effective biological control methods are not available. A good soil drainage system will aid to control of the disease. However, present systems may be less effective against *P. lateralis* than against the *Phytophthora* species

already present. Thus, more drastic measures may be needed to control *P. lateralis* in field soil than those currently applied against other *Phytophthora* species. These measures could include:

- immediate removal of symptomatic plants and healthy looking plants around the symptomatic plants,
- hygienic measures to prevent further spread, and
- avoidance of growing host plants on infested plots for several years.

For container-grown plants, the pesticides that are currently applied in a preventive way against other *Phytophthora* pathogens will probably also have effect against *P. lateralis*. *P. lateralis* may, however, be active earlier in the season before the first pesticide application and it might be necessary to apply pesticides earlier in the season.

The uncertainty is medium because experimental data on the efficacy of control measures against *P. lateralis* are lacking.

15. How great an impact is the pest likely to have in the PRA area when available control measures are applied

Commercial nurseries

Nurseries which grow *Chamaecyparis*, *Abies* and/or *Taxus* spp. have problems with *Phytophthora* spp. but disease incidence vary among years (information from DLV, The Netherlands, December 2010). The average yield loss in conifers due to *Phytophthora* diseases has been assessed on approximately 0.1% (Benninga, 2013). Growers seem to limit yield losses by cultivation and crop protection measures. The introduction of the new species *P. lateralis* may, however, enhance problems depending on the cropping system applied (field-grown or container-grown) which is discussed below.

Field-grown plants

Control measures already applied against other *Phytophthora* root and stem diseases on nurseries may partially control *P. lateralis* but they are not expected to be sufficient to control *P. lateralis*. *P. lateralis* is expected to infect plants earlier in the season and cause more damage than *Phytophthora* spp. already present (see question 13). No pesticides are available to control *Phytopthora* species in field soil and available measures are, thus, limited. Therefore, we expect a major impact for plants grown in field soil despite measures already taken against *Phytophthora* species already present at a nursery. This is supported by the fact that *P. lateralis* was detected in a commercial field in 2010 after the grower had contacted the Plant Protection Service because he could not control the disease.

It is expected that growers will take more drastic measures to prevent further spread and if possible to eradicate the pathogen from the field when they become more aware of the potential impact of this new *Phytophthora* species. Such measures could include immediate removal and destruction of diseased plants and also healthy looking plants in close proximity to the diseased ones. The cost of these measures can be high: plants need to be discarded and parts of a field plot may not suitable to grow host plants for several years. Because of the slow natural spread rate, we expect, however, a moderate impact with locally major problems. The uncertainty is medium because no yield loss data are available and it is also uncertain if aerial spread can occur in the Netherlands (see also question 12).

Container-grown plants

For container-grown plants that are already treated with pesticides that are effective against *Phytophthora* root rot, the additional impact of *P. lateralis* may be minor. *P. lateralis* may, however, be active earlier in the season before the first pesticide application and it may be necessary to apply pesticides earlier in the season. Therefore, we assess a minor to moderate impact (medium uncertainty).

Impact level with measures already applied against other *Phytophthora* spp. (this impact level only considers the plant losses due to *P. lateralis* despite existing measures; there are no additional control costs)

- field-grown plants: **major**; uncertainty: **medium**
- container-grown plants: **minor – moderate**; uncertainty: **medium**

Note: on the short term, e.g. first 10 years, a major impact for field-grown plants is only expected at the local (field) level because of the slow natural spread; on the longer term the total impact could increase when more nurseries would become infested.

Impact level with additional measures against *P. lateralis* (this impact level considers any plant losses due to *P. lateralis* despite the additional measures and the costs of these additional measures)

- field-grown pants: **moderate** (locally: major); uncertainty: **medium**
- container-grown plants: **minor - medium**; uncertainty: **medium**

Municipalities, consumers, landscape etc

Locally, a major impact might occur: *Chamaecyparis* trees in parks or gardens may die. Costs will be made by private owners to replace plants in private gardens, parks and hedgerows. The flat landscape in the Netherlands will, however, not favour rapid spread of the pathogen and the Dutch climate seems less suitable for aerial dispersal than the climate in western Brittany. Therefore, we assess overall a moderate impact while locally major impacts could occur.

Impact level: **moderate** (locally: major)
Uncertainty: **medium**

16. To which extent will the introduction of the pest affect export markets

P. lateralis is not known as a quarantine pest (see question 8). However, *P. lateralis* is a relatively newly described pathogen. It has been recommended to be listed as a quarantine pest by EPPO. EU- and third countries may decide to take action when the pathogen is found or intercepted. The UK has for examples decided to take statutory action after the finding of *P. lateralis* in a park in Scotland. *P. lateralis* spreads slowly by natural means and its presence in the Netherlands will likely not lead to an export ban but countries may require that plants originate from a pest free production place (see also EPPO, 2006).

In conclusion, the impact on export markets will be moderate with a medium uncertainty. As far as we know, *P. lateralis* is presently not listed as quarantine pest. However, importing countries may require host plants and possibly non-host plants to originate from pest free production places (in the future).

Effect export markets: **moderate**
Uncertainty: **medium**

17. Conclusions

- *Phytophthora lateralis* is a soilborne pathogen which infects roots of its host plants but aerial infections may also occur under humid conditions.
- *P. lateralis* can cause tree mortality of *Chamaecyparis lawsoniana*; other *Chamaecyparis* spp. are probably less susceptible. *Taxus brevifolia* is known as an occasional host plant; other *Taxus* spp. may also be host plants but that is currently unknown. *Thuja occidentalis* has very recently been described as a new host plant species of *P. lateralis* but only the foliage may be susceptible.
- *P. lateralis* may originate from Eastern Asia but this is uncertain.
- *P. lateralis* is known as a devastating pest (killing trees and younger plants) in ornamental nurseries and in native *Chamaecyparis lawsoniana* stands in north-western USA.
- In Europe, *P. lateralis* was found in France in 1996 and 1998 and in the Netherlands in 2004 for the first time. These outbreaks have been declared eradicated. More recently in 2010 and later years, several new outbreaks have been reported in Europe:
    - outbreaks at three nurseries in the Netherlands which are presently under eradication,
    - several outbreaks on *Chamaecyparis lawsoniana* hedgerows outside nurseries in western Brittany (France),
    - outbreaks at several sites in the United Kingdom,
    - one infected tree in Ireland.
    - one nursery in Belgium
- *P. lateralis* can very likely establish in the Netherlands.
- In the Netherlands, *P. lateralis* will probably spread slowly and mainly by human assistance. The affected area is, therefore, expected to increase slowly.
- Aerial infections can occur under humid conditions. It is uncertain if aerial infections can occur under Dutch conditions.
- *P. lateralis* is assessed to have a higher impact on *Chamaecyparis lawsoniana* than the *Phytophthora* species that are already present and fairly widespread in the Netherlands.
- The potential impact of *P. lateralis* on *Chamaecyparis lawsoniana* grown in commercial fields, in parks, private gardens and hedgerows is assessed MAJOR.
- No control measures are available to control *P. lateralis* in field soil except cultural measures such as good soil drainage systems, use of healthy planting material, removal of diseased plants, precautionary removal of healthy looking plants around diseased plants and hygienic measures to prevent further spread. With the application of such measures, the impact is assessed as generally MODERATE and locally MAJOR.
- In container-grown *Chamaecyparis* plants, pesticides are already applied to control *Phytophthora* spp. These pesticide applications will possibly also be effective against *P. lateralis*. For container-grown plants, the impact of *P. lateralis* additional to the impact caused by *Phytophthora* pathogens already present is, therefore, assessed MINOR – MODERATE.
- The uncertainty of the impact assessment is medium:
    - the ability of *P. lateralis* to spread naturally (aerial dispersal) under Dutch conditons is uncertain; the potential impact would increase if aerial dispersal could occur.
    - the pathogenicity on *Taxus spp.* other than *T. brevifolia* is uncertain.
- Although currently not known as a quarantine pest, presence of the pest on tree nurseries may lead to requirements by importing countries to guarantee that plants are free of the pathogen.
- A major uncertainty in the PRA is the present distribution of *P. lateralis* in Europe and worldwide (especially the distribution in eastern Asia from where the pathogen may originate).

References

Atkinson RG (1965) *Phytophthora* species inciting root rot of *Chamaecyparis lawsoniana* and other ornamentals in coastal British Columbia. *Canadian Journal of Botany* **43**, 1471–1475.

Benninga J (2013) Impact assessment ziekten en plagen in plantaardige productie. LEI-nota 13-016, LEI Wageningen UR, Den Haag.

Brasier CM, Vettraino, AM, Chang TT, Vannini A (2010) *Phytophthora lateralis* discovered in an old growth *Chamaecyparis* forest in Taiwan. *Plant Pathology* **59**, 595 – 603.

Breedeveld M (2002) Biomiddelen remmen wortelrot iets af. *De Boomkwekerij* **14**, 10.

CSL (2006) Pest Risk Analysis for *Phytophthora lateralis*. Available at http://www.fera.defra.gov.uk/plants/plantHealth/pestsDiseases/praTableNew.cfm. Accessed 9th December 2010.

DeNitto GA, Kliejunas JT (1991) First Report of *Phytophthora lateralis* on Pacific Yew. *Plant Disease* **75** 968.

Erwin DC, Ribeiro OK (1996) *Phytophthora lateralis*. In: *Phytophthora* diseases worldwide. American Phytopathological Society, St Paul, 365-367.

EPPO (2001) *Phytophthora lateralis*: addition to the EPPO Alert List. EPPO Reporting Service 2001/034.

EPPO (2006) Pest Risk Analysis for *Phytophthora lateralis*. Available at http://www.eppo.org/QUARANTINE/Pest_Risk_Analysis/PRA_documents.htm. Accessed 9th December 2010.

EPPO (2009) Data sheets on pests recommended for regulation: *Phytophthora lateralis*. *EPPO Bulletin* **39**, 43-47.

EPPO (2011a) First report of *Phytophthora lateralis* in Ireland. EPPO Reporting Service 2011/221.

EPPO (2011b) Further detections of *Phytophthora lateralis* in the United Kingdom. EPPO Reporting Service 2011/222.

EPPO (2011c) Situation of *Phytophthora lateralis* in France. EPPO Reporting Service 2011/029.

Europhyt (2013) European database on plant health information. (last acces September 2013)

Green (2011). Understanding *Phytophthora lateralis*. Presentation hold during a seminar on *Phytophthora lateralis* 31st March 2011, Balloch, Scotland. http://www.forestry.gov.uk/fr/INFD-8ESFTT (accessed June 2011)

Hansen EM, Goheen DJ, Jules ES, Ullian B (2000) Managing Port-Orford-Cedar and the introduced pathogen *Phytophthora lateralis*. *Plant Disease* **84**, 4-14.

Hansen EM, Hamm PB, Roth LF (1989) Testing Port-Orford-Cedar for resistance to *Phytophthora*. *Plant Disease* **73**, 791-794.

Hartz TK, Devay JE, Elmore CL (1993) Solarization is an effective soil disinfestation technique for strawberry production. *Hortscience* **28**, 104-106

Jules ES, Kauffman MJ, Ritts WD, Carroll A (2002) Spread of an invasive pathogen over a variable landscape: a nonnative root rot on port orford cedar. *Ecology* **83**, 3167 – 3181.

LEI-CBS (2010) Land- en tuinbouwcijfers 2010. LEI, 's Gravenhage. LEI-rapport 2010-068.

Mumford JD, Booy O, Baker RHA, Rees M, Copp GH, Black K, Holt J, Leach AW, Hartley M (2010) Invasive species risk assessment in Great Britain. *Aspects of Applied Biology* **104**, 49-54.

Murray SM, Hansen EM (1997) Susceptibility of Pacific Yew to *Phytophthora lateralis*. *Plant Disease* **81**, 1400-1404.

Orlikowski LB (2000) The most dangerous pathogens in ornamental plant nurseries. *Sylwan* **144**, 155-159.

Orlikowski LB (2010) Occurrence and Harmfulness of *Phytophthora* spp. in Polish Hardy Ornamental Nursery Stock. *Acta Horticulturae* **885**, 243-248.

Pinkerton JN, Ivors KL, Miller ML, Moore LW (2000) Effect of soil solarization and cover crops on populations of selected soilborne plant pathogens in western Oregon. *Plant Disease* **84**, 952-960

Robin C, Piou D, Feau N, Douzon G, Schenck N, Hansen EM (2010) Root and aerial infections of *Chamaecyparis lawsoniana* by *Phytophthora lateralis*: a new threat for European countries. Forest pathology. Blackwell Verlag GmbH. Published online http://wileyonlinelibrary.com/.

Roth LF, Kuhlman EG (1966) *Phytophthora cinnamomi*, an unlikely threat to Douglas-Fir forestry. *Forest Science* **12**, 147-159.

Sansford C (2008) Revised summary pest risk analysis for *Phytophthora kernoviae*. http://www.fera.defra.gov.uk/plants/plantHealth/pestsDiseases/phytophthora/documents/pker.pdf

Sansford CE, Inman AJ, Baker R, Brasier C, Frankel S, de Gruyter J, Husson C, Kehlenbeck H, Kessel G, Moralejo E, Steeghs M, Webber J, Werres S (2008) Report on the risk of entry, establishment, spread and socio-economic loss and environmental impact and the appropriate level of management for *Phytophthora ramorum* for the EU. Deliverable Report 28. EU Sixth Framework Project RAPRA. http://rapra.csl.gov.uk/

Schlenzig A, Campbell R & Mulholland V, 2011. *Thuja occidentalis*: a new host for *Phytophthora lateralis*. New Disease Reports **24**, 8.

Swiecki TJ, Bernhardt EA,, Garbelotto M (2003) First Report of Root and Crown Rot Caused by *Phytophthora cinnamomi* Affecting Native Stands of *Arctostaphylos myrtifolia* and *A. viscida* in California. Plant Disease **87**, 1395.

Trione EJ (1959) The pathology of *Phytophthora lateralis* on native *Chamaecyparis lawsoniana*. *Phytopathology* **49**,306–310.

Trione EJ, Roth LF (1957) Aerial infection of *Chamaecyparis* by *Phytophthora lateralis*. *Plant Disease Reporter* **41**, 211-215.

Utkhede RS, Smith EM (2000) Impact of chemical, biological and cultural treatments on the growth and yield of apple in replant-disease soil. *Australasian Plant Pathology* **29**, 129-136

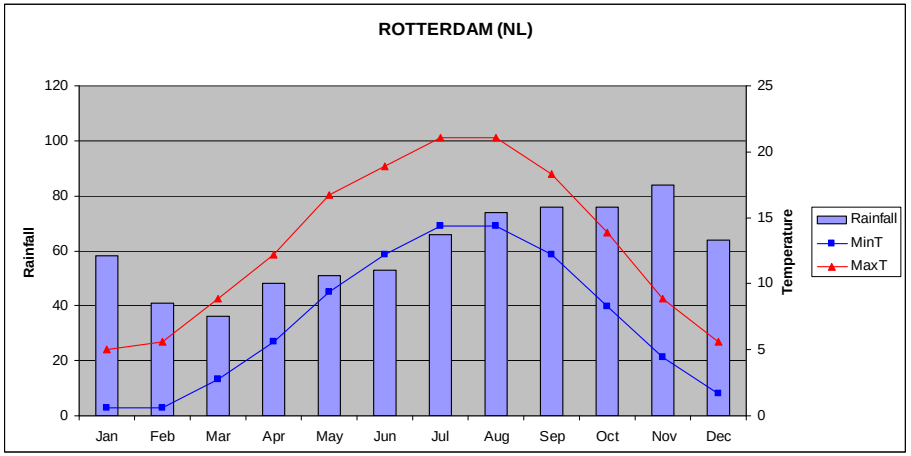
Utkhede RS, Sholberg PL, Smirle MJ (2001) Effects of chemical and biological treatments on growth and yield of apple trees planted in *Phytophthora cactorum* infested soil. *Canandian Journal of Plant Pathology* **23**, 163-167.

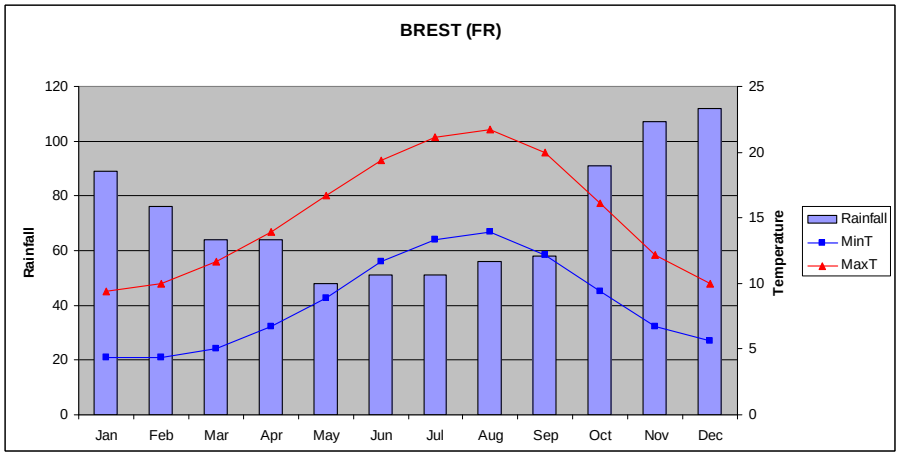
Webber JF, Mullett M, Brasier CM (2010) Dieback and mortality of plantation Japanese larch (*Larix kaempferi*) associated with infection by *Phytophthora ramorum*. New Disease Reports **22,** Article 19.

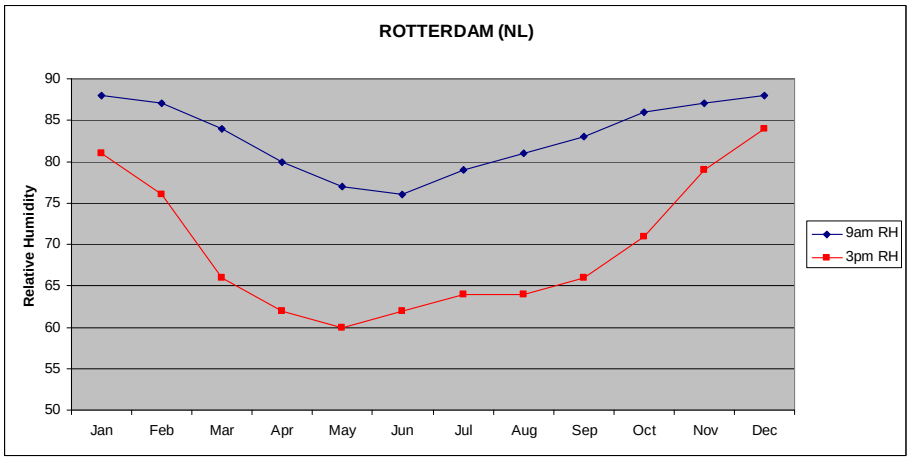
Wijchman G (2005) Over *Chamaecyparis* gesproken… *De Boomkwekerij* **4**, 14-16.

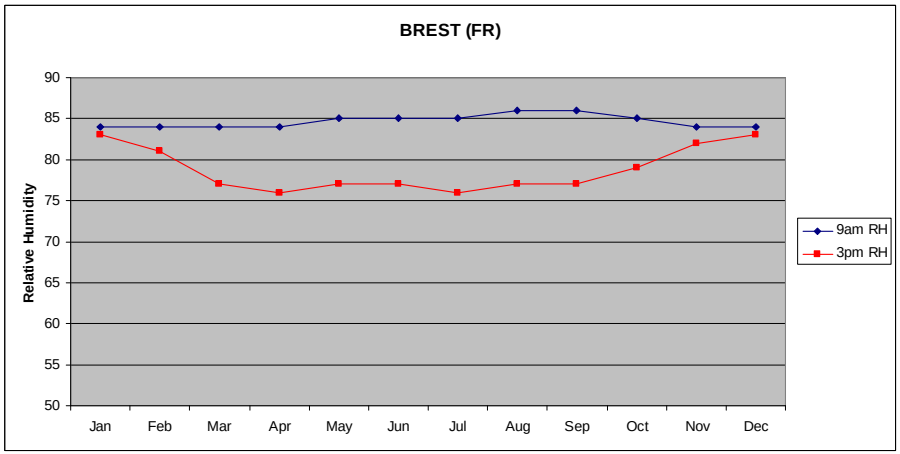
Annex I: Climatic data of The Netherlands and western Brittany

(Source: Climex version 3)









Long-term average maximum and minimum temperature and rainfall in Rotterdam (the Netherlands) and Brest (France)