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Report of a Pest Risk Analysis for *Bursaphelenchus xylophilus*

This summary presents the main features of a pest risk analysis which has been conducted on the pest, according to EPPO Decision support scheme for quarantine pests.

Pest: *Bursaphelenchus xylophilus*

PRA area: EPPO region

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STAGE 1: INITIATION

Reason for doing PRA: The PRA for *Bursaphelenchus xylophilus* (Pine Wood Nematode - PWN) has been performed by EPPO for the territory of EU (of that time) in 1996 and published in the EPPO Bulletin (v.26, pp. 199-249). The pest was included in the EPPO A1 list absent from the territory of the organization. Revision of this PRA has been done for the following reasons:
1) the pest has established in Portugal and its phytosanitary status for the EPPO territory has changed
2) new data have been gathered on natural and man-assisted capacities of spread of the pest
3) new data have been gathered on the pest impact
4) under the new EPPO procedure on conducting PRA, it is necessary to perform it for the whole of the EPPO region
5) the pest is being considered for inclusion in the EPPO A2 list

Taxonomic position of pest: Nematoda: Aphelenchoididae, Parasitaphelenchinae

STAGE 2: PEST RISK ASSESSMENT

Probability of introduction

Entry

Geographical distribution: *B. xylophilus* is believed to be native in North America and has been spread to Asia (Japan, China, Taiwan, Korea) and Portugal (Europe) (OEPP/EPPO, 1986; EPPO/CABI, 1996; Evans *et al.*, 1996). *B.*

xylophilus is widespread in Canada and USA (Ryss *et al.*, 2005; Sutherland 2008) and there is a single report of its presence in Mexico (Dwinell, 1993). It occurs in practically all states/provinces of Canada and USA where pine and other conifer forests exist. The northernmost limit to its distribution in North America is uncertain. In Japan, *B. xylophilus* is now widespread in three of the four main islands, Kyushu, Shikoku and Honshu, but has not yet been reported from the prefectures Hokkaido and Aomori (Futai, 2008). It has spread into China (Zhao *et al*, 2008), Korea (Shin 2008) and Taiwan during the past 35 years and is thought to have reached these locations from Japan. In all these new Asian areas, *B. xylophilus* has become associated with *M. alternatus* as principal vector (Nakamura-Matori 2008). In China, it is restricted to the provinces of Jiangsu, Anhui, Fujian, Jiangxi, Guangxi, Guizhou, Hubei, Hunan, Guangdong, Shandong, Sichuan, Yunnan, Zhejiang and Chonquing City (Zhao *et al*, 2008; Robinet *et al*, 2009). In the Republic of Korea it is present in 54 districts, counties, and cities in 11 provinces (Shin 2008; Shin et al. 2009). Pine wilt symptoms are evident in all these locations. There is a record of the presence of *B. xylophilus* in dying pines in Nigeria but this has not been confirmed by specialist taxonomists (Khan & Gbadegesin 1991). In the EPPO region, PWN has established in continental Portugal where his main vector is *Monochamus galloprovincialis* (Mota et al. 1999, Sousa et al. 2001), and there is a single recorded incursion in Spain.

Geographic distribution of *B. xylophilus*
EPPO region: Portugal (OEPP/EPPO, 1986; EPPO/CABI, 1996; Evans *et al*., 1996, Mota *et al*., 1999, Sousa *et al*., 2001).

Asia: China (Jiangsu, Anhui, Fujian, Jiangxi, Guangxi, Guizhou, Hubei, Hunan, Guangdong, Shandong, Sichuan, Yunnan, Zhejiang and Chonquing City) (Zhao 2008; Robinet *et al*, 2009), Japan (main islands, Kyushu, Shikoku and Honshu) (Futai, 2008), Republic of Korea (54 districts, counties, and cities in 11 provinces) (Shin 2008; Shin *et al*., 2009), Taiwan.

Africa: Nigeria – not confirmed (Khan & Gbadegesin, 1991).

North America: Canada and USA – widespread (Ryss *et al.*, 2005; Sutherland, 2008), Mexico (Dwinell, 1993).

Major host plants or habitats:

PWN prefers *Pinus* species, but is also able to attack other Coniferae: *Abies*, *Picea*, *Larix*, *Cedrus* and *Pseudotsuga*. These genus are considered as PWN host plants.

Its vectors in the genus *Monochamus* can also attack trees of above mentioned species and some other Coniferae: *Juniperus*, *Chamaecyparis*, *Cryptomeria* and sometimes *Tsuga* (OEPP/EPPO, 1986; EPPO/CABI, 1996; Evans *et al*., 1996), but it is uncertain whether these genera are hosts for PWN. They may become infested. Neither *Thuja* nor *Taxus* are regarded as hosts of PWN and its vectors.

The EU Directive 2006/133 EC includes plants of *Abies*, Cedrus, *Larix*, *Picea*, *Pinus*, *Pseudotsuga* and *Tsuga* and all coniferous wood and bark except *Thuja* as hosts of PWN.

Pest: *Bursaphelenchus xylophilus*

Which pathway(s) is the pest likely to be introduced on:

The EWG considered the following possible pathways:

1) Plants for planting (except seeds) of host species (including bonsai plants)
2) Cut branches (including Christmas trees) of host species
3) Wood (except particle wood and waste wood) of host species (including any wood products made from raw untreated coniferous wood)
4) Particle wood and waste wood of host species
5) Coniferous wood packaging material
6) Isolated bark of host species

Other pathways discussed
1) Seeds and cones of host species
There is no report up to now that *B. xylophilus* has been isolated from cones or seeds. Fresh green cones may be a possible commodity to harbour nematodes as *Monochamus* species use them for maturation feeding (Hellrigl, 1971). Mature cones are dry. Size and morphology of the cones and seeds alone rules out the possibility of vector carriage. There is no evidence to suggest that *B. xylophilus* could be found in seeds or cones, although it is known that some nematodes can be associated with coniferous seeds. Potential transfer to Europe could occur if *B. xylophilus* was present because the cones could contain fungal growth similar to that noted in chip piles. However, it seems extremely unlikely that transfer from the commodities to susceptible trees could occur in the absence of a vector final pathway. The risks from this pathway are unknown but are likely to be negligible.

2) Hitchhiking *Monochamus* beetles
Beetles of *Monochamus* emerging from PWN-infested trees/wood are able to carry PWN and transmit it to non-infested trees during maturation feeding. Theoretically, hitchhiking beetles could present a risk of introducing PWN to new areas/countries but the lack of information on hitchhiking *Monochamus* risk would require expert judgement to answer most of questions in the corresponding section of PRA. The risks from this pathway are unknown but are likely to be negligible.

Establishment

Plants or habitats at risk in the PRA area:

Most of *Pinus*, *Abies*, *Picea* and *Larix* species are known hosts of PWN. Some other conifers could also be infested. Large numbers of these tree species are present in the PRA area.

The host plants of PWN are very widely spread in the PRA area (Schütt et al. 2004; Kindel 1995).

Monochamus species are required for the pest spread and are widely distributed in the PRA area on different coniferous trees (Hellrigl 1971, Bense1995).

Climatic similarity of present distribution with PRA area (or parts thereof):

Most of the EPPO region has climatic conditions similar to the current area of PWN distribution including its native range in North America where environmental conditions are generally unsuitable

	for wilt expression and the nematode remains in its saprophytic phase (Evans et al. 1996).
<u>Characteristics (other than climatic) of the PRA area that would favour establishment:</u>	Large part of the EPPO region has abiotic factors (including soil types, range of slopes, etc.) similar to the current area of PWN distribution but they do not much affect PWN establishment. Local wood nematode species (e.g. *Bursaphelenchus mucronatus*) are unlikely to be an obstacle for the PWN establishment. It is extremely unlikely that natural enemies existing in the PRA area (if any) could be an obstacle for the PWN establishment.
<u>Which part of the PRA area is the endangered area:</u>	Coniferous plants are present in all EPPO countries. PWN is likely to establish throughout the distribution range of suitable hosts in the PRA area. Tree damage will be different in different parts of the EPPO region, but even in areas where direct damage will be negligible, the presence of the pest will have important impacts on international trade. So, the whole of the PRA area where host plants are present is considered as an endangered area. Climate change is likely to increase the zones within the PRA area where PWN can result in wilt expression in susceptible host trees. Previous indications were that the 20°C July or August isotherms would delimit the area of wilt expression (De Guiran 1990) and new process modelling methods are now being used to refine this gross assumption (Evans, Evans & Ikegami, 2008). The impact of climate change on productivity of existing and future forests must be taken into account and include possible effects of PWN and other biotic damaging agents.

POTENTIAL ECONOMIC CONSEQUENCES

How much economic impact does the pest have in its present distribution:	The current area of PWN includes the area of the pest origin (North America) and the areas where it has been introduced (Japan, China, Korea, Portugal). While the negative effect in the area of origin is low, the negative effects in other parts of the current area are massive. Very few host trees in the native area of origin succumb to the disease but the impact on export markets is substantial. It is clear that PWN is able to cause significant damage to plants in the PRA area (Kulinich & Kolossova, 1993, 1995; Evans *et al.*, 1996; Mota et al 1999). This damage would be expressed in tree mortality in the southern part of the EPPO region (as demonstrated in Portugal) and in restrictions to trade in its northern part. In Portugal, almost 24 mln euros during 2001 – 2009 were spent to control/eradicate PWN (CIRCA information). In Spain, almost 344 thousand euros were spent in 2009 and almost 3 mln euros will be spent in 2010.
Describe damage to potential hosts in PRA area:	In areas where wilt expression is predicted there will be significant tree mortality. In the young *Pinus* shoots, *B. xylophilus* multiplies in the resin canals, attacking their epithelial cells. The tree shows first symptoms of 'drying out', in the form of reduced oleoresin exudation. The nematodes can now move freely throughout the dying tree. As a consequence of the reduction of its defence

mechanisms (e.g. reduced oleoresin), the tree becomes attractive to adult insects which gather on the trunks to mate. At this stage, intensified wilting and yellowing of the needles is seen. The tree dies 30-40 days after infection, and may then contain millions of nematodes throughout the trunk, branches and roots.

How much economic impact would the pest have in the PRA area:

In areas where wilt expression is predicted there will be significant tree mortality. Simulation presented in the final report of the EU PHRAME project (QLK5-CT-2002-00672) suggests that up to 90% of susceptible pine trees could die in the Setubal region of Portugal.

An increase in production costs is likely to be major due to costs of phytosanitary and control measures, commodity treatments, early replanting compared with expected rotation age, possible changes of tree species to be grown and other costs. In Japan, tens of millions of dollars have been spent for PWN control annually (Kulinich, Kolossova, 1993). In Portugal, almost 24 mln euros during 2001 – 2009 were spent to control/eradicate PWN (information SANCO). In Spain, almost 344 thousand euros were spent in 2009 and almost 3 mln euros will be spent in 2010.

In areas where wilt expression is not predicted and where the direct damage will be negligible, the presence of the pest will have important impacts on the international trade.

CONCLUSIONS OF PEST RISK ASSESSMENT

Summarize the major factors that influence the acceptability of the risk from this pest:

Estimate the probability of entry:

The overall probability of entry of PWN is high.

In order of priority, the probability of entry of PWN and its vectors is:

1) untreated coniferous wood packaging materials (but the implementation of ISPM No 15 reduces this risk to an acceptable level),
2) wood (except particle and waste wood) of host species,
3) plants for planting (except seeds) of host species (including bonsai plants),
4) particle and waste wood of host species,
5) cut branches (including Christmas trees) of host species,
6) isolated bark (including Christmas trees) of host species.

Nevertheless the risk of PWN entry, but not necessarily establishment, with those commodities is substantial.

Estimate the probability of establishment:

The establishment of PWN in new areas of the EPPO region is highly likely, which is shown by experience in Portugal and non-EPPO countries and by climate comparison with the area of current distribution as well as widespread availability of *Monochamus* spp. in the EPPO region.

Spread of PWN in the PRA area is likely without eradication/containment measures, which should be based on biological characteristics of the pest.

Spread of PWN in the PRA area is likely without eradication/containment measures, which should be based on biological characteristics of the pest and its vectors, particularly on the capacity of PWN to be present in host trees that are not exhibiting symptoms of wilt expression.

Elements favouring establishment
Host plants, including wild hosts, are widely available.
Climatic conditions are suitable both outdoors and under protected conditions.
Biological control agents are not known.
Key biological characteristics of this pest are its ability to establish in trees without symptoms expression, and it capacity to live saprophytically.
Few (10s to low hundreds) specimens transmitted to a host tree are sufficient to enable a PWN population to establish in that tree.

Elements inhibiting establishment (in protected crops)
No elements.

The whole of the PRA area where host plants are present is considered as an endangered area. Climate change is likely to increase the zones within the PRA area where PWN can result in wilt expression in susceptible host trees.

Estimate the potential economic impact:

Tree damage will be different in different parts of the EPPO region, but even in areas where the direct damage will be negligible, the presence of the pest will have important impacts on international trade. So, the whole of the PRA area where host plants are present is considered as an endangered area.

Degree of uncertainty

The main uncertainties arise from the lack of information available on the risk of infestation of "secondary" hosts (such as *Juniperus, Tsuga*, etc.) and "secondary" commodities (such as bark or cut branches) by PWN and especially by its *Monochamus* vectors. *Juniperus, Chamaecyparis* and *Cryptomeria* could be hosts of *Monochamus* but not of PWN: the lack of evidence creates some uncertainty. Considerable uncertainties remain concerning transmission of PWN from certain consignments to suitable hosts and its possible transmission to trees in the absence of vectors. These involve consignments that do not carry *Monochamus* and cannot be attacked by *Monochamus* because non-vector transmission has only been demonstrated in experiments, but has never been reported in field conditions. Although there is substantial information on flight capacities of *M. alternatus* and *M. carolinensis*, there is only fragmentary information on flight distances for *Monochamus* spp. in the EPPO region. Other uncertainties (e.g. on the degree of social damage) are not important for overall conclusions on the phytosanitary risks involved.

OVERALL CONCLUSIONS

The EWG considered that the pest was an appropriate candidate for pest risk management given the high potential for establishment and the potential for economic impact in the whole of the PRA area.

STAGE 3: PEST RISK MANAGEMENT

IDENTIFICATION OF THE PATHWAYS

Pathways studied in the pest risk management	**Pathway 1: 1) Plants for planting (except seeds) of host species (including bonsai plants)** **Pathway 2: Cut branches of host species (including Christmas trees)** **Pathway 3: Wood (except particle wood and waste wood) of host species** **Pathway 4: Particle wood and waste wood of host species** **Pathway 5: Coniferous wood packaging material** **Pathway 6: Isolated bark of host species**
Other pathways identified but not studied	**Pathway 7: Seeds and cones of host species.** **Pathway 8: Hitchhiking *Monochamus* beetles.**

IDENTIFICATION OF POSSIBLE MEASURES

Possible measures for pathways

Pathway 1: Host plants for planting (except seeds) of host species (including bonsai plants).

Measures related to consignments:

Specified testing

This testing requirement is not sufficient when used alone. The plants should have been tested and found free from *Bursaphelenchus xylophilus* and its vectors and should be produced under vector-proof conditions according to EPPO National Regulatory Control System No 9/1.

Measures related to the crop or to places of production:

Pest Free Area for *Bursaphelenchus xylophilus*

Growing in specified vector-proof conditions could ensure place of production freedom of plants for planting, but this measure could not be regarded as efficient alone and should be combined with testing.

Any of identified measures taken alone could not reduce the risk to an acceptable level and should be combined.

Combination of measures

The pest-free area requirement in combination with measures preventing the infestation of the commodity in transit (transportation outside of *Monochamus* flight period, or through areas not infested with *Bursaphelenchus xylophilus*, or in sealed containers or packaging to prevent infestation) could reduce the risk to an acceptable level. The pest-free area requirement could be replaced by testing plants for PWN freedom in combination with production under vector-proof conditions, and always in combination with measures preventing the infestation of the commodity in transit mentioned above.

Measures in the importing counttry

Portugal experience shows that even a very intensive survey and phytosanitary measures do not make successful eradication of PWN easily achievable. In principle, PWN eradication is possible but very complicated and expensive. It could not be considered as an effective measure alternative to phytosanitary measures taken in the exporting country and in transit.

Pathway 2: Cut branches of host species (including Christmas trees).

Measures related to consignments:

Specified testing
This testing requirement is not sufficient when used alone. The cut branches should have been tested and found free from *Bursaphelenchus xylophilus* and its vectors, and must come from a pest-free place of production whose immediate vicinity was free from *Bursaphelenchus xylophilus*.

Measures related to the crop or to places of production:
Pest Free Area for *Bursaphelenchus xylophilus*
Growing in specified vector-proof conditions could ensure place of production freedom of cut branches, but this measure could not be regarded as efficient alone and should be combined with testing for PWN freedom. But these measures are not considered practical for cut branches.

Any of identified measures taken alone could not reduce the risk to an acceptable level and should be combined.

Combination of measures
The pest-free area requirement in combination with measures preventing the infestation of the commodity in transit (transportation outside of PWN vectors flight period, or through areas not infested with PWN, or in sealed containers or packaging to prevent infestation) could reduce the risk to an acceptable level. The pest-free area requirement could be replaced by testing the consignments in combination with place of production and immediate vicinity freedom, always in combination with measures preventing the infestation of the commodity in transit mentioned above.

Measures in the importing counttry
Portugal experience shows that even a very intensive survey and phytosanitary measures do not make successful eradication of PWN easily achievable. In principle, PWN eradication is possible but very complicated and expensive. It could not be considered as an effective measure alternative to phytosanitary measures taken in the exporting country and in transit.

Pathway 3: Wood (except particle wood and waste wood) of host species.

Measures related to consignments:
Specified testing. Reliable testing method is available but testing all volume is not practical.
Three treatments are effective against PWN: (1) heat treatment (by using a reliable method/process to achieve 56ºC in the core of wood for at least 30 min), (2) methyl-bromide fumigation (according to the EPPO Phytosanitary Procedure No 10/7) and (3) irradiation according to PM 10/8. Debarking could prevent infestation if PWN-free consignment is transported through or stored on territories infested both by PWN and its vectors.

Measures related to the crop or to places of production:
Pest Free Area for *Bursaphelenchus xylophilus*

Any of identified measures taken alone could not reduce the risk to an acceptable level and should be combined.

Combination of measures
The pest-free area requirement in combination with debarking or other measures preventing the infestation of the commodity in transit or during storage (transportation outside of PWN vectors flight period, or through areas not infested with PWN, or in sealed containers or packaging to prevent infestation) could reduce the risk to an acceptable level. Heat treatment or methyl-bromide fumigation[1] or irradiation could reduce the risk to an acceptable level in combination with debarking or other measures preventing the infestation of the commodity in transit or during storage.

[1] Prior removal of bark must be carried out for the efficacy of methyl bromide treatment

Measures in the importing counttry
Portugal experience shows that even a very intensive survey and phytosanitary measures do not make successful eradication of PWN easily achievable. In principle, PWN eradication is possible but very complicated and expensive. It could not be considered as an effective measure alternative to phytosanitary measures taken in the exporting country and in transit.

Pathway 4: Particle wood and waste wood of host species.

Measures related to consignments:
<u>Specified testing</u>. This testing is possible in theory but difficult in practice. Wood chips tend to be imported in large quantities and could encourage development and breeding of PWN. Testing of particle wood and waste wood is more feasible than testing other wood because only large peaces of wood (suitable for development of PWN vectors) require testing.
One <u>treatment</u> is effective against PWN: <u>heat treatment</u> (by using a reliable method/process). If PWN-free particle and waste wood <u>originate from debarked wood</u>, it could prevent further infestation if consignments are transported through or stored in territories infested both by PWN and its vectors.
If particle/waste wood is imported outside of *Monochamus* flight period (e.g. during winter) and processed before *Monochamus* flight period starts, there is no risk of PWN introduction, but it may not be feasible for NPPOs to ensure that all imported particle/waste wood is completely processed before *Monochamus* flight period.

Measures related to the crop or to places of production:
<u>Pest Free Area for *Bursaphelenchus xylophilus*</u>

Any of identified measures taken alone could not reduce the risk to an acceptable level and should be combined.

Combination of measures
The pest-free area requirement in combination with production from debarked wood or other measures preventing the infestation of the commodity in transit (transportation outside of PWN vectors flight period, or through areas not infested with PWN, or in sealed containers or packaging to prevent infestation) could reduce the risk to an acceptable level. Heat treatment could reduce the risk to an acceptable level in combination with production from debarked wood or measures preventing the infestation of the commodity in transit.

Measures in the importing counttry
Portugal experience shows that even a very intensive survey and phytosanitary measures do not make successful eradication of PWN easily achievable. In principle, PWN eradication is possible but very complicated and expensive. It could not be considered as an effective measure alternative to phytosanitary measures taken in the exporting country and in transit.

Pathway 5: Coniferous wood packaging material.

The EWG believed that the implementation of ISPM No 15 reduces the risk to an acceptable level.

Pathway 6: Isolated bark of host species.

Measures related to consignments:

Specified testing. This testing is possible in theory but not practical used alone. Testing of bark is however more feasible than testing of wood (see above). Sampling procedures may limit the confidence level of detection if PWN is present
One treatment of bark is effective against PWN: heat treatment (by using a reliable method/process).

Measures related to the crop or to places of production:
Pest Free Area for *Bursaphelenchus xylophilus*

Each of two identified measures taken alone could not reduce the risk to an acceptable level and should be combined. The pest-free area requirement could reduce the risk to an acceptable level. Heat treatment could reduce the risk to an acceptable level.

Measures in the importing counttry
Portugal experience shows that even a very intensive survey and phytosanitary measures do not make successful eradication of PWN easily achievable. In principle, PWN eradication is possible but very complicated and expensive. It could not be considered as an effective measure alternative to phytosanitary measures taken in the exporting country and in transit.

EVALUATION OF THE MEASURES IDENTIFIED IN RELATION TO THE RISKS PRESENTED BY THE PATHWAYS

CONCLUSION:
Recommendation for possible measures:

Plants for planting (except seeds) of Coniferae host species	PC[2] and, if appropriate, RC[3]
Plants for planting (except seeds) of host species originating in countries where *Bursaphelenchus xylophilus* occurs	Pest-free area for *Bursaphelenchus xylophilus* or The plants should have been tested and found free from *Bursaphelenchus xylophilus* and its vectors and produced under vector-proof conditions according to EPPO National Regulatory Control System No 9/1 AND Transported outside of *Monochamus* flight period or Not transported through areas infested with *Bursaphelenchus xylophilus* or Transported in sealed containers or packaging to prevent infestation

Cut branches of Coniferae host species	PC and, if appropriate, RC
Cut branches (including Christmas trees) of host species originating in countries where *Bursaphelenchus xylophilus* occurs	Pest-free area for *Bursaphelenchus xylophilus* or Tested and found free from *Bursaphelenchus xylophilus* and its vectors and must come from a pest-free place of production whose immediate vicinity was free from *Bursaphelenchus xylophilus* AND Transported outside of *Monochamus* flight period or Not transported through areas infested with *Bursaphelenchus xylophilus* or Transported in sealed containers or packaging to prevent infestation

Wood of Coniferae host species	PC and, if appropriate, RC
Wood (including squared wood, but excepting packaging wood, particle wood and waste wood) of host species originating in countries where *Bursaphelenchus xylophilus* occurs	Fumigated according to EPPO Phytosanitary Procedure PM 10/7[4] OR Pest-free area for *Bursaphelenchus xylophilus* or

[2] PC – Phytosanitary Certificate
[3] RC – Re-export Phytosanitary Certificate
[4] Prior removal of bark must be carried out for the efficacy of methyl bromide treatment

	Heat treated (commodity is heated until the core temperature reached at least 56°C for at least 30 min according to an officially recognized technical specification) or Irradiation treatment according to EPPO Phytosanitary Procedure PM 10/8 AND Debarking or Transported outside of *Monochamus* flight period or Not transported through areas infested with *Bursaphelenchus xylophilus* or Transported in sealed containers or packaging to prevent infestation
Particle wood (sawdust, chips, particles) and waste wood (shavings, scrap) of host species originating in countries where *Bursaphelenchus xylophilus* occurs	Pest-free area for *Bursaphelenchus xylophilus* or Heat treatment (commodity is heated until the core temperature reached at least 56°C for at least 30 min according to an officially recognized technical specification) AND Originating from debarked wood or Transported outside of *Monochamus* flight period or Not transported through areas infested with *Bursaphelenchus xylophilus* or Transported in sealed containers or packaging to prevent infestation
Wood packaging material of Coniferae	Requirements of ISPM No 15

Isolated bark of Coniferae	PC and, if appropriate, RC
Isolated bark of Coniferae originating in countries where *Bursaphelenchus xylophilus* or its vectors occur	Pest-free area for *Bursaphelenchus xylophilus* or Heat treatment (commodity is heated until the core temperature reached at least 56°C for at least 30 min according to an officially recognized technical specification)

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