PEST RISK ANALYSIS FOR : Agrilus anxius
(report generated with CAPRA; Appendices added by the risk assessor)

Stage 1: Initiation

1.01 - Give the reason for performing the PRA

Identification of a single pest

1.02a - Enter the name of the pest

Pest name (what you enter here will appear as a heading)

Agrilus anxius

1.02b - Indicate the type of the pest

arthropod

1.02d - Indicate the taxonomic position

Order: Coleoptera, Family: Buprestidae

1.03 - Clearly define the PRA area

EPPO

1.04 - Does a relevant earlier PRA exist?

no

The PRA is not performed from a previous PRA. There is no indication of the existence of a previous PRA for *A. anxius*. However, the information in the EPPO Alert List for *A. anxius* provides the key points on the potential risk posed by this pest to the EPPO region (EPPO, 2010).
In addition, the present PRA makes many references to the related species *Agrilus planipennis* (emerald ash borer), an Asian wood-boring buprestid of ash that is now also present in North America and Moscow, Russia. A PRA was done by EPPO in 2003 and *A. planipennis* was included in the EPPO A1 List based on this PRA (EPPO, 2003a, 2003b). *A. planipennis* pest has a similar biology and ecology to *A. anxius* with respect to the general timing of major life-history events and it has been introduced outside of its natural range with substantial impact (e.g. in USA and Canada; see Loerch & Cameron, 1983b; Haack *et al*., 2002; Cappaert *et al.*, 2005; Petrice & Haack 2006, 2007; Poland & McCullough 2006; USDA–APHIS, 2009). The expert working group considered that, for many aspects of the PRA, *A. planipennis* is a good model of what would happen if *A. anxius* was introduced in the PRA area, and the experience with this pest is very relevant for the present PRA.

1.06 - Specify all host plant species (for pests directly affecting plants) or suitable habitats (for non parasitic plants). Indicate the ones which are present in the PRA area.

In North America, *Betula* spp. are hosts of *A. anxius* at all stages of development. *B. nigra* does not appear to be a host (Nielsen *et al.*, in press). *B. nana* has never been documented as a host, but this could be related to thermal constraints and small stem size. *Betula* spp. are widespread in the PRA area, as forest or ornamental trees, some of the species identified as natural hosts in North America are present in the PRA area. See 14 and Section B – risk of establishment.

Host species

Betula spp. (birch), including *Betula alleghaniensis* (yellow birch), *B. davurica* (black birch), *B. jacquemontii* (white-barked Himalayan birch), *B. lenta* (sweet birch), *B. maximowicziana* (monarch birch), *B. occidentalis* (water birch), *B. papyrifera* (paper birch), *B. pendula* (silver or European birch), *B. platyphylla* (Manchurian birch), *B. populifolia* (gray birch), *B. pubescens* (downy birch), *B. utilis* (Himalayan birch). *B. albosinensis* var *septentrionalis* and *B. ermanii* have been reported as rarely attacked by *A. anxius*. *A. anxius* is known to attack many native and introduced birch species (and their numerous crosses) in North America. Susceptibility varies between birch species, with European and Asian birch species being much more susceptible than North American birch species (Miller *et al.*, 1991; Nielsen *et al.*, in press). *A. anxius* has been recognized as a pest of both ornamental/landscape/urban birch and forest birch (Anderson 1944; Ball & Simmons, 1980). *A. anxius* is considered to be a secondary pest of highly stressed North American hosts in North America (Haack, 1996; Santamour, 1990a); however, stress does not appear to be necessary for colonization of European and Asian species (Nielsen *et al.*, in press; Hale & Herms, unpublished data).

The available literature does not provide information on the host status of some North American birch species (e.g. *B. pumila* – although this is not known to be present in the PRA area) or species that are also widely distributed in the PRA area (e.g. *B. nana*). In the latter case, it might be that the stems or branches are too small in diameter or that climatic conditions are not suitable. In Scandinavia (in the moutain region) *Agrilus paludicola* Krogerus 1922 reproduce in *B. nana*. The size of this Agrilus species (about 6mm) is much smaller than *A. anxius* (10-12mm).

Notes on other plants recorded as hosts:
There is no indication that *A. anxius* adults breed on other woody plants besides *Betula* spp. in the wild, and there are no published records of *A. anxius* emerging from any hosts other than *Betula* spp. There are however a few records of other host plants, which can be explained as follows:

- There were early records of *A. anxius* on beech (*Fagus* spp.) and aspen (*Populus* spp.), in addition to birch (*Betula* spp.) (e.g. in Anderson, 1944). However, Barter & Brown (1949) and MacAloney (1968) note that evidence has shown that the species attacking aspen is the closely-related *A. liragus* Barter and Brown (bronze poplar borer) and Johnson & Lyon (1976) note that *A. liragus* is very similar to *A. anxius* in its life history and morphology, and that the identity of the adults of these species are often confused.
- Some later articles also report feeding by *A. anxius* adults on other plant species, without egg laying on these species, nor of larval development. The studies concerned were conducted in cages or laboratories:
  - Cage experiments in the field on willow (*Salix elaeagnos*), poplar (*Populus deltoides*) (Akers & Nielsen, 1990; Johnson & Lyon, 1976).
  - Cage or laboratory experiments on cottonwood (*Populus deltoides*), *P. generosa*, aspen (*P. tremuloides*), *Acer saccharinum* (soft maple), *Quercus palustris* (pin oak) (Barter, 1957; Akers & Nielsen, 1990). These are probably the source of records of maple and oak as hosts (CABI, 2005).

1.07 - Specify the pest distribution for a pest initiated PRA, or the distribution of the pests identified in 2b for pathway pests

EPPO region: Absent.

North America:
Canada: Alberta, British Columbia, Manitoba, New Brunswick, Newfoundland, Nova Scotia, Ontario, Quebec, Saskatchewan (Bousquet, 1991; Bright, 1987), Prince Edward Island (Department of Agriculture of Prince Edward Island). NRC (2010) specifies that *A. anxius* occurs throughout the range of birch in Canada.

USA

Alaska	Bousquet (1991)	Arkansas	Hopkins (ed.) (undated)
California	Dreistadt *et al*. (2004)	Colorado	Crawnshaw *et al*. (2000)
Connecticut	Douglas & Cowles (ed.) (2006)	Delaware	Caron (2004)
Georgia	Nelson *et al*. (1996)	Idaho	Solomon (1995), Johnson & Lyon (1976), Shetlar (2000)
Illinois	Appleby *et al*. (1973)	Indiana	Gibb & Sadof (2007)
Iowa	Iles & Vold (2003)	Kansas	Bauernfeind (2006)
Kentucky	Johnson & Lyon (1976)	Maine	Katovich *et al*. (2005)
Maryland	Katovich *et al*. (2005)	Massachusetts	Arnett (2000)
Michigan	Jones *et al*. (1993)	Minnesota	Wawrzynski *et al*. (2009)
Missouri	Solomon (1995)	Montana	Denke *et al*. (2008)
Nebraska	Keith *et al*. (2003)	Nevada	Carlos *et al*. (2002), Wescott (1990)
New Jersey	Johnson & Lyon (1976)	New Hampshire	Swier (2003)
New York	Arnett (2000)	New Mexico	Anonymous (undated, a)
North Dakota	Zeleznik *et al*. (2005)	Ohio	Johnson & Lyon (1976)
Oregon	Katovich *et al*. (2005), Nelson *et al*. (2004)	Pennsylvania	Hoover (2002)

South Dakota	SDDA (2009), Barter & Brown (1949)	Tennessee	Johnson & Lyon (1976)
Utah	Karren & Roe (2000)	Vermont	Hanson & Walker (1996)
Washington	Katovich *et al*. (2005)	West Virginia	Johnson & Lyon (1976), Shetlar (2000)
Wisconsin	WIDNR (2008)	Wyoming	WSFD (undated)
Washington DC	Santamour (1999)		

There are statements in the literature that *A. anxius* is present throughout the range of birch in the USA (Johnson & Lyon, 1976; Katovich *et al.*, 2005). In the absence of documented records, there is some uncertainty on the presence of *A. anxius* in the extreme southern USA where birch is present at least as an ornamental tree. *A. anxius* is also sometimes mentioned "in passing" in extension brochures as a parameter in the selection of ornamental birch species, but it is not specifically listed as a serious pest, presumably because birch is present as an ornamental tree and is not very adapted to the climate there. For example,

- reported as "uncommon in Texas because of the lack of host trees" (Drees *et al.*, 1994), but specific pesticides for its control are mentioned.
- reported as a factor to be taken into account for storm-damaged trees in Oklahoma by Smith *et al.,* 2008.
- *Betula papyrifera* and *B. pendula* are on a list of prohibited plants in South Carolina upstate region (Tourkow, 2009) with, among others, the reasons that they are susceptible to *A. anxius*, and intolerant to urban stress.

However *A. anxius* is likely to be present wherever birch is used, as forest or ornamental, as it has widely extended its range to locations where non native birch species have been introduced as ornamentals (references in tables above).

Stage 2: Pest Risk Assessment Section A: Pest categorization

Identity of the pest (or potential pest)

1.08 - Does the name you have given for the organism correspond to a single taxonomic entity which can be adequately distinguished from other entities of the same rank?

yes

Stage 2: Pest Risk Assessment Section B: Probability of entry of a pest

2.01a - Describe the relevant pathways and make a note of any obvious pathways that are impossible and record the reasons. Explain your judgement (edit in the part justification)

Possible pathways:

1. Wood chips containing *Betula* spp. originating from where the pest occurs in Canada and in the USA

This pathway was the main pathway of concern when adding this pest to the EPPO Alert List. Hardwood wood chips are a commodity class. Birch might be used alone or in mixture with other species for producing wood chips. Wood chips might be imported for pulpmills, energy production or fiberboard production. Wood chips might also be used as mulch, but it is not known if some wood chips imported from North America would be used as mulch.

Wood chips might be produced from lower quality wood that might be infested. A small percentage of larvae of the related species emerald ash borer *A. planipennis* have been shown to survive the chipping process (McCullough *et al*., 2007). To date, neither *A. anxius* nor *A. planipennis* have been intercepted in wood chips.

Wood chunks are another commodity used in wood industry but not mentioned in custom codes for trade. They are often referred to as "biomass chunks" and are usually not screened and are much bigger in size (e.g. cubes that are 5 cm or 10 cm on a side). The EWG was not aware of this type of commodity as the time of the PRA, but similar measures should be considered as for wood chips. The risk would be at least as high as for chips (as probability of survival of larvae and pupae in chunks is more likely than in chips).

2. Plants for planting of *Betula* spp. originating from where the pest occurs in Canada and in the USA

This pathway considers birch plants for planting traded as nursery plants for forest or amenity uses. There might be trade of such plants for nurseries wishing to use specific varieties or hybrids in the PRA area, especially as ornamentals. Bonsais are also considered, as some practical bonsai websites mention *A. anxius* as a pest problem (e.g. Caine, 2000; Anonymous, undated, b).

A. anxius is not likely to be associated with plants with a stem diameter below 2 cm (Herms, personal observations, 2010; Nielsen pers. obs., 2010). However, larvae may move from larger wood into branches as small as 1 cm. Scion stems bigger than 1cm diameter are therefore included,

3. Wood with or without bark of *Betula* spp. originating from where the pest occurs in Canada and in the USA

This includes round wood, wood with bark, wood without bark, and firewood. There is a trade of birch wood from North America (see Appendix 2). Birch wood has many uses, such as furniture, boxes, crates, doors, plywood, pulpwood, fuel wood, toothpicks, etc. (Alden, 1995). UNECE (2009) also reports an increasing trade of small diameter logs for energy production. Firewood might also be a pathway, and birch is listed as a species used and traded for firewood in Canada (CFIA, 2010) and the USA (Haack *et al.*, 2010).

North American *Betula* spp. are the main species for this pathway, as they are grown as forest trees and used to produce wood. European and Asian *Betula* spp. are grown as ornamentals in North America.

4. Furniture and other objects made of untreated birch wood originating from where the pest occurs in Canada and in the USA

The expert working group considered that there could be a risk of presence of fourth instars, prepupae and pupae if untreated/air dried/bark-covered sapwood was used. This is often the case in rustic birch furniture where whole logs with intact bark are used to construct table legs, bed frames, etc. The expert working group considered that the risk of entry from this pathway would be similar to that for wood with bark. This pathway was not studied in detail because it was not possible to retrieve trade data for this commodity.

Pathways not studied further as considered less likely:

5. Wood packaging material (including dunnage) containing *Betula* spp.

Wood packaging material mostly accompanies other commodities. Since the adoption of ISPM 15 (FAO, 2009), all wood packaging material moved in international trade should be debarked and then heat treated or fumigated with methyl bromide and stamped or branded, with a mark of compliance.

Birch is used for the production of wood packaging material, including dunnage. Wood packaging material is suspected to be the source for the introduction of other *Agrilus* species into North America: *A. planipennis* and *A. sulcicollis* (first recorded, respectively, in 2002 and 1995; Haack, 2006; Haack *et al*., 2002, 2009; Jendek & Grebennikov, 2009) and as the source of several interceptions of *Agrilus* spp. there (Haack *et al.*, 2002, 2009), but these records date from before the implementation of ISPM 15 (FAO, 2009).

In theory, treatments applied to wood packaging material if undertaken according to ISPM 15 *Regulation of Wood Packaging Material in International Trade* (FAO, 2009) should destroy the pest (methyl bromide fumigation or heat treatment at 56° C for 30 minutes throughout the entire profile of the wood including the core). For this reason, the EWG did not continue the assessment of this pathway. However, some concerns were raised about the efficacy of heat treatment against *A. planipennis*: some recent studies indicate that ISPM 15 heat treatment might not be 100% effective (Goebel *et al*., 2010), but treatments in this study measured temperature at a depth of 2.5 cm into the wood rather that at the core. Additional consideration of the results above is needed in terms of the risk management options for pathways 1 and 3[1].

6. Cut branches of *Betula* spp. originating from where the pest occurs in Canada and in the USA
Data are not available for imports on this pathway into the PRA area. Cut branches of birch are harvested (e.g. State of Alaska, 2008; Centre for Non-Timber Resources, 2006) and sold in North America as decorations around Christmas time, without leaves, but no evidence of export/import was found. In any case, such cut branches are very likely to have a small diameter, and it is thought that branches would probably have to be at least 1 cm in diameter to support bronze birch borer (Herms, pers. comm., 2010; Nielsen pers. comm., 2010).

7. Natural spread
Intercontinental spread from North America to the PRA area is very unlikely. However, this pathway would become a likely pathway of movement within the PRA area following an introduction.

8. Hitchhiking
Adults have a short life span (average 23 days) and have a limited survival time (4-7 days) without feeding on a host (Barter, 1957). Maturation feeding on host foliage is also necessary to allow oviposition (Akers & Nielsen, 1990). Adults also have a high affinity with host plants and are not likely to be on non-host material. However, this pathway would become a likely pathway of movement within the PRA area following an introduction.

9. Bark and objects made of bark
Birch bark is traditionally used for arts and handicrafts (State of Alaska, 2008; Centre for Non-Timber Resources, 2006). Only larvae might be present at the interface between the bark and the wood, but if they were removed with the bark, they would dry-out and not survive.

10. Birch processed wood material and commodities made of this (plywood, etc.), wood pellets
The degree of processing would not allow survival of larvae or pupae in the wood.

11. Individual live insects moved by amateur entomologists
A. anxius is a beautiful insect and might be sent to hobbyist entomologists. This pathway is difficult to regulate as such but could be covered once the pest is regulated.

2.01b - List the relevant pathways that will be considered for entry and/or management. Some pathways may not be considered in detail in the entry section due to lack of data but will be considered in the management part.

[1] Since the meeting of the EWG, the *International Forestry Quarantine Research Group* discussed this issue (Lisbon, 2010-09-27/10-01) on the basis of recent research. The IFQRG concluded that the current schedule of 56°C for 30 minutes was adequate for *A. planipennis*. Later, in 2011, the treatment requirement was reduced to 60°C for 60 minutes (USDA APHIS, 2011).

Pathway 1: Wood chips containing Betula spp. originating from where the pest occurs in Canada and in the USA

2.03 - How likely is the pest to be associated with the pathway at the point(s) of origin taking into account the biology of the pest?

moderately likely

Level of uncertainty: low

A. anxius is associated with birch in forests throughout the distribution of its native host species in North America (see answer to question 7). Imported wood chips might be used for paper, energy production, fibreboard production or as mulch (UNECE, 2009; Kopinga *et al*., 2010). They might be composed purely of birch or mixed with other hardwood species. Mixed hardwood wood chips might contain a limited amount of birch wood, which would lower the likelihood of association with the pathway. Wood chips are often produced from lower quality trees, which increases the probability of infestation.

Due to the life cycle of the pest, larvae might be present in the wood at any time of the year. As the life cycle of *A. anxius* is similar to that of *A. planipennis*, it would be possible to have living *A. anxius* fourth larval instars, prepupae, or pupae in wood chips greater than 2.5 cm in each dimension (McCullough *et al.*, 2007; Roberts & Kuchera, 2006). The EWG considered that earlier larval instars will not be able to complete their development in the chips.

2.04 - How likely is the pest to be associated with the pathway at the point(s) of origin taking into account *current management* conditions?

unlikely

Level of uncertainty: low

Concentration will depend on the population dynamics. *A. anxius* is present typically at low density, although in this situation some trees might still be heavily infested. Concentration is likely to be high in forests only during outbreaks. Outbreaks are infrequent in space and time (Jones *et al*., 1993; Haack & Petrice, unpublished data). Wood chips are typically made of low quality wood. Trees used to produce wood chips are more likely to have a high concentration of *A. anxius* than trees used to produce logs. There are no cultivation practices in forests that would limit the association of *A. anxius* with this pathway. However, the process of wood chipping is likely to reduce the concentration: wood chips are processed through grinding or chipping, which cut the wood into pieces and expose large amounts of the wood surface to drying. This is likely to kill actively feeding larvae, but survival of prepupal larvae and pupae would be possible in wood chips greater than e.g. 2.5 cm in each dimension.

Wood chips have been shown to carry viable prepupae of the related species *A. planipennis*, depending on the process and treatments applied, and in particular depending upon the size of the resulting chips (McCullough *et al*., 2007). As *A. planipennis* and *A. anxius* larvae and pupae are of similar width and length, it can be extrapolated that *A. anxius* larvae and pupae may also survive the chipping process. It should be stressed that not much research has been performed up to now and it is therefore not possible to give a definitive minimal size for the chips to support survival of the pest.

Furthermore, there is a wide variation in the size of wood chips, which can be quite large. A screen with a maximum size of 2.5 cm will guarantee this length only in 2 dimensions, while the third dimension can vary (e.g. 2.5 x 2.5 x 10 cm). For example, McCullough *et al*. (2007) reported a maximum chip size of 14 x 4 x 2.5 cm when a 10-cm square screen was used, and 12 x 2.5 x 1 cm when a 2.5-cm square screen was used. Similarly, in a survey of a boat load of hardwood wood chips imported to Norway in 2010 for a wood pellet production factory, chips from 1.6 to 22.9 cm (measured along their maximum length) were found (Økland, Norwegian Forest and Landscape Institute, pers. comm., 2010). In the Netherlands the common maximum chip size is 200 mm, which accounts for either of the dimensions, although chips are normally flake-shaped (Kopinga *et al*., 2010). According to Kopinga *et al*. (2010), there are no data on the average size of chips that are sold to power plants, nor on the probability that chips exceed certain sizes (e.g. 2.5 cm long). After visiting several wood chip factories in the US, Roberts & Kuchera (2006) found that none of the chip piles consistently contained only chips of one inch (2.5 cm) or smaller. Some chips were observed to carry live adult *A. planipennis* (Several trees were given a primary grinding, which resulted in many small wood chips, one inch or less, but which also resulted in a few larger chips, for example, 1 inch by 6 inches (2.5 by 15 cm). Approximately 4.5 kg of bark chips were collected and dissected for evidence of surviving beetles and three intact live adult beetles were found.).

2.05 - Consider the volume of movement along the pathway (for periods when the pest is likely to be associated with it): how likely is it that this volume will support entry?

likely

Level of uncertainty: medium

There are no specific data on imports of birch as wood chips, i.e. pure versus mixed, proportion of birch in mixed wood chips. However, the import of hardwood wood chips from North America to certain countries of the PRA area is rapidly increasing (see USA and Canada export statistics in Appendix 2). Analysis anticipates that this increase will continue to allow EU countries to meet the targets of the EU energy policy to 2020, although North America is not the only source of hardwood chips and supply of chips from other continents (e.g. South America) is also growing (UNECE, 2009).

Canada is recorded as a principal provider of wood chips for Europe (together with Germany, France, Latvia, Czech Republic, Russia, Uruguay, and Brazil). Non- coniferous wood chips would be expected to include large proportions of birch because there are extensive birch forests in Canada. Europe became a net importer of wood chips in 2008 with 29.8 million m^3 of wood chips and wood pellets (and there is an increasing demand for small diameter pulp wood for energy purposes, to complete the requirement for wood chips and wood pellets). Some new wood-fired power plants have been established in Europe and these will require massive quantities of wood fibre in coming years.

In Norway (Økland, pers. comm., 2010) a new wood pellet factory (second largest in the world) started operating in 2010 and it is importing nonconiferous wood from North America. Wood includes *B. papyrifera* and *B. alleghanensis* from Canada, and samples taken in the first shipment showed chips sizes of 1.6 to 22.9 cm in length. The content of birch in these shipments was about 30%.

2.06 - Consider the frequency of movement along the pathway (for periods when the pest is likely to be associated with it): how likely is it that this frequency will support entry?

likely

Level of uncertainty: medium

Wood chips are imported throughout the year, at least once a month.

2.07 - How likely is the pest to survive during transport or storage?

moderately likely

Level of uncertainty: low

There are no data on how long late larval stages would survive in wood chips (i.e. whether they would survive the duration of transport). Nevertheless, it is assumed that actively feeding larvae would not survive as they would be exposed to desiccation and suffer from a lack of fresh phloem (inner bark). Only 4^{th} instars that have completed feeding, prepupae and pupae would survive, if not injured during chipping.

2.08 - How likely is the pest to multiply/increase in prevalence during transport or storage?

unlikely

Level of uncertainty: low

There is no data on temperature during transport/storage. Adults may emerge from pupae if temperature is sufficiently high (e.g. about 20-25°C). Even if adults are associated with the wood chips or did emerge during transport, they would not find food (i.e. host foliage) which is necessary to become reproductively mature, and thus would not reproduce (as they have a limited survival time without food) (Barter, 1957). Mating and reproduction is therefore impossible/very unlikely.

2.09 - Under current inspection procedures how likely is the pest to enter the PRA area undetected?

very likely

Level of uncertainty: low

In the EU countries, there are no phytosanitary measures targeting wood chips or other management procedures, and no phytosanitary certificate is required. The commodity would not be submitted to inspection.
An EU standard for quality of wood chips is being developed (CEN prEN 14961-1 2008.4 solid biofuel cited in

Kopinga *et al*., 2010) which is to replace all other national legislation. This standard will describe the requirements for fraction size, moisture content, ash content and density of the wood chips.

Even if inspection was carried out, it is unlikely to detect the pest, as:
- wood chips might contain several tree species
- signs of presence of the pest in wood (e.g. galleries) would not be easy to observe.

Sampling rates for a possible detection of such pests in wood chips have not been defined but large samples would be needed to be confident that *A. anxius* is not present.

In Israel (Israel, 2009a) wood chip importation does not require an import permit but it does require a phytosanitary certificate. The consignment must meet the following requirements: (1) The woodchips do not include bark; (2) The consignment has undergone a vapour treatment with methyl bromide in accordance with the requirements detailed in the treatment manual (exposure for 16 hours, at $48g/m^3$ at 21°C or more, or at $80g/m^3$ at 10-20°C) (Israel, 2009b).
In Turkey (Turkey, 2007), requirements for imported woodchips of broadleaved (hardwood) trees are that they should be produced from wood that has been fumigated or stripped of its bark, or has been dried to below 20% moisture content, expressed as a percentage of dry matter.
In Russia, an import permit is required.

No requirements are specified for Tunisia or Morocco (according to the EPPO collection of phytosanitary regulations).

2.10 - How likely is the pest to be able to transfer from the pathway to a suitable host or habitat ?

moderately likely
Level of uncertainty: medium

Wood chips might be stored in areas where birch is present as forest or amenity trees. Birch grows also along roads, railroads, abandoned industry ground, etc. Large quantities of wood chips are likely to be stored in the open. Some of the main importers are also countries where birch is widespread (e.g. Finland, Norway, Germany, Sweden). In Norway, the new wood pellet factory (see 1.5, pathway 3) mentioned earlier is storing wood chips in the open, and is located in the vicinity of birch forests (Økland, pers. comm., 2010).
Wood chips are imported to be fully burned for energy production, transformed into fibreboard or used in pulpmills (UNECE, 2009). All these processes are fully destructive and would not allow survival of the pest. Storage before use would increase the likelihood of pest transfer, if wood chips are stored long enough to allow *A. anxius* adult emergence prior to being used.

Use of wood chips as mulch would increase the risk of transfer.

2.11 - The probability of entry for the pathway should be described

unlikely
Level of uncertainty: medium

probability of entry is <u>low to medium</u> with <u>medium</u> uncertainty.
Even if the likelihood of association or concentration on the pathway is not high, the probability of entry would be increased by the volume of the commodity traded. There are constraints for entry on this pathway, i.e. only 4^{th} instars that have completed feeding, prepupae and pupae could survive on this pathway, they would first need to survive the chipping process, and then emerge after import and before the intended use (i.e. destructive processes and transfer most likely only if the commodity is stored). However, if wood chips are used as a mulch transfer will be more likely.

Uncertainties:
- whether imported wood chips originate from trees killed by the beetle (i.e. low quality wood with potentially high concentration of pest)
- proportion of birch in hardwood chips imports
- data on pathway: volume, frequency of import (per month) in the PRA area, timing of imports, distribution throughout the PRA area
- whether chips would be stored for some time on arrival and in which conditions
- whether imported wood chips are used as mulch.

2.13b - Describe the overall probability of entry taking into account the risk presented by different pathways and estimate the overall likelihood of entry into the PRA area for this pest (comment on the key issues that lead to this conclusion).

unlikely

Level of uncertainty: medium

The expert group considered that the overall probability of entry is low to medium with medium uncertainty. But over a long time horizon (e.g. 20 years) and if the volume of wood chips/wood for bioenergy uses does increase dramatically, the risk of entry may increase.

Stage 2: Pest Risk Assessment Section B: Probability of establishment

Host plants and suitable habitats

3.00.01A - Is the factor likely to have an influence on the limits to the area of potential establishment ?

yes

3.00.01B - Is the factor likely to have an influence on the suitability of the area of potential establishment ?

yes

Alternate hosts and other essential species

3.00.02A - Is the factor likely to have an influence on the limits to the area of potential establishment ?

no

3.00.02B - Is the factor likely to have an influence on the suitability of the area of potential establishment ?

no

3.00.02C - Justifications for No answers

A. anxius has no alternate host.

Climatic suitability

3.00.03A - Is the factor likely to have an influence on the limits to the area of potential establishment ?

yes

3.00.03B - Is the factor likely to have an influence on the suitability of the area of potential establishment ?

yes

Other abiotic factors

3.00.04A - Is the factor likely to have an influence on the limits to the area of potential establishment ?

no

3.00.04B - Is the factor likely to have an influence on the suitability of the area of potential establishment ?

no

3.00.04C - Justifications for No answers

No other abiotic factors are expected to affect the establishment of *A. anxius* in the PRA area.
In North America *A. anxius* is considered in the literature to attack native birch only if subject to stress. Predisposing stress factors in North America are drought and high soil temperature; air pollution, ozone. Overall stress is not a factor that will influence the susceptibility of European and Asian birch trees in the PRA area because they are highly

susceptible even when healthy.

Competition and natural enemies

3.00.05A - Is the factor likely to have an influence on the limits to the area of potential establishment ?

no

3.00.05B - Is the factor likely to have an influence on the suitability of the area of potential establishment ?

no

3.00.05C - Justifications for No answers

Stage 2: Pest Risk Assessment Section B: Conclusion of introduction

c1 - Conclusion on the probability of introduction.

very high rate of spread

The probability of entry was rated as low to medium with medium uncertainty; the probability of establishment as very high with low uncertainty. So the probability of introduction can be rated as high with low uncertainty.

Stage 2: Pest Risk Assessment Section B: Probability of spread

4.01 - What is the most likely rate of spread by natural means (in the PRA area)?

moderate rate of spread
Level of uncertainty: low

4.02 - What is the most likely rate of spread by human assistance (in the PRA area)?

very high rate of spread
Level of uncertainty: low

Stage 2: Pest Risk Assessment Section B: Eradication, containment of the pest and transient populations

5.01 - Based on its biological characteristics, how likely is it that the pest could survive eradication programmes in the area of potential establishment?

very likely

Level of uncertainty: low

The pest would be hard to eradicate. Eradication could be attempted by destroying infested trees and other host trees in a certain (unspecified) area around the outbreak, but the pest is a strong flier (see question 1.30), which would imply that a large quarantine area would be required to contain it (e.g. over 35 km radius). The pest might be easier to eradicate if it enters an area of low presence of birch, where there are not too many birch trees around and establishing a quarantine area might be easier. Aggressive eradication programmes against the related species *A. planipennis* have not been successful in Canada and in the USA (GAO, 2006).

If birch is present, it is likely to be present in several types of habitats in the same area, e.g. forests, amenity areas, gardens, nurseries, which might be difficult to subject to an eradication programme.

5.02 - Based on its biological characteristics, how likely is it that the pest will not be contained in case of an outbreak within the PRA area ?

very likely

Level of uncertainty: low

Due to its 1- or 2-year life cycle and its mostly hidden life stages (eggs, larvae, prepupae, pupae), the pest might not be detected before a population is already well-established. There are no effective monitoring tools for *Agrilus* species and so delimiting an outbreak would be difficult. It might be easier to detect an outbreak in a nursery, but by the time an outbreak is detected, the pest might already have had a chance to spread to other birch trees. If birch is present, it is likely to be present in several types of habitats in the same area, e.g. forests, amenity areas, gardens, nurseries, which might be difficult to subject to an containment programme.

5.03 - Are transient populations likely to occur in the PRA area through natural migration or entry through man's activities (including intentional release into the environment) or spread from established populations?

No

Level of uncertainty: low

Considering the lenght of *A. anxius* life cycle, it is unlikely that transient populations may occur.

Stage 2: Pest Risk Assessment Section B: Assessment of potential economic consequences

6.01 - How great a negative effect does the pest have on crop yield and/or quality of cultivated plants or on control costs within its current area of distribution?

major

Level of uncertainty: low

Birch is an ecologically and economically important tree in North America (Miller *et al.*, 1991). *A. anxius* was first mentioned as a pest of ornamental birch in the 1890s (Slingerland, 1906), and reported as a forest pest in 1918 (Akers & Nielsen, 1984, Katovich *et al.*, 2005). Outbreaks developed during the long period of widespread birch dieback in forests in Northern USA and Canada beginning in the early 1930's (MacAloney, 1968; Jones *et al*., 1993). The pest is also considered to be one of the major contributing factors in the decline and death of amenity birch trees in North America (Ball & Simmons, 1980). It attacks and kills trees, which die in a few years if no remedial action is taken (Appleby *et al*., 1973). Johnson & Lyon (1976) mention it as a limiting factor to extending the range of white birch in the southern USA.

In landscape/urban environment/nurseries:

A. anxius is the most destructive pest of species with white-barked birch in the urban environment (Akers & Nielsen, 1984), and a major mortality factor in landscape birch (Ball & Simmons, 1980). Carlos *et al.* (2002) report that several thousands of mature birch trees were killed by the pest in urban areas in Nevada since the droughts in 1990s. *A. anxius* is a major pest and the most important limiting factor to the long-term cultivation of white-bark birch in landscape plantings (Santamour, 1990a, 1990b; Iles & Vold, 2003). European white birch is no longer recommended as suitable for use in landscape and other plantings due to its susceptibility to *A. anxius* attacks throughout North America.

In nurseries, Lanthier (2008) mentions *A. anxius* as a serious pest of nurseries in British Columbia (interior) and Southern Alberta (both regions having high temperatures with minimal precipitations in summer, and below 0°C with rain/snow during winter). There has been a shift by nursery producers from European and Asian birch to birch species that are endemic to North America because of their higher level of resistance to bronze birch borer. There are no data available on control costs in nurseries specific to *A. anxius*.

In forests

In North America *A. anxius* is considered in several publications to be a key factor contributing to birch mortality in forests during severe drought or during other stress events (e.g. Barter, 1957; Jones *et al*., 1993; Houston, 1987; Anderson, 1944; NRC, 2010; Katovich *et al*., 2005). Extensive damage is sometimes recorded in forests (e.g. WIDNR, 2008, Hodge *et al*., 2009, Scarr *et al.*, 2010). There have been no control costs documented in North America for forests as the pest is not being managed (and no other high impact scolytids require management).

Relationship between damage by *A. anxius* and tree stress in North America

In North America *A. anxius* is considered in the literature to attack native birch only if subject to stress, whereas European and Asian birch are attacked even when healthy. A number of articles discuss the relationship between *A. anxius* and birch dieback, and whether *A. anxius* causes birch dieback, or is a factor associated with it due to weakened trees. There has been discussion on whether *A. anxius* is a minor pest, killing trees already predisposed to death by other factors, or if it is sufficient in itself to contribute significantly to birch dieback (Anderson, 1944; Barter, 1957).

Possible predisposing stress factors mentioned in the literature are (e.g. Balch & Prebble, 1940; Clark & Barter, 1958, Haack, 1996; Herms, 2002):

- drought and high soil temperature
- attacks by other insects, especially insect defoliation (e.g. forest tent caterpillar - WIDNR, 2008)
- air pollution, ozone
- climatic conditions (Jones *et al*. (1993) detail the links between birch dieback, *A. anxius* and climatic conditions).

Widespread mortality of birch associated with activity of *A. anxius* after several years of climatic stress is reported (Haack, 1996). It is noted that factors like frost, drought or warmer temperatures have been considered to be important stress factors. Paper birch (*Betula papyrifera*) is sensitive to temperature and moisture in the surface soil. Drought and extreme temperature were observed to favour attacks. Increases of temperature of 2°C and decrease of summer precipitation of 15% have caused high mortality.

- localized stress, such as damage to branches or trunks due to other insects or cutting injuries (Santamour, 1990a), root injuries.
- old age (weaker defenses)

- specific stresses in urban environments (e.g. soil compaction, de-icing salts, lawncare herbicides).

Overall stress is not a factor that will greatly influence the susceptibility of European and Asian birch trees in the PRA area because they are highly susceptible even when healthy.

6.02 - How great a negative effect is the pest likely to have on crop yield and/or quality of cultivated plants in the PRA area without any control measures?

minor

Level of uncertainty: low

European and Asian birch grown in North America, especially *B. pendula*, *B. pubescens*, *B. platyphylla*, *B. maximowicziana*, (Nielsen *et al.*, in press; Herms, 2002), *B. jacquemontii* (Katovitch *et al.*, 2005), are highly susceptible to *A. anxius* and healthy trees are attacked and killed in North America. The impact of the pest is likely to be high mortality of birch in the PRA area in landscapes, gardens, nurseries and forests. There are birch species in the PRA area that are not present in North America (see question 1.16), and their susceptibility is not known.

The high susceptibility of North American ash to *A. planipennis* when these were planted in China proved to be a good predictor of the impact that *A. planipennis* would have when it was introduced to North America (Liu *et al.*, 2003), where it is killing both healthy and stressed ash trees.

6.03 - How great a negative effect is the pest likely to have on yield and/or quality of cultivated plants in the PRA area without any additional control measures?

massive

Level of uncertainty: low

There are practically no management practices that would prevent establishment of the pest in forests, in forestry nurseries, and in amenity areas.

In some nurseries for the production of ornamental birch, insecticides are applied to control the tenthredinid leaf miner *Fenusa* spp. and aphids (e.g. *Euceraphis punctipennis)*. Active substances mentioned to control these pests in Belgium are thiacloprid against *Fenusa pumila;* the range of active substances used against aphids is larger*:* nicotinoids (acetamiprid, thiacloprid, imidacloprid), pyrethroids (cyfluthrin, cypermethrin, deltamethrin, lambda-cyhalothrine), organophosphate (dimethoate), carbamate (pirimicarb), flonicamid, pymetrozine. These cover sprays to trunk, branches and foliage are recommended between April and August (Fassotte *et al.*, 2010a and b). Among the active substances used in these birch nurseries, thiacloprid and lambda-cyhalothrine have been shown to be very effective against *Agrilus sinuatus* (the pear tree borer) as cover treatments (see question 2.3) to trunk, branches and foliage of young pear trees, in insecticide trials conducted in 2008-2009 by the Walloon Agricultural Research Centre (Fassotte, pers. comm., 2010) and thus these two insecticides would probably control the similar pest *A. anxius* if used during its flight period. It is yet difficult to evaluate whether current applications against other birch pests would cover the entire flight period of *A. anxius* in the PRA area. No other data were found on insecticide treatments in ornamental nurseries in other EPPO countries.

In North America experience with these other pests showed that the timing of application was not appropriate to control *A. anxius*. In addition, application rates labelled for use in nurseries in the USA, are too low to provide systemic control of *A. anxius*.

It can therefore be concluded that the insecticides already applied in ornamental nurseries against other pests in the PRA area will possibly partially control *A. anxius* populations but it is unlikely to prevent establishment of the pest.

Some management practices are mentioned in the literature for North America, but these are not likely to prevent establishment of the pest in the PRA area because European and Asian birch species have high susceptibility to the pest and stress is not necessary for colonization. They are:

Proper planting and maintenance of birch, improving tree health

- selection of tree species (Bauernfeind, 2006; Carlos *et al*,. 2002; Gibb & Sadof, 2007; Katovich *et al.*, 2005; Wawrzynski *et al*., 2009).
- appropriate location: birch needs cool moist soil (Wawrzynski *et al*., 2009; Katovich *et al*., 2005) and lawn conditions are often not favourable to birch (Gibb & Sadof, 2007).

- appropriate watering, mulching and fertilizing (Ball & Simmons, 1980; Bauernfeind, 2006; Crawnshaw *et al*., 2000; Hoover, 2002; Katovich *et al*., 2005). Santamour (1990a) notes that watering should not be excessive and that it might not be possible to maintain the continuity of adequate water supply as trees grow.
- control of other pest problems likely to affect the tree (Ball & Simmons, 1980).
- avoiding damage to trunk and branches (Carlos *et al*., 2002).
- avoiding stresses of urban landscape sites, soil compaction, de-icing salts, lawncare herbicides (Santamour, 1990a).

Sanitation/area management
- removal and proper destruction of infested trees (KSU, 2009).

6.04 - How great a negative effect is the pest likely to have on yield and/or quality of cultivated plants in the PRA area when all potential measures legally available to the producer are applied, without phytosanitary measures?

major
Level of uncertainty: low

A. anxius is not easy to control. The control measures applied in North America are applied mostly to amenity birch in urban/landscape/garden environments, and not in forests. It would be difficult to apply any control measures in forests in the PRA area, and amenity areas are also minimally managed. However, an insecticide regime targeted specifically at *A. anxius* could effectively control this insect in nurseries, should it be detected.

The pest management practices that are recommended in the area where *A. anxius* occurs are likely to provide adequate control only in defined situations, e.g. nurseries, but would not prevent damage. It might take several years before symptoms show, as some infested trees might not show symptoms quickly. The measures aim mostly at managing the populations of the pest and depend on the situation.

Ornamental birch
Because of the high susceptibility of European and Asian birch species, the only effective measure would be application of preventive insecticides on an ongoing basis to protect high value amenity trees.
Two approaches have been shown to be effective in the USA:

- Systemic insecticides applied to the soil or trunk targeting early instar larvae. Imidacloprid (soil or trunk) , dimethoate* (soil only), dicrotophos* (trunk injections only) are currently recommended in the USA (Shetlar & Herms, 2003; Gibb & Sadof, 2007; KSU, 2009)
- Preventive cover sprays to trunk, branches and foliage targeting adults during their flight period and young larvae before they bore into the trees (e.g. Ball & Simmons, 1980; Bauernfeind, 2006; Carlos *et al*., 2002; Crawnshaw *et al*., 2000; Gibb & Sadof, 2007; Katovich *et al*., 2005; KSU 2009). Example: 2-3 applications at 2-3 week intervals, beginning with first adult emergence. Insecticides mentioned in USA literature: chlorpyrifos, permethrin*, bifenthrin. The first emergence of adults in north central USA coincides with the blooming period of *Robinia pseudoacacia*, as calculated by day degree accumulation (average day degrees in Ohio is 550 from base temperature 50°F starting January 1, which is equivalent to 306 DD in base temperature 10°C) (Herms, 2003)
*Note: * indicates active substances that are not registered in the EU (EU Pesticides Database, 2010)*

A number of other control measures (maintain the health of the tree and area management) are applied in North America aiming at reducing the impact of the pest (see 1.23), but they are not expected to be effective in controlling the pest in the PRA area.

In forests
In USA the following good silvicultural practices limit the impact of outbreaks (Katovich *et al*., 2005), but they will not be sufficient in the PRA area to control *A. anxius* as the native birch species are highly susceptible:
- silvicultural practices that increase stand health and vigour
- avoid management practices that cause significant disturbance
- thinning done with care in birch stands
- enhance age class diversity (the pest is more likely to attack old trees and can better build populations in areas of old birch trees).

Biological control
There are natural enemies of *A. anxius* in North America (parasitoid wasps) but these do not protect European birch

trees when planted in North America (see answer to 1.21). The parasitoids might be introduced with the pest. The control that would be provided by natural enemies and woodpeckers in the PRA area is not known, but it is expected from the North American experience with *A. anxius* and *A. planipennis* that they would not provide adequate control. Nevertheless in forests the use of introduced biological control agents seems to be the only realistic possibility to reduce populations of *A. anxius*.

6.05 - How great an increase in production costs (including control costs) is likely to be caused by the pest in the PRA area in the absence of phytosanitary measures?

moderate
Level of uncertainty: low

General costs: surveillance and monitoring, eradication/containment efforts.
In forests: additional costs would be incurred by pest surveillance, removal of infested trees and destruction/processing, and sanitation practices where applicable, and possible phytosanitary measures applied to wood for export specifically for *A. anxius*.
In nurseries: control operations (additional spray and associated surveillance/model to predict emergence, looking for damage, pruning), destruction of infested trees (in case of control failure), initial costs of shifting to producing alternative species.
In landscapes and gardens: additional costs of surveillance, removal of infested trees and destruction, cost of replacing trees.

6.06 - Based on the total market, i.e. the size of the domestic market plus any export market, for the plants and plant product(s) at risk, what will be the likely impact of a loss in export markets, e.g. as a result of trading partners imposing export bans from the PRA area?

minimal
Level of uncertainty: medium

Birch is mostly produced in North America and the PRA area (especially Russia). There has been no documented effect on export markets for North American birch and birch products. The expert working group was not aware of any existing phytosanitary regulation against *A. anxius*. There are data on exports of birch wood from the PRA area although it is not known to which countries such exports occur (UNECE, 2006).

Main exporters were as follows in 2004 (UNECE, 2006):

Country	**1000m3 of non-coniferous sawnwood exported (total)**	**1000m3 of birch sawnwood exported**	**Percentage (birch/total)**
Belarus	58	58	100
Denmark	36	7	19
Estonia	153	128	84
Finland	18	14	78
Latvia	556	78	14
Russian Federation	413	269	65

There is a high demand for birch as ornamental tree and as wood. Export markets might be affected by shifts to non-infested areas or other tree species. Importing countries may also impose phytosanitary requirements.

6.07 - To what extent will direct impacts be borne by producers?

moderate
Level of uncertainty: low

6.08.0A - Do you consider that the question on the environmental impact caused by the pest within its current area of invasion can be answered? **(Read the note)**

no, but there is some evidence that the environmental impact may be significant in the PRA area

Ayres & Lombardero (2000) and Houston (1987) mention *A. anxius* among the herbivores that are significant agents of biological disturbance in North American forests. Any impacts on the environment, such as biodiversity, have not been measured. Even in the case of outbreaks in forests, most trees are not killed and therefore birch is always

available. Effects on biodiversity are most probably limited.
It is expected that the ecological impact in the PRA area will be higher because of the higher susceptibility of European and Asian birch species.

6.08 - How important is the environmental impact caused by the pest within its current area of invasion?

Major
Level of uncertainty: low

Ayres & Lombardero (2000) and Houston (1987) mention *A. anxius* among the herbivores that are significant agents of biological disturbance in North American forests. Any impacts on the environment, such as biodiversity, have not been measured. Even in the case of outbreaks in forests, most trees are not killed and therefore birch is always available. Effects on biodiversity are most probably limited.

You have considered that Q6.08 could not be answered (i.e. the species has not invaded any other area, or if the invasion is too recent and too little is known on its ecology in the invaded areas) or the situation in the PRA area is likely to be different, you may use another, simpler rating system based on simpler impact predictors.
For plant pests, six indicators will be related to:
- Direct impact on native plants (2 indicators)
- Impact on ecosystem patterns and processes (1)
- Conservation impact (2)
- Impact of pesticides (1)

6.09.01 - What is the risk that the host range of the pest includes native plants in the PRA area?

High risk
Level of uncertainty: low

In the PRA area, birch grows in pure and mixed forest stands. As the most common broadleaved species in northern Europe, birch is very important for the biodiversity of coniferous forests.
In northern European countries, birch constitutes a large proportion of the forest tree volume, ranging from 11 % in Sweden to 28 % in Latvia (Hynynen *et al*., 2010). In Scandinavian forests, the dominance of birch increases with latitude and altitude.
The main species of birch in the western part of the PRA area in forests are *B. pendula* and *B. pube*scens, with also *B. humilis* from central Europe to the eastern part of the PRA area (see distribution maps in Appendix 3). A number of Asian or American species that have been shown to be attacked by *A. anxius* in North America (e.g. *B. davurica*, *B. ermanii*, *B. maximowicziana*, *B. platyphylla*, *B. occidentalis*, *B. papyriferae*, *B. populifolia*), are present in the PRA area.

6.09.02 - What is the level of damage likely to be caused by the organism on its major native host plants in the PRA area? (If possible, this question should be answered by taking account the impacts on its major host plants in the PRA area. If the effects on the host plants in the PRA area are not well known, then the answer should be based on damage levels in other areas, but with a higher level of uncertainty).

High level
Level of uncertainty: low

Susceptibility varies between birch species, with European and Asian birch species being much more susceptible than North American birch species (Miller *et al*., 1991; Nielsen *et al.*, in press) and are generally killed by infestation.

Impact on ecosystem patterns and processes

6.09.03 - What is the ecological importance of the host plants in the PRA area?

Medium importance
Level of uncertainty: high

In the PRA area, birch grows in pure and mixed forest stands. As the most common broadleaved species in northern

Europe, birch is very important for the biodiversity of coniferous forests. In different phases of succession, a large number of species feed on or live together with birch, including mycorrhiza-forming fungi, herbivores, wood-decaying fungi and saproxylic insects (Hynynen *et al.*, 2010). Given the high susceptibility of European and Asian birch, the impact of *A. anxius* would be to dramatically change the ecological balance and composition of several forest types in the PRA area. It might affect sensitive ecosystems. Biodiversity and ecosystem processes are likely to be affected. The importance of dead wood is highlighted in Scandinavian forest management. If trees affected by *A.anxius* are cut and remowed out of the forest, this will reduce the amount of dead wood used by other species.

Conservation impacts

6.09.04 - To what extent do the host plants occur in ecologically sensitive habitats (includes all officially protected nature conservation habitats)?

Low extent
Level of uncertainty: medium

Birch as stand-forming tree species are especially common in northern Europe and Russia, but also throughout western and central Europe. Birch is mostly not present in the warmest Mediterranean areas, although there are some birch forests in Mediterranean mountainous habitats, e.g. Turkey, Spain, Italy (including Sicily), France (including the Pyrénées and Corsica).

6.09.05 - What is the risk that the pest would harm rare or vulnerable species? (includes all species classified as rare, vulnerable or endangered in official national or regional lists within the PRA area)

Medium risk
Level of uncertainty: medium

A. anxius might constitute an additional threat for several species of birch that are already threatened with extinction in Central Asia such as *Betula jarmolenkoana, B. khirghisorum, B. tianshanica* (Eastwood *et al.*, 2009) or are restricted to limited areas in sensitive conditions (EEA, 2006).

Impact of pesticides

6.09.06 - What is the risk that the presence of the pest would result in an increased and intensive use of pesticides?

Low risk
Level of uncertainty: low

It would be difficult to apply any control measures in forests in the PRA area, and amenity areas are also minimally managed. However, an insecticide regime targeted specifically at *A. anxius* could effectively control this insect in nurseries, should it be detected.

Because of the high susceptibility of European and Asian birch species, the only effective measure would be application of preventive insecticides on an ongoing basis to protect high value amenity trees.
Two approaches have been shown to be effective in the USA:

- Systemic insecticides applied to the soil or trunk targeting early instar larvae. Imidacloprid (soil or trunk), dimethoate* (soil only), dicrotophos* (trunk injections only) are currently recommended in the USA (Shetlar & Herms, 2003; Gibb & Sadof, 2007; KSU, 2009)
- Preventive cover sprays to trunk, branches and foliage targeting adults during their flight period and young larvae before they bore into the trees (e.g. Ball & Simmons, 1980; Bauernfeind, 2006; Carlos *et al.*, 2002; Crawnshaw *et al.*, 2000; Gibb & Sadof, 2007; Katovich *et al.*, 2005; KSU 2009). Example: 2-3 applications at 2-3 week intervals, beginning with first adult emergence. Insecticides mentioned in USA literature: chlorpyrifos, permethrin*, bifenthrin. The first emergence of adults in north central USA coincides with the blooming period of *Robinia pseudoacacia*, as calculated by day degree accumulation (average day degrees in Ohio is 550 from base temperature 50°F starting January 1, which is equivalent to 306 DD in base temperature 10°C) (Herms, 2003)

*Note: * indicates active substances that are not registered in the EU (EU Pesticides Database, 2010)*

6.09 - How important is the environmental impact likely to be in the PRA area?

Major
Level of uncertainty: low

In the PRA area, birch grows in pure and mixed forest stands. As the most common broadleaved species in northern Europe, birch is very important for the biodiversity of coniferous forests. In different phases of succession, a large

number of species feed on or live together with birch, including mycorrhiza-forming fungi, herbivores, wood-decaying fungi and saproxylic insects (Hynynen *et al*., 2010). Given the high susceptibility of European and Asian birch, the impact of *A. anxius* would be to dramatically change the ecological balance and composition of several forest types in the PRA area. It might affect sensitive ecosystems. Biodiversity and ecosystem processes are likely to be affected. The importance of dead wood is highlighted in Scandinavian forest management. If trees affected by *A.anxius* are cut and remowed out of the forest, this will reduce the amount of dead wood used by other species.
Birch is a dominant species in the boreal forest, and widespread mortality would affect carbon sequestration.

A. anxius might constitute an additional threat for several species of birch that are already threatened with extinction in Central Asia such as *Betula jarmolenkoana, B. khirghisorum, B. tianshanica* (Eastwood *et al*., 2009) or are restricted to limited areas in sensitive conditions (EEA, 2006).

6.10 - How important is social damage caused by the pest within its current area of distribution?

minimal

Level of uncertainty: low

Social damage has been principally aesthetic due to the loss of ornamental trees in the landscape. Historically in the USA, *A. anxius* had an important impact when European birch (*B. pendula*) was the dominant species in the nursery industry, but the impact is now minor as North American species dominate in nurseries. The pest is an important pest of non-native ornamental birch. This has resulted in many garden, city and landscape trees having to be cut down once infested, and in other control measures being applied to affected/susceptible trees.

6.11 - How important is the social damage likely to be in the PRA area?

major

Level of uncertainty: low

Birch is the most common broadleaved species in northern Europe (Hynynen *et al*., 2010). In forests, establishment of *A. anxius* will result in potential loss of large areas of native birch forests as well as a potential loss of recreational areas. It may also affect livelihoods where birch forests are economically important, e.g. in Russia and Belarus (Hynynen *et al*., 2010).
Infested birch in gardens, cities and amenity areas will first affect the aesthetic value of amenity trees, and they might also have to be felled and replaced.

Birch has a large cultural significance in northern European countries. It is considered to be a national tree of Russia and Finland. Birch has spiritual importance in several religions, both modern and historical. Birch is associated with the Tír na nÓg, the land of the dead and the Sidhe, in Gaelic folklore, and as such birch frequently appears in Scottish, Irish, and English folksongs and ballads in association with death, or fairies, or returning from the grave (source Wikipedia).
Birch sap is a traditional beverage in Russia (Russian: Берёзовый сок), Latvia (Latvian: Bērzu sula), Estonia, Finland, Lithuania (Lithuanian: Beržų Sula), Belarus (Belarusian: Бярозавы сок), Poland (Polish: Sok z Brzozy) and Ukraine (Wikipedia, Tschirpke, 2006).

6.12 - To what extent is the pest likely to disrupt existing biological or integrated systems for control of other pests?

minor

Level of uncertainty: medium

In nurseries and for amenity/garden trees, chemical control is the most likely measure, but this is already in use against other pests in some countries. Where pesticides are not currently used or it results in increased pesticide use, this could disrupt biological systems and may have a negative effect on the environment where the pest is present.

In forests, possible measures (cutting-down trees or the use of biological control) might affect ecosystem functioning.

6.13 - How great an increase in other costs resulting from introduction is likely to occur?

moderate

Level of uncertainty: medium

Costs would include research for biological control agents and pesticides, research on *A. anxius* host susceptibility, investigation of natural enemies, outreach and education, administration.

6.14 - How great an increase in the economic impact of other pests is likely to occur if the pest can act as a vector or host for these pests or if genetic traits can be carried to other species, modifying their genetic nature?

minimal

Level of uncertainty: low

There is no evidence of *A. anxius* being a vector or carrier for other pests in North America. Unlike the adult stage of bark and ambrosia beetles that vector mutualistic fungi, bronze birch borer adults (the mobile phase of the pest) do not enter the tree.
No example of impact on genetic traits to other species has been found for *A. anxius* in the literature.

6.15a - Describe the overall economic impact *(sensus stricto)*

massive

Level of uncertainty: low

Due to the higher susceptibility of European and Asian birch species, it is expected that the pest would have major economic consequences where birch is present in the PRA area. On the whole, introduction would result in high mortality of birch throughout the PRA area, and major economic impacts (including major environmental impacts).

6.15b - With reference to the area of potential establishment identified in Q3.08, identify the area which at highest risk from economic, environmental and social impacts. Summarize the impact and indicate how these may change in future.
For information, the conclusion given at Q6.09 was: Major
For information, the conclusion given at Q6.11 was: major

massive

Level of uncertainty: low

It is considered that all areas where birch is present in the PRA area would be at risk, i.e. Northern Europe, from Western Europe to Siberia to the East, and from Nordic countries to Centre France to the South. Distribution data suggest that birch is not present in North Africa, Israel, Malta, Cyprus, southern Turkey.

Stage 2: Pest Risk Assessment Section B: Degree of uncertainty and Conclusion of the pest risk assessment

c2 - Degree of uncertainty : list sources of uncertainty

Below each subheader the following medium or high uncertainties were noted during the assessment (overall uncertainty is given first):

Probability of entry on pathways originating from where the pest occurs in Canada and in the USA:

- **hardwood wood chips** (medium uncertainty overall)

- proportion of birch in hardwood chips imports
- data on pathway: volume, frequency of import (per month) in the PRA area, timing of imports, distribution throughout the PRA area
- whether chips would be stored for some time on arrival and in which conditions
- whether imported wood chips are used as mulch.

- **plants for planting of *Betula* spp.** (medium uncertainty overall)

- association of the pest in North American nurseries for plants for export
- data on trade, i.e. volume, birch species traded (as the pest is more likely to be associated with susceptible species), frequency of movement, lack of data on distribution of imported plants for planting throughout the PRA area, size of plants (the pest is associated with stems >2cm diameter).

- **wood with or without bark of *Betula* spp.** (medium uncertainty overall)

- frequency of outbreaks (the pest is most likely to be associated with the pathway during outbreaks in North America)
- data on pathway: volume, proportion of birch in hardwood imports from Canada, frequency of import (per month) in the PRA area, timing of imports, distribution of the commodity throughout the PRA area, end-use of the wood.

Probability of establishment (low uncertainty)
- susceptibility of some birch species (those present in the PRA area but not in North America; also *B. nana*; and some North American species)
- how widely treatments are used against other pests in nurseries, and would they be effective against *A. anxius*.

Probability of spread: No uncertainty identified.

Potential impact (low uncertainty overall)
- whether consumer demand would be affected, i.e. shift to other tree species or origins
- effect on export markets and whether Russia currently exports birch products to some Asian countries
- what would be done about the pest, i.e. there would be other costs resulting from introduction.

c3 - Conclusion of the pest risk assessment

***A. anxius* is a pest of birch, present throughout the range of its native host species in North America and in areas where birch has been planted as an amenity tree, but it has not been recorded in the PRA area. In North America, the pest causes damage to forests and ornamental birch. European and Asian species of birch are especially susceptible, particularly *B. pendula* and *B. pubescens* which are widespread in the PRA area. Whereas *A. anxius* attacks mostly weakened North American birch, it attacks healthy European and Asian birch, and has proved to be a limiting factor for the use of these species as ornamentals in North America.**

The expert group considered that the most likely pathways for its introduction would be hardwood wood chips, plants for planting of *Betula* spp., and wood with or without bark of *Betula* spp. Detailed trade data were missing for these pathways as this pest is currently not subjected to phytosanitary requirements and *Betula* spp. are not recorded as a category in trade data included in Eurostat. The pathway analysis showed an overall low likelihood of entry. Details are given in the conclusion of the probability of entry.

It should be noted that the pathways for plants for planting and wood are probably relatively minor, and presumably have existed for some years (at least 10), but *A. anxius* is (yet) not known to have entered or

established in the PRA area. It is not expected that there would be an increase in the trade of birch plants for planting or wood between North America and the PRA area (except possibly for small logs for energy production plants; this might increase in the future). Different wood commodities might present different risks depending on how they have been processed (i.e. wood with or without bark), their intended use (e.g. firewood for private consumption, energy production plants, pulpmills) and their by-products, the birch species, and whether wood is stored on arrival (or processed before the pest can emerge).

On the other hand, the probability of entry on wood chips is moderate, and the volume of wood chips in general is expected to continue increasing to satisfy demands for energy production. However, the exact amount of birch in this trade is not known, as well as whether the trade would be from North America or other regions.

If *A. anxius* entered the PRA area, the pest would have a very high probability of establishment wherever birch is present. It is adapted to a wide range of climatic conditions and would find susceptible hosts. Eradication or containment would be difficult due to the hidden life stages of the pest and the fact that it might not be detected before it has already established and caused damage. It is also very likely that it would spread (natural spread as it is a strong flier; human-assisted through movement of infested birch material). Due to the higher susceptibility of European and Asian birch species, it is expected that the pest would have major economic consequences where birch is present in the PRA area. On the whole, introduction would result in high mortality of birch throughout the PRA area, and major economic impacts (including major environmental impacts).

It is considered that all areas where birch is present in the PRA area would be at risk, i.e. Northern Europe, from Western Europe to Siberia to the East, and from Nordic countries to Centre France to the South. Distribution data suggest that birch is not present in North Africa, Israel, Malta, Cyprus, southern Turkey (see Appendix 3).

Stage 3: Pest Risk Management

A decision has to be made to determine whether the risk from any pest/pathway combination is an acceptable risk. This decision will be based on the relationship between the level of risk identified in the pest risk assessment stage (i.e. the combination of the probability of introduction and the potential economic impact) and the importance/desirability of the trade that carries the risk of introduction of the pest.

7.01 - Is the risk identified in the Pest Risk Assessment stage for all pest/pathway combinations an acceptable risk?

no

7.02 - Is natural spread one of the pathways?
The pathways identified in the entry section were:
Wood chips containing Betula spp. originating from where the pest occurs in Canada and in the USA
Plants for planting of Betula spp. originating from where the pest occurs in Canada and in the USA
Wood with or without bark of Betula spp. originating from where the pest occurs in Canada and in the USA

no

Pathway 1: Wood chips containing Betula spp. originating from where the pest occurs in Canada and in the USA

7.06 - Is the pathway that is being considered a commodity of plants and plant products?

yes

Yes
See under 1.1., point 3.

7.09 - If the pest is a plant, is it the commodity itself?

no (the pest is not a plant or the pest is a plant but is not the commodity itself)

7.10 - Are there any existing phytosanitary measures applied on the pathway that could prevent the introduction of the pest? (if yes, specify the measures in the justification)

no
Level of uncertainty: low

See question 1.9 for this pathway.
At least in the EU, there are no measures applied for this pathway.
It is worth noting that EU legislation for quality of wood chips is being developed (CEN prEN 14961-1 2008.4 solid biofuel) which is to replace all other national legislation. This standard will describe the requirements for fraction size, moisture content, ash content and density of the wood chips (Kopinga *et al*., 2010). It is not known when this standard will be finalized and how much it will address phytosanitary issues.

7.13 - Can the pest be reliably detected by visual inspection at the place of production (if the answer is yes specify the period and if possible appropriate frequency, if only certain stages of the pest can be detected answer yes as the measure could be considered in combination with other measures in a Systems Approach)?

yes or could be considered in a Sytems Approach
Level of uncertainty: low

Complementary answer:
visual inspection at the place of production
The pest would be difficult to detect in wood chips but could be detected in trunks before they are chipped down.

7.14 - Can the pest be reliably detected by testing at the place of production? (if only certain stages of the pest can be detected by testing answer yes as the measure could be considered in combination with other measures in a Systems Approach)

no
Level of uncertainty: low

Not relevant for insect.

7.15 - Can infestation of the commodity be reliably prevented by treatment of the crop?

no
Level of uncertainty: low

Treatment is not possible in forests.

7.16 - Can infestation of the commodity be reliably prevented by growing resistant cultivars? (This question is not relevant for pest plants)

no
Level of uncertainty: low

Wood chips are often produced from a mixture of woods and wood types. *B. nigra* is the only species that is known to be not susceptible to *A. anxius* and this species is only in mixed stands with other hardwood species (the natural range of *B. nigra* does not overlap with the natural range of susceptible *Betula* spp.). Nevertheless wood chips containing only *B. nigra* would be considered safe.

7.17 - Can infestation of the commodity be reliably prevented by growing the crop in specified conditions (e.g. protected conditions such as screened greenhouses, physical isolation, sterilized growing medium, exclusion of running water, etc.)?

yes or could be considered in a Sytems Approach
Level of uncertainty: low

Complementary answer:
specified growing conditions of the crop
Wood chips could be stored in the exporting country under the strict control of the NPPO for a sufficient period, i.e.1 year, since only prepupae and pupae would be likely to survive the chipping process and should have emerged as adults within this period of time.

7.18 - Can infestation of the commodity be reliably prevented by harvesting only at certain times of the year, at specific crop ages or growth stages?

no
Level of uncertainty: low

Larvae are less likely to be present at certain times of the year, but any stage (except adults) might be present all year round. In addition, this might be difficult to implement for the production of wood chips.

7.19 - Can infestation of the commodity be reliably prevented by production in a certification scheme (i.e. official scheme for the production of healthy plants for planting)?

no
Level of uncertainty: low

Not relevant.

Note that in this question pest spread capacity is considered without prejudice to any other measure that can be recommended. For some pests, growing the plant in specific conditions can prevent natural spread (e.g. production in a glasshouse may provide protection against pest with high capacity for natural spread). These measures should have been identified in question 7.17.

7.20 - Based on your answer to question 4.01 (moderate rate of spread with low uncertainty), select the rate of spread.

no
Level of uncertainty: low

Complementary answer:
pest-free place of production or pest free area

7.21 - The possible measure is: pest-free place of production or pest free area
Can this be reliably guaranteed?

no
Level of uncertainty: low

The pest is present throughout the range of birch in North America (natural and planted) and it would be difficult to establish and maintain a PFA in areas climatically suitable for cultivation of birch.

7.22 - Can the pest be reliably detected by a visual inspection of a consignment at the time of export, during transport/storage or at import?

no
Level of uncertainty: low

The pest would be difficult to detect in wood chips.

7.23 - Can the pest be reliably detected by testing of the commodity (e.g. for pest plant, seeds in a consignment)?

no

Level of uncertainty: low

not relevant.

7.24 - Can the pest be effectively destroyed in the consignment by treatment (chemical, thermal, irradiation, physical)?

yes or could be considered in a Sytems Approach

Level of uncertainty: medium

Complementary answer:

specified treatment of the consignment

Chipping down to a certain size (with screen smaller than 2.5 cm) is considered effective against *A. planipennis* (McCullough *et al*., 2007, USDA-APHIS, 2009). The current EU requirement for wood chips against *Agrilus planipennis* is that the wood "has been processed into pieces of not more than 2.5 cm thickness and width". It may be considered that chips with a size smaller than 2.5 cm in either dimensions would probably be safe also for *A. anxius*. The typical chip size is: Thickness: 4 to 8 mm / Length: 40 to 45 mm / Width: 15 to 20 mm (see answer to 1.4 in the entry section for wood chips). Considering the above chip sizes and a *A. anxius* pupa or larva during the winter time (when it is doubled-over on itself like a letter V), then it is possible for *A. anxius* to fit inside a chip that is of the following dimensions: Thickness: 8 mm / Length: 40 mm / Width: 20 mm. If the chip is thinner than 8 mm, the individual would likely be exposed or cut, and die.

Roberts & Kuchera (2006) note that the cost of a secondary chip grinding in the marshalling yards, to reduce the chips to a smaller size (2.5 cm or less), can be prohibitive (three times as much as the primary grind). Therefore to be cost effective, chips should be ground to a small size on the first grind. It should also be noted that chipping with certain screen size produces a variety of chip sizes; a maximum is only guaranteed in 2 dimensions, while the third dimension can vary (e.g. 2.5 x 2.5 x 10 cm).

Further research should be considered to determine the safe size for wood chips.

Other treatments could be effective but their practical implementation should be defined based on further research. New Zealand regulates wood chips, sawdust and wood for a number of pests, including *A. sexsignatus* (MAF, 2003). Wood pieces should be either no larger than 15 mm in length and 10 mm in cross-section, or no greater than 3 mm in cross-section if longer than 15 mm. Treatment options required for import in New Zealand are either heat treatment or fumigation as outlined below:

- heat treatment. It has been shown that heat treatment at 55°C for 120 minutes applied to wood chips does not destroy all prepupae (overwintering 4th larval stage) of the related species *A. planipennis* (McCullough *et al*., 2007). No prepupae survived exposure of 60°C for 120 minutes. In logs, it is considered that 60°C for 60 min is an efficient treatment[2] (see answer to 3.16 for wood). In New Zealand heat treatment of wood chips for at least 4 hours at a minimum core temperature of 70°C is required to destroy a range of wood boring pests including *A. sexsignatus*.
- fumigation. In New Zealand, requirements for wood chips against insects are methyl bromide or sulphuryl fluoride fumigation (80 g/m^3), in separate units no larger than 2 m^3, for more than 24 continuous hours at a minimum temperature of 10°C. In Israel (Israel, 2009b), methyl-bromide fumigation is required against internal and external pests for 16 hours at 80 g/m^3 at 10-20°C or at 48g/m^3 for 16 hours at 21°C or more (see question 1.9 for this pathway).
- irradiation. As irradiation is considered effective to destroy wood boring insects in wood (EPPO Standard PM 10/8, EPPO (2008c)), it might also be used for wood chips, although this might be difficult to apply in practice for large quantity of chips.

7.25 - Does the pest occur only on certain parts of the plant or plant products (e.g. bark, flowers), which can be removed without reducing the value of the consignment? (This question is not relevant for pest plants)

no

Level of uncertainty: low

Not relevant.

[2] However efficacy of this treatment is being consider by EFSA. A scientific opinion should be delivered in 2011.

7.26 - Can infestation of the consignment be reliably prevented by handling and packing methods?

no

Level of uncertainty: low

No handling and packing methods will not prevent infestation. A long storage before export would ensure that no live stage are present in the wood but this option is considered under see 3.22.

7.27 - Can the pest be reliably detected during post-entry quarantine?

no

Level of uncertainty: low

Theoretically post-entry quarantine is a possible option [It should be long enough to allow time for adults to emerge as adults will not be able to reinfest chips (the pest only attack living trees). A 1-year storage will be sufficient for wood chips as only prepupae and pupae are likely to survive the chipping process. Transport and storage should be designed to prevent escape of any emerging beetles (i.e. under closed conditions).]

The Panel on Phytosanitary Measures agreed that in practice post-entry quarantine is not suitable for such material.

7.28 - Could consignments that may be infested be accepted without risk for certain end uses, limited distribution in the PRA area, or limited periods of entry, and can such limitations be applied in practice?

yes

Level of uncertainty: low

Complementary answer:

import of the consignment under special licence/permit and specified restrictions

The wood chips for processing could be imported at a time of the year when adults could not emerge (winter) and be processed before the next flight period of *A. anxius*. This will vary dramatically depending on the origin, destination and storage conditions. This might be possible for wood chips imported by specific plants for burning for energy production or for the production of fiberboards or paper. Chips must be covered during transport from the point of entry to the process plant (but using covered truck, containers and railcars). Additionally, chips should not be stored outside. This would be possible only if use can be guaranteed and verified.

The specifications of the requirements need to be done on a case by case basis depending on the origin and the country of destination.

7.29 - Are there effective measures that could be taken in the importing country (surveillance, eradication, containment) to prevent establishment and/or economic or other impacts?

no

Level of uncertainty: low

Surveillance might allow detection of the pest, but detection is likely to occur when the pest is already established. There are no effective monitoring tools for *A. anxius*, as for other buprestids.

7.30 - Have any measures been identified during the present analysis that will reduce the risk of introduction of the pest?

Q.	Standalone	System Approach	Possible Measure	Uncertainty
7.13	X		visual inspection at the place of production	low
7.17	X		specified growing conditions of the crop	low
7.20	X		pest-free place of	low

			production or pest free area	
7.24	X		specified treatment of the consignment	medium
7.28	X		import of the consignment under special licence/permit and specified restrictions	low

yes

7.31 - Does each of the individual measures identified reduce the risk to an acceptable level?

Q.	Standalone	System Approach	Possible Measure	Uncertainty
7.13	X		visual inspection at the place of production	low
7.17	X		specified growing conditions of the crop	low
7.20	X		pest-free place of production or pest free area	low
7.24	X		specified treatment of the consignment	medium
7.28	X		import of the consignment under special licence/permit and specified restrictions	low

yes

Level of uncertainty: low

- treatment: chipping down to a certain size (to be defined) or heat treatment (but the conditions required to destroy *A. anxius* are not clearly-defined and require research) or fumigation
- storage in country of export (1 year)
- import permit and specified restrictions: importing in winter and processing before the next flight period

(*Requirements need to be specified on a case by case basis depending on the origin and the country of destination)*

7.34 - Estimate to what extent the measures (or combination of measures) being considered interfere with international trade.

The measures will interfere with international trade as there are currently no measures in place and the volume on this pathway is increasing. Some other countries (e.g. New Zealand, Israel) require measures for wood chips for phytosanitary purposes.

Level of uncertainty: low

The measures will interfere with international trade as there are currently no measures in place and the volume on this pathway is increasing. Some other countries (e.g. New Zealand, Israel) require measures for wood chips for phytosanitary purposes.

7.35 - Estimate to what extent the measures (or combination of measures) being considered are cost-effective, or have undesirable social or environmental consequences.

The measures create additional costs.

Importing countries would have costs of inspection related to the requirement for a PC, and of post-entry quarantine if this measure is used.

Exporting countries will have to apply measures. Exporters should have the necessary equipment to process wood chips to the specified size. However, stringent measures for wood chips are already applied by some countries (e.g. New Zealand), and treatments are equivalent to others for wood.

There would be a negative impact on the quality of wood chips in case of storage (particularly for the paper industry). Treatments are expensive and might not be cost-effective (albeit the heat treatment requirements are not yet defined for this pest).

This pest would be difficult to eradicate if introduced, and the measures have lower cost than attempting eradication or bearing the costs of impact by A. anxius if it established.

Level of uncertainty: low

Similar measures are already imposed for other species, but the measures create additional costs.
Importing countries would have costs of inspection related to the requirement for a PC.
Exporting countries would have costs of issuing PCs.
Storage for 2 years, treatment for low quality wood, may not be cost-effective. Removal of outer sapwood would result in loss of some of the product.
This pest would very difficult to eradicate and possible probably only if it is detected within a few years after its introduction unless it is decided to remove large areas of birch. The measures suggested above have lower costs than attempting eradication or bearing the costs of the effect of *A. anxius* if it established.

7.36 - Have measures (or combination of measures) been identified that reduce the risk for this pathway, and do not unduly interfere with international trade, are cost-effective and have no undesirable social or environmental consequences?

yes

- treatment: chipping down to a certain size (to be defined) or heat treatment (but the conditions required to destroy *A. anxius* are not clearly-defined and require research) or fumigation
- storage in country of export (1 year)
- import permit and specified restrictions: importing at certain time and processing before the next flight period

7.41 - Consider the relative importance of the pathways identified in the conclusion to the entry section of the pest risk assessment

- Wood chips is a growing pathway (but the proportion/importance of birch in hardwood wood chips is unknown). The likelihood of the pest surviving the chipping process appears lower than for other two pathways. However as the volume of imported chips increases, so does the risk of introduction of A. anxius by this route.
- Plants for planting of Betula spp. is probably a small stable pathway. One infested consignment might introduce the pest as all stages could be associated with this pathway.
- Wood of Betula spp. is probably a small stable pathway at the moment. Its importance could increase if import of birch logs to be used in energy plants increases.

- Wood chips is a growing pathway (but the proportion/importance of birch in hardwood wood chips is unknown). The likelihood of the pest surviving the chipping process appears lower than for other two pathways. However as the

volume of imported chips increases, so does the risk of introduction of *A. anxius* by this route.
- Plants for planting of *Betula* spp. is probably a small stable pathway. One infested consignment might introduce the pest as all stages could be associated with this pathway.
- Wood of *Betula* spp. is probably a small stable pathway at the moment. Its importance could increase if import of birch logs to be used in energy plants increases.

Despite the lack of detailed data, there are enough data to indicate that movement of the host (birch, *Betula* spp.) along the three pathways analyzed exists (though interceptions were not made in the EU/EPPO region), that the pathways present a risk of introduction of *A. anxius*, and that the consequences of introduction would be devastating given the high susceptibility of European and Asian host plants and the large and wide distribution of birch in the PRA area.

The expert working group concluded that *A. anxius* posed an unacceptable risk to the EPPO region and identified phytosanitary measures which could substantially reduce the risk. Specific details of heat treatments that would be required to destroy *A. anxius* in wood or wood chips have not been defined and require further investigation. Measures could interfere with trade, but costs of eradication or containment attempts would be high and introduction is likely to threaten birch on a continental scale because European and Asian birch species are extremely susceptible, resulting in major economic (including environmental) impact.

Data are lacking on imports for these pathways, specific to birch. It was thought that none of the pathways considered is regulated at the moment.

Note: if there is a risk of entry with wood chips, then a similar risk might exist for some other invertebrate wood pests.

7.42 - All the measures or combination of measures identified as being appropriate for each pathway or for the commodity can be considered for inclusion in phytosanitary regulations in order to offer a choice of different measures to trading partners. Data requirements for surveillance and monitoring to be provided by the exporting country should be specified.

Notes:

only the least stringent measure (or measures) capable of performing the task should be selected. Thus, if inspection is truly reliable, it should not be necessary to consider treatment or testing. Note also that some measures may counteract each other; for example the requirement for resistant cultivars may make detection more difficult. It may be that some or all of these measures are already being applied to protect against one or more other pests, in which case such measures need only be applied if the other pest(s) is/are later withdrawn from the legislation. The minimum phytosanitary measure applied to any pest is the declaration in phytosanitary regulations that it is a quarantine pest. This declaration prohibits both the entry of the pest in an isolated state, and the import of consignments infested by the pest. If other phytosanitary measures are decided upon, they should accompany the declaration as a quarantine pest. Such declaration may occasionally be applied alone, especially: (1) when the pest concerned may be easily detected by phytosanitary inspection at import (see question 6.13), (2) where the risk of the pest's introduction is low because it occurs infrequently in international trade or its biological capacity for establishment is low, or (3) if it is not possible or desirable to regulate all trade on which the pest is likely to be found. The measure has the effect of providing the legal basis for the NPPO to take action on detection of the pest (or also for eradication and other internal measures), informing trading partners that the pest is not acceptable, alerting phytosanitary inspectors to its possible presence in imported consignments, and sometimes also of requiring farmers, horticulturists, foresters and the general public to report any outbreaks.

7.43 - In addition to the measure(s) selected to be applied by the exporting country, a phytosanitary certificate (PC) may be required for certain commodities. The PC is an attestation by the exporting country that the requirements of the importing country have been fulfilled. In certain circumstances, an additional declaration on the PC may be needed (see EPPO Standard PM 1/1(2) Use of phytosanitary certificates).

7.44 - If there are no measures that reduce the risk for a pathway, or if the only effective measures unduly interfere with international trade (e.g. prohibition), are not cost-effective or have undesirable social or environmental consequences, the conclusion of the pest risk management stage may be that introduction cannot be prevented. In the case of pest with a high natural spread capacity, regional communication and collaboration is important.

7.45 - Summarize the conclusions of the Pest Risk Management stage.
List all potential management options and indicate their effectiveness.
Uncertainties should be identified.

The EWG considered that it was not possible to maintain a Pest free area for the pest in Canada or USA.

The EWG considered that it was not possible to maintain a Pest free area for the pest in Canada or USA.

- **Pathway 1: Wood chips originating in areas where the pest occurs in Canada and in the USA**

Measures related to consignments:
- Storage in country of export under the strict supervision of the NPPO (1 year)
A 1-year storage is sufficient for wood chips as only prepupae and pupae are likely to survive the chipping process.
- Treatment:
  - chipping down to a certain size. Although it is agreed that the smaller the chips, the smaller the risk, there is not much research on the impact of chipping wood on survival on pests. Some (limited) research showed that chipping with a screen smaller than 2.5 cm destroyed *A. planipennis*. The typical chip size in trade is: 4-8 mm x 40-45 mm x 15-20 mm. Considering the size of *A. anxius* pupa or larva, a chip thinner than 8 mm would be safe (e.g. 7 x 40 x 20 mm).
  - or heat treatment (the conditions required to destroy *A. anxius* are not clearly-defined but in New Zealand heat treatment of wood chips for at least 4 hours at a minimum core temperature of 70°C is required to destroy a range of wood boring pests including *A. sexsignatus*)
  - or fumigation with sulphuryl fluoride (the conditions required to destroy *A. anxius* are not clearly-defined but in New Zealand fumigation at a dose of 80 g/m^3, in separate units no larger than 2 m^3, for more than 24 continuous hours at a minimum temperature of 10°C is required to destroy a range of wood boring pests including *A. sexsignatus*).

- Import permit and specified restrictions: importing at certain time (i.e. winter or when temperature is less than 9 degrees) and processing before the next flight period (i.e. before 200 degree-days have accumulated). Chips must be covered during transport from the point of entry to the process plant (but using covered truck, containers and railcars). Additionally, chips should not be stored outside. This would be possible only if use can be guaranteed and verified. ***The specifications of the requirements need to be done on a case by case basis depending on the origin and the country of destination.***

- **Pathway 2: Plants for planting of *Betula* spp. originating in areas where the pest occurs in Canada and in the USA**

Measures related to consignments:
- Growing plants under specified conditions (insect-proof) with appropriate inspections (twice a year, including immediately prior to export).
This measure may be appropriate only for high value material (e.g. bonsais)

- Importing plants with stems below 2 cm diameter, or scion below 1 cm diameter.
In the USA, larvae have not been reported to colonize trees with main stems below 2 cm diameter, but have been observed to bore from larger stems and branches into branches as small as 1 cm diameter (Herms, pers. obs.; Nielsen, pers. obs.)

- **Pathway 3: Wood with or without bark of *Betula* spp. originating in areas where the pest occurs in Canada and in the USA**

Measures related to consignments:
- storage for 2 years in country of export under the strict supervision of the NPPO
- treatment: heat treatment (specific conditions to be defined), irradiation.

- removal of outer sapwood
- import permit and specified restrictions: import at certain time (i.e. winter or when temperature is less than 9 degrees) and processing before the next flight period (i.e. before 200 degree-days have accumulated). This measure is not practical for firewood. ***The specifications of the requirements need to be done on a case by case basis depending on the origin and the country of destination.***

Pathway 4: Furniture and other objects made of untreated birch wood originating in areas where the pest occurs in Canada and in the USA

Measures related to consignments: treatment (heat treatment, irradiation)

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

Specific details of heat treatments that would be required to destroy *A. anxius* in wood or wood chips have not been defined and require further investigation. Measures could interfere with trade, but costs of eradication or containment attempts would be high and introduction is likely to threaten birch on a continental scale because European and Asian birch species are extremely susceptible, resulting in major economic (including environmental) impact.

Degree of uncertainty

Uncertainties in the management part are:

- Survival of the pest in wood chips depending of the size of chips
- Proportion of chips above the required size in a consignment
- Efficacy of treatments for wood
- Impact of the storage on the quality of wood
- Practical application of post-entry quarantine
- Practical implementation of the import under specific conditions

Appendix 1: **Climatic maps**

Fig 1. World Map of Köppen – Geiger Climate Classification

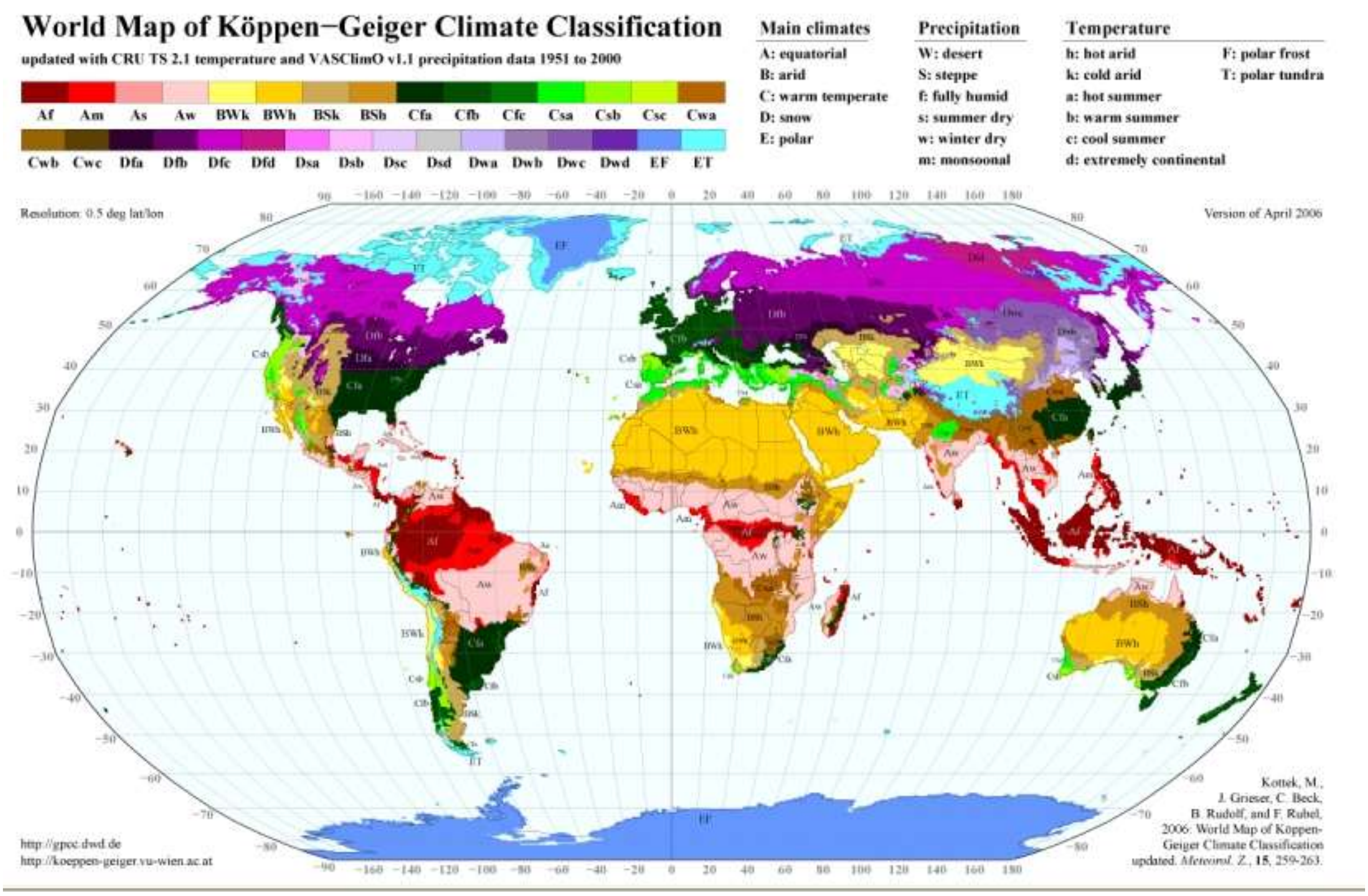


Fig 2a: European Map of Temperature Accumulation (Degree Days) based on a threshold of 10°C using 1861-90 monthly average maximum and minimum temperatures taken from the 10 minute latitude and longitude Climatic Research Unit database (New *et al.*, 2002).

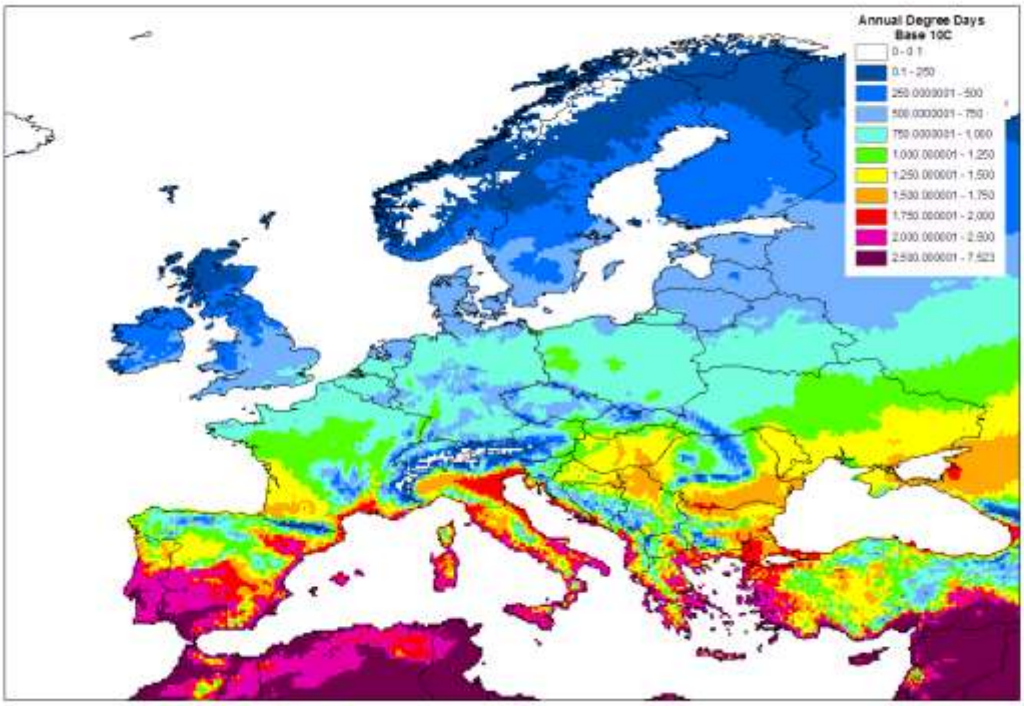
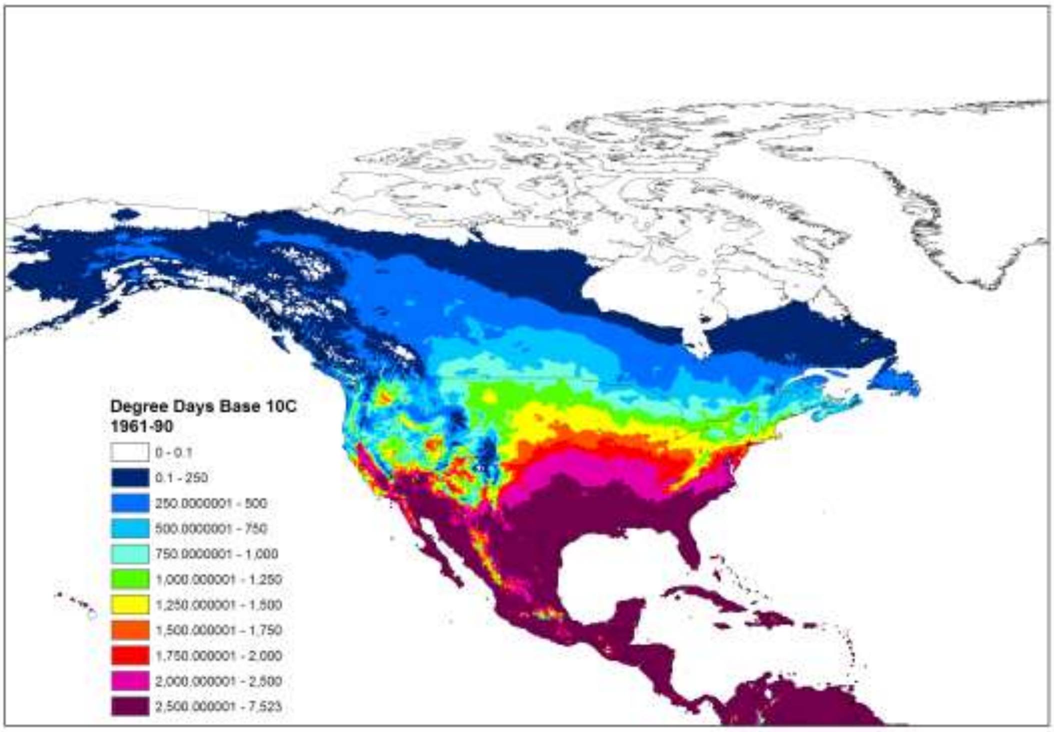


Fig 2b European Map of Temperature Accumulation (Degree Days) based on a threshold of 10°C using 1861-90 monthly average maximum and minimum temperatures taken from the 10 minute latitude and longitude Climatic Research Unit database (New *et al.*, 2002).

Appendix 1



Degree Days Base 10C
1961-90
0 - 0.1
0.1 - 250
250.0000001 - 500
500.0000001 - 750
750.0000001 - 1,000
1,000.000001 - 1,250
1,250.000001 - 1,500
1,500.000001 - 1,750
1,750.000001 - 2,000
2,000.000001 - 2,500
2,500.000001 - 7,523

Appendix 2. **Data on Canada (A) and USA (B) exports to the PRA area**

A- CANADA (Statistics Canada, Canadian International Merchandise Trade Database http://cansim2.statcan.gc.ca/cgi-win/CNSMCGI.PGM?Lang=E&CIMT_Action=Sections&ResultTemplate=CII_CIMT5)

Tables below:

1- wood in chips, non coniferous

2- wood in the rough, non-coniferous, and logs for pulping

3- lumber, non-coniferous, of thickness > 6 mm

1- Wood in chips, non-coniferous (among 12 top countries) (440122). Quantities in metric tons

	2010	2009	2008	2007	2006
Finland	98,563	118,307	57,709	28,500	0
Turkey	33.146	37,730	146,964	156,295	0
United Kingdom	0	2,039	881	253	0
Italy	-	22	0	7	112,247
Netherlands	16	3	0	21	0
Belgium	-	2	0	0	0
Norway	66,280	0	0	0	0

2- Wood in the rough, non-coniferous, and logs for pulping (440399). Quantities in m³

	2009	2008	2007	2006
Netherlands	1,210	346	3,207	227
Germany	839	595	755	630
Italy	1,047	767	1,148	1,537
Israel	66	80	45	0
France	61	71	30	131
Turkey	1	0	492	0

Includes birch, alder, cherry, ash, maple, poplar, walnut, other temperate

3- Lumber, non-coniferous, of thickness > 6 mm (440799). Quantities in m³ Includes birch, maple alder, cherry, poplar, ash, other temperate

Appendix 2

	2009	2008	2007	2006
Germany[1]	3,260	5,091	6,619	23,407
United Kingdom	2,583	5,354	11,135	15,528
Netherlands	526	1,069	2,343	2,991
France	1,104	1,455	2,461	3,622
Italy	943	1,292	3,020	6,191
Ireland, Republic of (EIRE)	502	1,291	2,058	1,767
Poland	480	510	573	1,124
Sweden	373	835	1,197	3,615
Israel	298	926	66,600	4,769
Finland	204	998	835	1,413
Spain	271	782	2,164	5,503
Denmark	179	1,445	1,495	3,061
Belgium	213	695	1,538	3,242

Malaysia	179	567	737	2,140
Portugal	112	51	1,158	1,756
Lithuania	59	1,046	293	1,453
Austria	48	493	447	1,925
Estonia	103	1,254	379	0
Jordan	31	84	43	1,034
Russian Federation	32	2	277	0
Switzerland	27	112	69	757
Croatia	52	68	46	137
Turkey	62	312	44	307
Greece	25	132	348	470
Malta	24	32	495	490
Cyprus	14	85	18	207
Czech Republic	3	142	106	65

B- USA (Global Agricultural Trade System USA http://www.fas.usda.gov/gats/default.aspx)

Tables below:

1- Harwood chips

2- Hardwood logs, birch

3, 4, 5- Lumber, birch

6- Hardwood logs and chips (all species)

7- Hardwood lumber (all species)

1 - HARDWOOD CHIPS (0440122000) in Metric tons

Partner	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Belarus	0	0	0	0	0	0	0	78	0	0
Belgium	0	0	58	0	0	14	9	0	664	0
Bulgaria	2	6	17	0	0	14	636	0	813	813
Czech Republic	0	0	0	0	0	0	0	0	65	0
Denmark	0	0	50.862	0	0	0	0	496	2.088	0
European Union-27	25.033	30.837	73.362	31.744	43.358	6.279	21.500	38.746	45.398	36.128
Finland	2.237	0	0	465	524	541	0	0	44	0
Former Soviet Union-12	0	151	0	0	0	0	0	78	473	0
France	1.559	769	77	19	8	103	7.100	12.578	15.341	10.075
Germany	0	42	428	1.040	90	340	3.666	5.360	3.309	3.470
Greece	30	865	3	11	0	4	0	0	0	0
Iceland	0	11	0	343	0	0	0	0	0	0
Ireland	66	3	0	0	0	0	0	0	0	0
Israel	10	3	22	0	6	465	491	2.228	1.319	2.181
Italy	19.916	28.059	21.840	30.048	39.892	4.292	6.103	8.594	8.318	13.364
Kazakhstan	0	151	0	0	0	0	0	0	0	0
Moldova	0	0	0	0	0	0	0	0	473	0
Morocco	0	2	5	258	5	1	0	0	0	0
Netherlands	0	0	0	10	5	1	164	893	5.642	2.745
Other Europe	0	11	0	343	0	0	270	0	0	476
Portugal	0	0	33	6	3	23	654	2.763	4.005	1.373

Slovenia	0	0	0	126	2.682	0	0	0	0	0
Spain	970	1.062	20	19	139	907	2.808	7.413	4.016	4.065
Sweden	0	0	0	0	0	0	0	421	965	0
Switzerland	0	0	0	0	0	0	270	0	0	476
Turkey	0	0	0	0	0	0	0	226	0	45
United Kingdom	253	31	24	0	15	40	360	228	128	223

2- HW LOGS, BIRCH 4403990030 in m^3

Partner	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Austria	41	0	0	0	0	0	0	0	0	0
Belgium	41	27	0	0	0	0	0	0	0	0
Denmark	0	0	0	0	28	0	0	0	0	0
Estonia	0	0	0	0	0	0	0	0	0	188
European Union-27	162	206	502	31	60	18	31	1.151	87	666
France	0	0	68	0	0	0	0	652	0	0
Germany	60	169	74	31	20	18	0	0	0	318
Italy	20	0	150	0	11	0	31	415	87	160
Norway	29	0	0	0	0	0	0	0	0	0
Other Europe	29	0	0	59	0	0	0	0	0	0
Portugal	0	0	210	0	0	0	0	0	0	0
Switzerland	0	0	0	59	0	0	0	0	0	0
United Kingdom	0	10	0	0	1	0	0	84	0	0

3. - LMBR,D, BIRCH (4407990051) in m³

Partner	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
European Union-27	0	0	0	0	0	64	0	0	0	0
Germany	0	0	0	0	0	6	0	0	0	0
Ireland	0	0	0	0	0	58	0	0	0	0
Jordan	299	0	0	0	0	0	0	0	0	0

4- LMBR,R, BIRCH 4407990050 in m³

Partner	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Austria	0	0	71	37	0	0	40	0	0	0
European Union-27	450	121	1.324	3.297	3.120	3.342	2.890	0	0	0
France	96	0	0	0	0	0	731	0	0	0
Germany	0	56	92	0	64	273	5	0	0	0
Ireland	0	0	0	0	0	2	5	0	0	0
Israel	55	0	0	35	0	0	0	0	0	0
Italy	0	31	1.091	3.231	3.019	3.067	2.109	0	0	0
Netherlands	29	0	0	0	0	0	0	0	0	0
Other Europe	0	0	60	0	0	0	0	0	0	0
Switzerland	0	0	60	0	0	0	0	0	0	0
United Kingdom	325	34	70	29	37	0	0	0	0	0

5. - LMBR, BIRCH (4407990110) in m³

Partner	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
European Union-27	0	0	0	0	0	0	0	339	326	0
France	0	0	0	0	0	0	0	113	0	0
Germany	0	0	0	0	0	0	0	24	198	0
Italy	0	0	0	0	0	0	0	114	128	0
Spain	0	0	0	0	0	0	0	88	0	0

6- Logs and chips (all species) in m³

Partner	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Albania	0	0	0	0	0	236	369	105	360	19

Appendix 2

Partner	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Algeria	0	0	0	0	0	0	0	0	117	166
Armenia	0	0	0	0	0	0	0	174	0	0
Austria	5.503	6.116	728	84	1.298	195	947	377	837	314
Azerbaijan	0	0	0	0	0	0	0	0	28	29
Belarus	0	0	0	0	0	0	0	0	33	29
Belgium	11.893	24.116	9.872	6.944	3.086	3.979	7.713	12.175	14.959	13.814
Bulgaria	0	0	0	153	0	18	0	28	28	0
Croatia	601	37	0	165	18	263	92	263	258	210
Cyprus	188	0	97	1.459	1.990	28	122	411	3.400	360
Czech Republic	0	0	1.335	4.398	911	1.761	621	1.884	549	421
Denmark	8.918	3.831	12.965	3.721	3.527	2.971	8.012	12.976	4.089	2.134
Estonia	0	0	0	0	70	0	32	2.763	3.565	3.769
European Union-27	323.551	335.230	262.107	303.378	335.081	256.827	298.217	533.356	489.556	340.285
Finland	663	58	704	967	987	1.216	667	3.502	4.373	2.378
Former Soviet Union-12	119	783	0	0	0	48	87	462	1.609	351
France	20.206	21.702	18.167	11.588	20.885	5.467	9.422	14.838	11.953	10.511
Georgia	70	534	0	0	0	0	0	0	0	0
Germany	91.771	106.131	65.557	65.020	54.770	49.309	54.026	90.731	93.544	58.887
Gibraltar	11	0	0	0	0	0	0	0	0	0
Greece	511	894	1.316	291	1.021	594	626	8.546	13.948	8.796
Greenland	0	0	0	0	0	0	0	0	0	0
Hungary	0	0	792	164	170	0	0	0	0	0
Iceland	558	0	86	83	127	19	626	980	1.415	672
Ireland	3.182	1.250	3.404	3.350	3.236	5.145	3.915	12.013	12.795	6.148
Israel	2.671	3.288	796	1.668	1.138	1.322	2.602	7.426	5.866	6.062
Italy	104.018	92.271	77.490	93.014	97.147	94.185	100.741	151.513	121.834	91.531
Jordan	117	86	341	1.541	1.512	486	249	2.370	3.481	4.437
Kazakhstan	0	0	0	0	0	0	0	0	0	0
Latvia	87	0	0	0	0	0	139	1.862	399	33
Lithuania	0	0	30	424	481	153	143	168	732	126
Luxembourg	178	0	0	0	0	0	0	0	0	0
Malta	27	214	56	348	469	241	231	1.163	1.848	1.270

Partner	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Moldova	49	141	0	0	0	0	0	0	29	0
Montenegro	0	0	0	0	0	0	0	0	1.268	0
Morocco	0	0	0	159	101	0	0	182	1.054	306
Netherlands	3.151	4.692	4.261	15.939	21.802	4.006	4.688	11.028	11.032	4.354
Norway	1.064	326	423	275	105	235	366	3.044	4.692	3.393
Other Europe	7.762	6.195	4.914	5.295	6.537	1.794	23.366	7.533	35.876	4.610
Poland	73	266	0	92	2.180	5.424	6.918	12.602	7.213	9.636
Portugal	16.312	18.039	13.720	17.088	19.359	17.665	20.242	34.947	27.666	20.597
Romania	666	0	34	20	27	37	0	180	785	29
Russia	0	0	0	0	0	48	87	288	1.492	293
Serbia and Kosovo	0	0	0	0	0	0	0	129	192	0
Serbia, Montenegro, and Kosovo	0	0	0	46	0	0	118	0	0	0
Slovenia	502	2.059	6.524	4.486	393	98	139	7.003	4.685	1.945
Spain	35.895	30.076	29.821	32.113	42.065	39.061	48.809	89.292	60.979	31.408
Sweden	4.538	1.684	2.298	6.902	9.102	1.332	2.168	7.030	7.357	7.047
Switzerland	5.528	5.832	4.405	4.726	6.287	1.041	21.795	3.012	27.691	316
Tunisia	0	30	30	112	315	75	100	0	1	98
Turkey	697	998	2.360	1.930	4.787	3.909	3.694	7.612	16.276	9.850
Ukraine	0	108	0	0	0	0	0	0	27	0
United Kingdom	15.269	21.831	12.936	34.813	50.105	23.942	27.896	56.324	80.986	64.777

7- Hardwood Lumber (all species) in m^3

Partner	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Albania	0	0	0	0	28	230	83	96	94	128
Algeria	0	0	0	0	0	26	28	0	33	38
Armenia	0	0	0	0	0	0	27	0	0	0
Austria	1.408	500	556	334	679	252	1.035	1.217	355	270
Azerbaijan	0	0	26	0	0	60	22	0	0	0
Belarus	0	0	0	0	0	0	0	0	163	0
Belgium	52.393	51.409	35.436	30.108	27.710	25.823	23.057	20.059	21.720	10.184
Bosnia and Herzegovina	122	0	0	0	0	0	0	0	0	0
Bulgaria	0	93	0	69	5	2	0	155	307	283

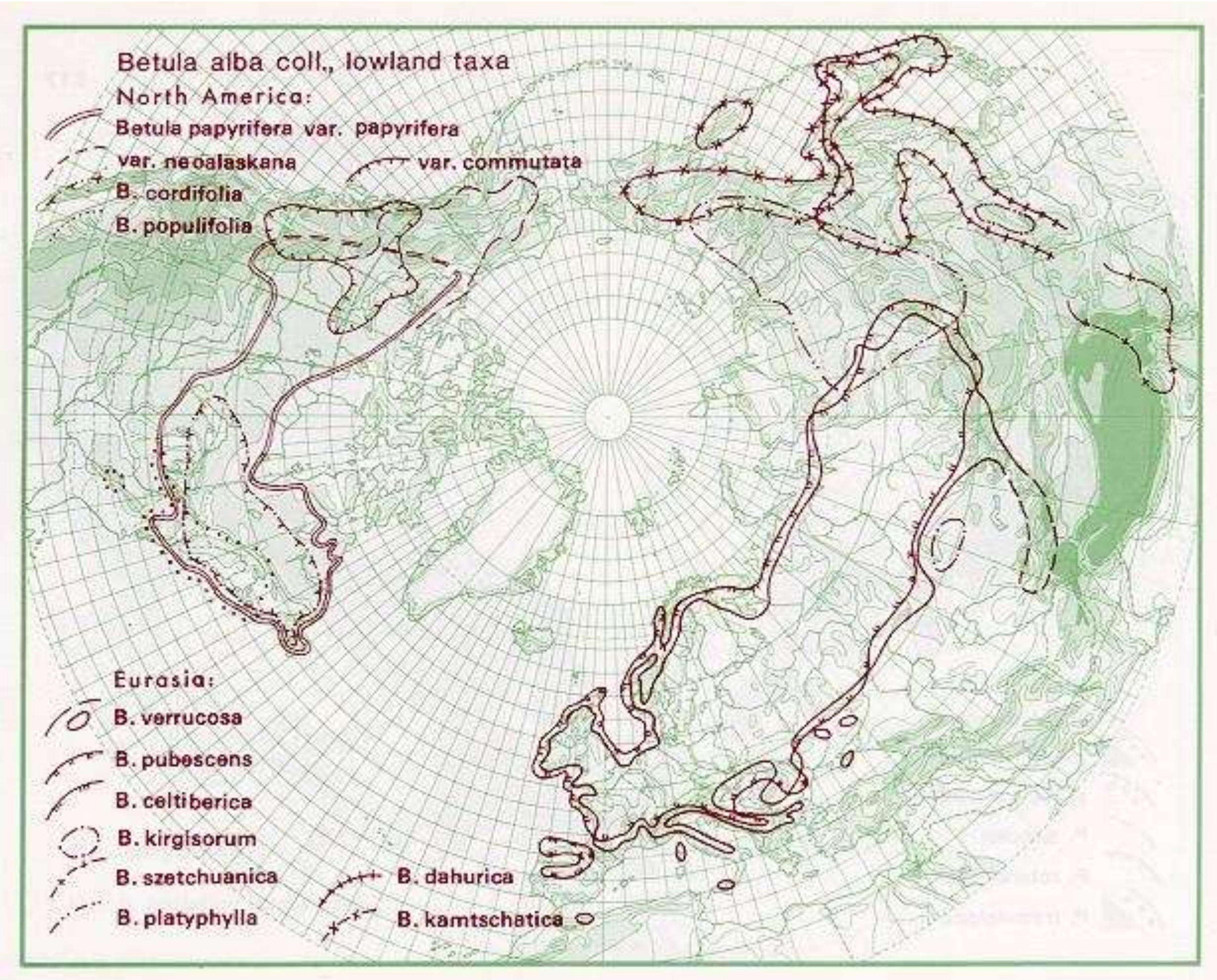
Croatia	23	0	0	142	259	0	132	360	202	178
Cyprus	1.927	1.522	821	982	1.184	917	774	1.080	592	602
Czech Republic	825	598	441	804	678	777	696	504	192	678
Denmark	22.963	16.681	18.582	11.884	15.314	16.785	29.754	12.042	5.422	3.215
Estonia	606	558	936	1.103	1.478	1.755	2.509	2.568	3.038	2.963
European Union-27	845.362	726.687	678.701	649.063	685.316	684.929	723.560	646.774	452.577	353.693
Finland	5.917	5.746	5.751	5.041	5.641	4.630	5.795	3.606	2.610	1.906
Former Soviet Union-12	427	2.503	1.096	1.188	212	306	1.060	361	1.796	1.675
France	45.084	30.456	28.925	21.470	23.187	18.272	15.728	11.552	10.829	7.926
Georgia	82	0	0	30	30	0	413	27	134	83
Germany	77.141	47.065	32.635	40.323	48.623	54.440	56.720	47.859	33.323	36.246
Gibraltar	27	0	0	0	0	0	0	0	0	0
Greece	12.692	10.643	13.851	14.377	13.771	15.915	17.548	15.379	17.900	11.606
Greenland	0	0	0	0	0	0	0	0	28	0
Hungary	696	30	282	133	71	0	0	29	0	0
Iceland	769	993	318	307	412	621	295	510	400	284
Ireland	24.306	17.979	21.962	20.144	22.985	27.695	35.181	25.694	13.522	11.593
Israel	8.804	5.508	7.476	6.471	5.465	5.651	3.049	7.400	7.260	7.839
Italy	200.989	163.514	160.606	165.267	175.925	160.556	201.315	209.019	152.170	125.513
Jordan	2.231	2.286	2.061	2.030	2.467	1.936	2.876	2.328	3.726	3.139
Kazakhstan	0	0	0	0	18	0	18	117	64	0
Latvia	0	0	0	141	54	152	627	988	810	154
Lithuania	25	87	603	710	655	562	1.412	841	1.269	734
Luxembourg	66	34	0	26	0	0	0	0	0	0
Malta	3.640	3.490	3.521	3.353	3.644	2.799	3.141	2.914	1.761	1.781
Moldova	203	22	61	0	0	0	0	0	0	0
Morocco	470	0	345	255	453	281	177	765	278	610
Netherlands	31.750	23.187	17.863	14.140	15.249	15.016	17.506	13.515	12.367	7.146
Norway	11.378	11.062	8.347	8.705	8.494	8.829	9.672	9.270	6.949	4.982
Other Europe	15.592	15.344	11.455	9.504	10.174	12.779	12.342	10.532	8.355	5.731
Poland	253	452	294	153	1.113	3.683	1.269	669	1.878	1.452
Portugal	32.788	31.296	37.626	39.347	40.079	40.186	38.639	40.383	26.872	21.660
Romania	126	12	32	81	76	397	293	193	308	30

Russia	142	0	0	867	137	246	508	180	1.227	1.512
Serbia and Kosovo	0	0	0	0	0	0	0	28	32	0
Serbia, Montenegro, and Kosovo	0	13	0	0	0	0	24	0	0	0
Slovakia	0	0	0	0	181	0	66	0	0	9
Slovenia	267	233	388	386	2.210	8.327	930	1.393	1.248	52
Spain	181.532	179.325	173.196	171.145	172.494	163.349	139.661	124.861	64.053	39.415
Sweden	22.471	21.255	20.484	18.502	20.868	21.370	23.474	19.344	10.174	9.406
Switzerland	3.273	3.276	2.790	350	981	3.099	2.136	268	678	159
Tunisia	44	0	128	138	290	116	36	36	0	180
Turkey	362	1.104	414	427	1.665	2.472	3.708	1.822	3.243	4.353
Ukraine	0	2.481	1.009	291	27	0	72	37	208	52
United Kingdom	125.497	120.522	103.910	89.040	91.442	101.269	106.430	90.910	69.857	58.869
Uzbekistan, Republic of	0	0	0	0	0	0	0	0	0	28

Appendix 3. Maps of some *Betula* spp. in the PRA area (or parts of)

Distribution of B. verrucosa, B. pubescens, B. celtiberica, B. kirgisorum, B. szetchanica, B platyphylla, B. dahurica, and B. kamtschatica in Eurasia, and of B. papyrifera, B. cordifolia and B. populifolia in North America.

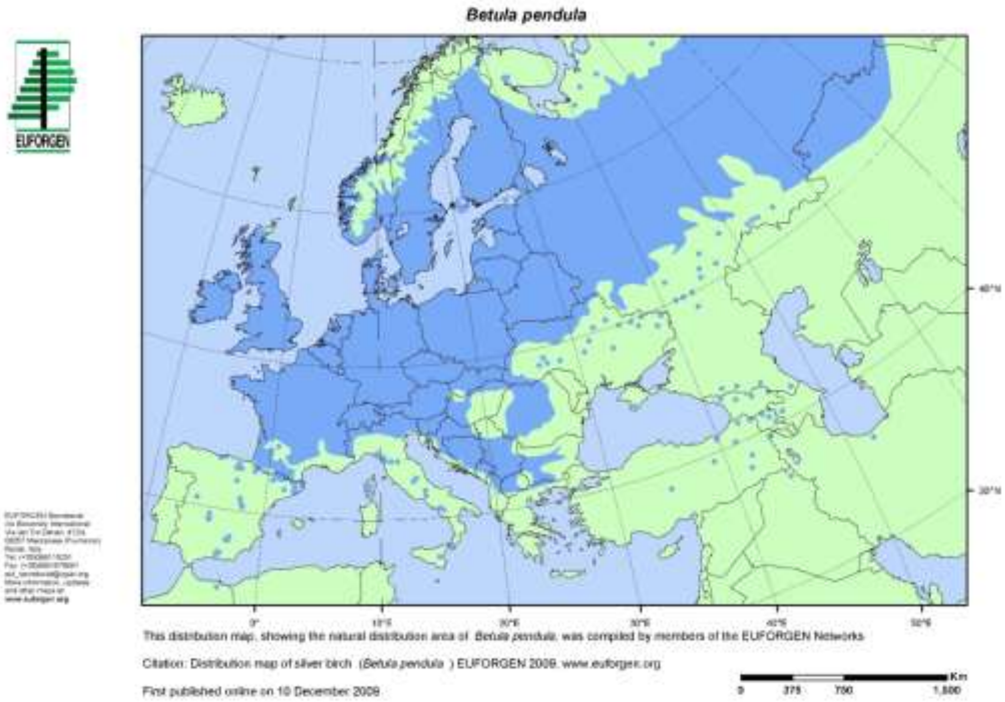
Source: http://linnaeus.nrm.se/flora/di/betula/betul/betupubv.jpg



Betula pendula,

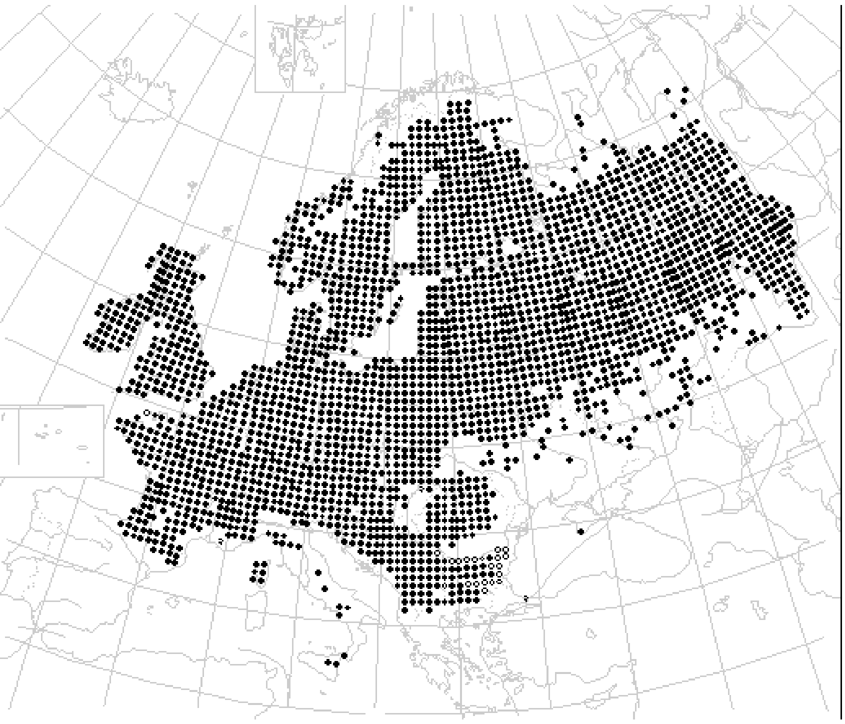
- source EUFORGEN (European Forest Genetic Resources Programme)

http://www.euforgen.org/distribution_maps.html

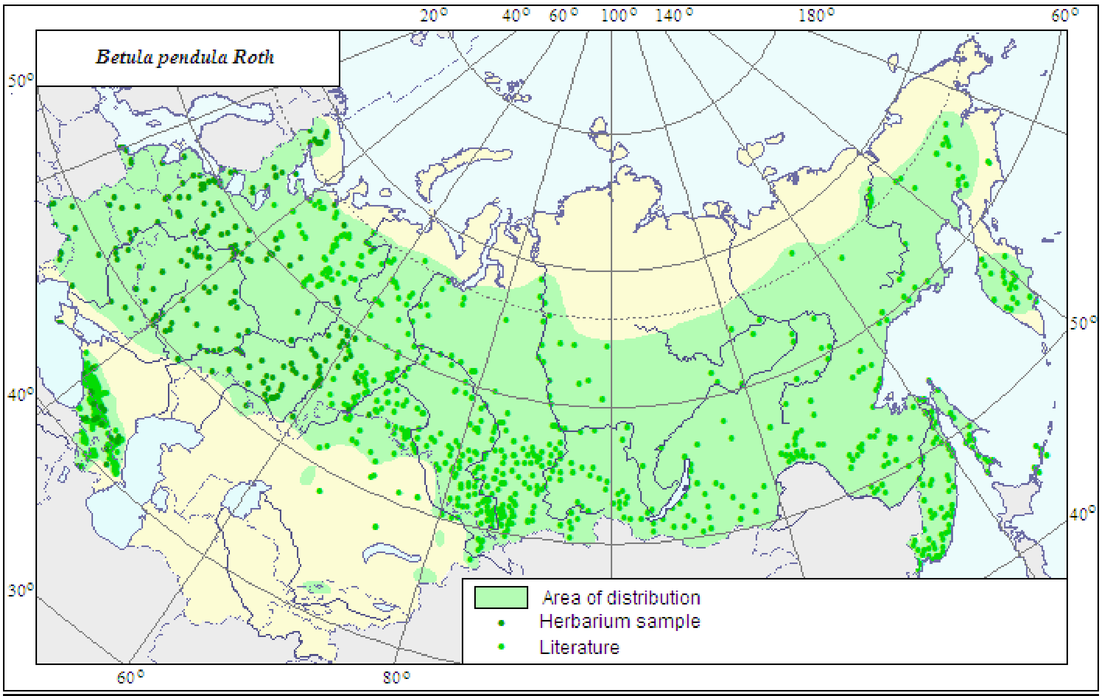


- Source Atlas Florae Europea (in Finnish Museum of Natural History)

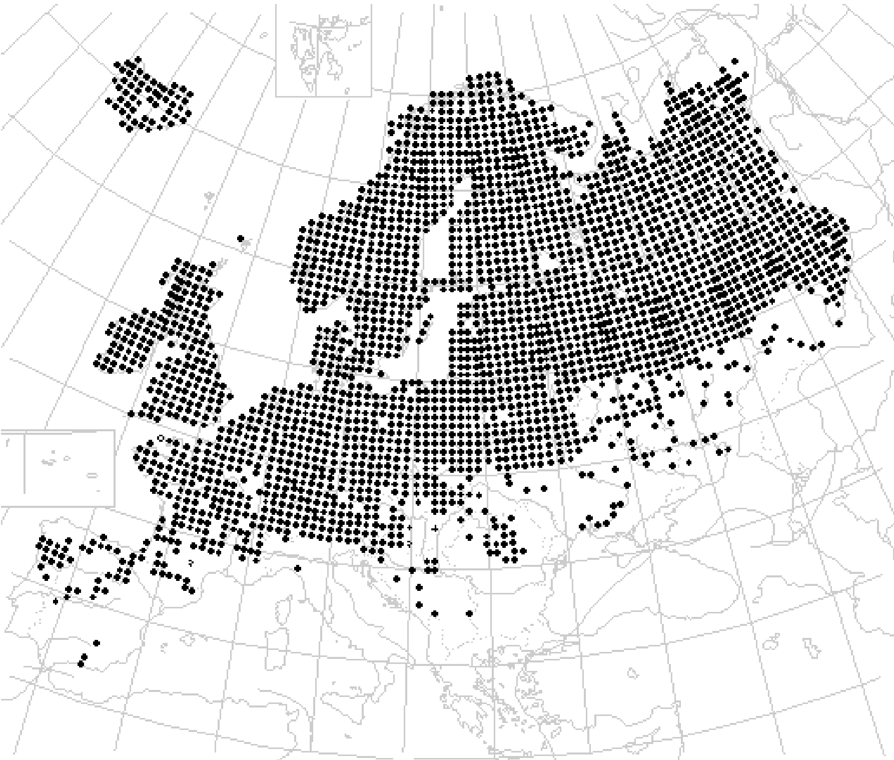
(http://www.luomus.fi/english/botany/afe/publishing/database.htm)



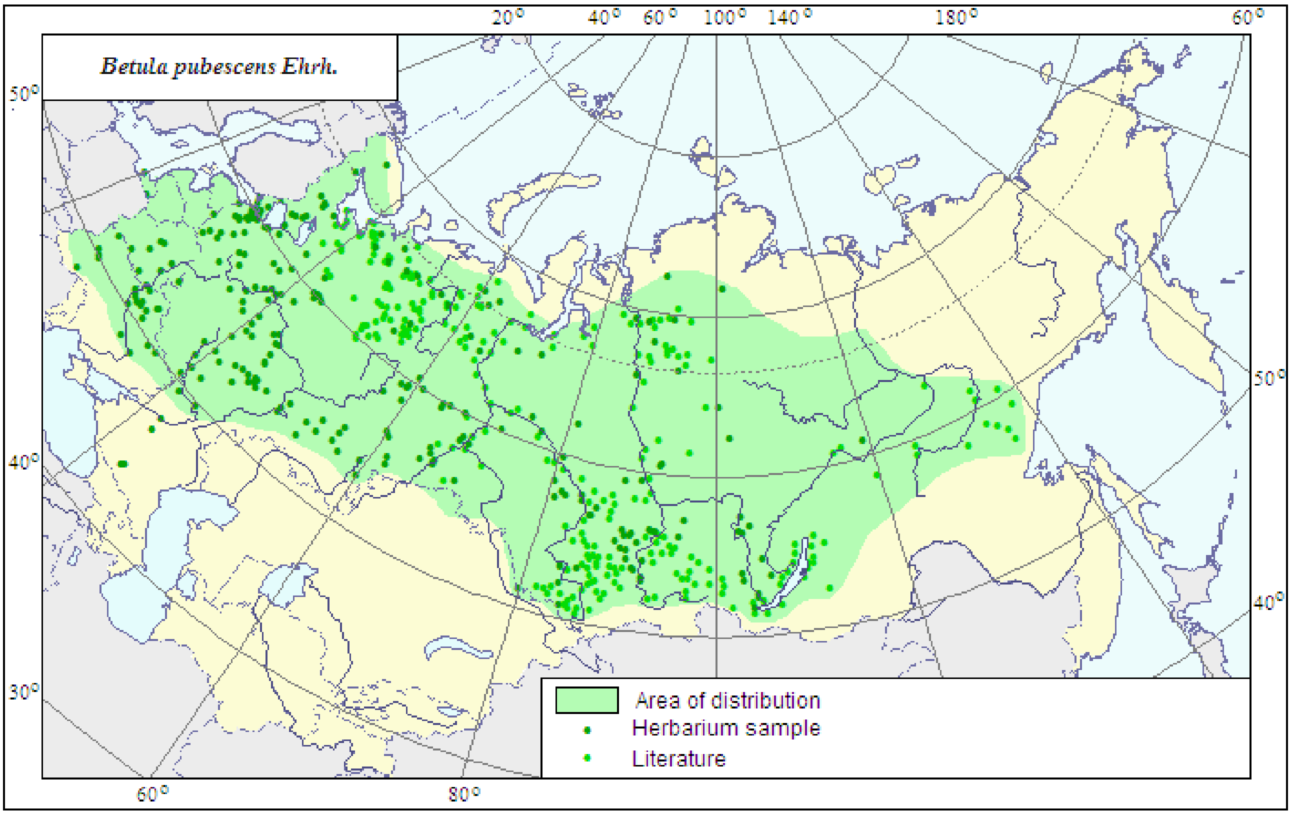
- *Betula pendula* in Russia. Source Afonin *et al*., 2008



B. pubescens – Atlas Florae Europea (*Betula celtiberica* recognized as synonym of *B. pubescens* in some publications, and as independent species in others)

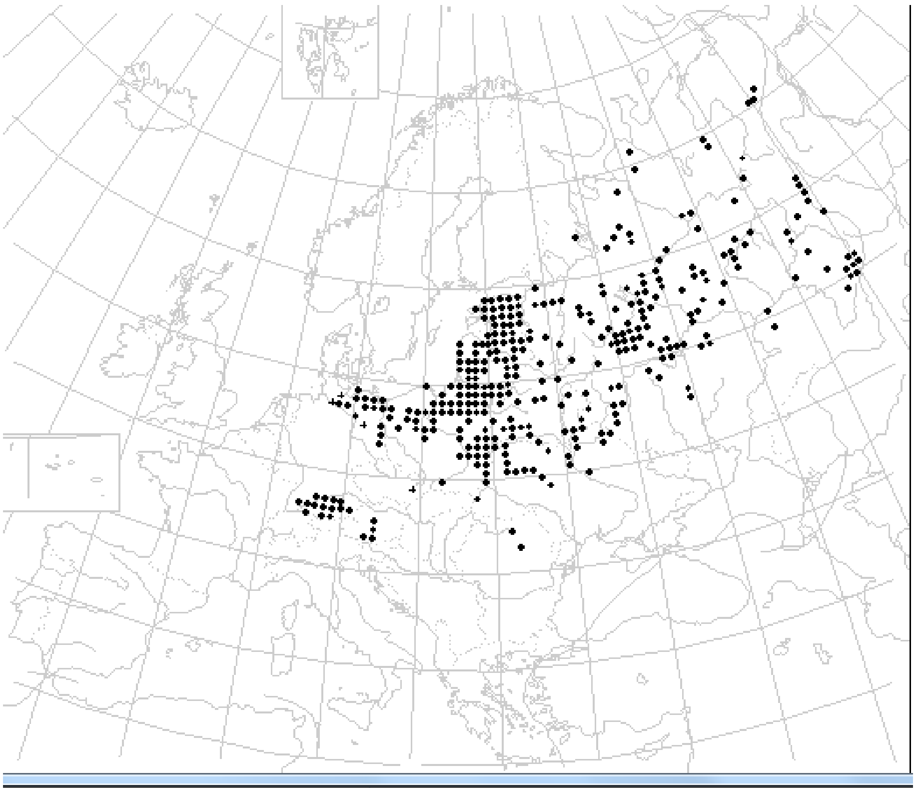


- *Betula pubescens* in Russia. Source Afonin *et al*., 2008



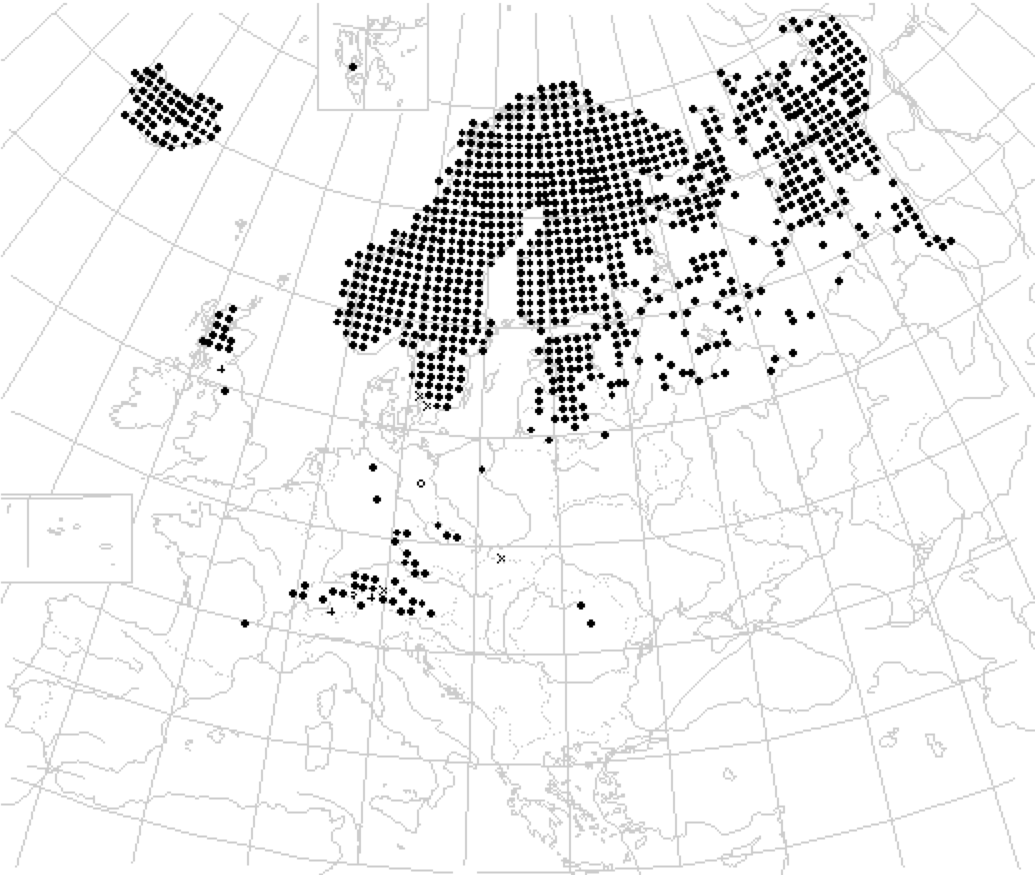
B. humilis

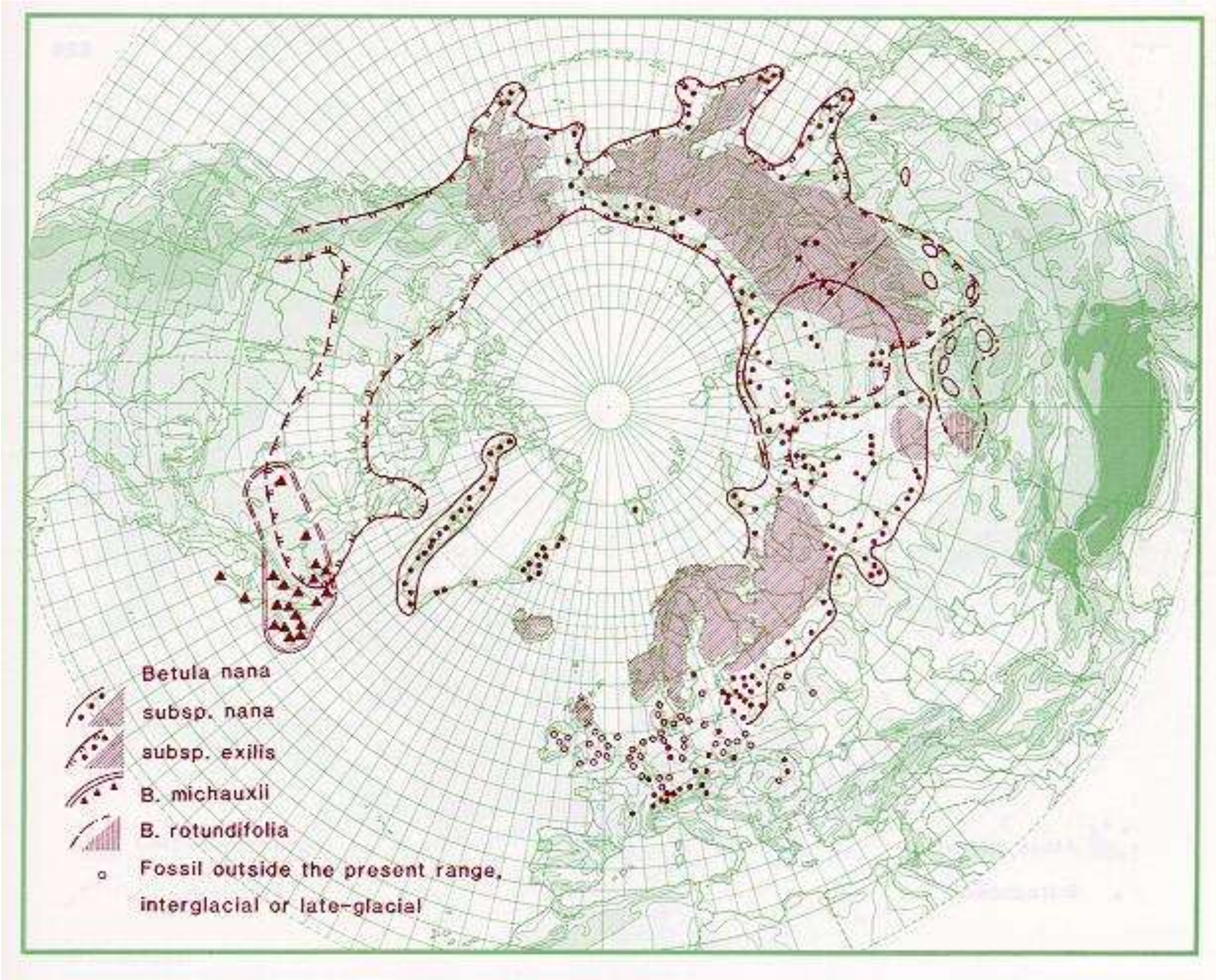
Atlas Florae Europea



B. nana

Source: Atlas Florae Europea





Source http://linnaeus.nrm.se/flora/di/betula/betul/betunanv.jpg

National Environmental Research Institute, Aarhus University

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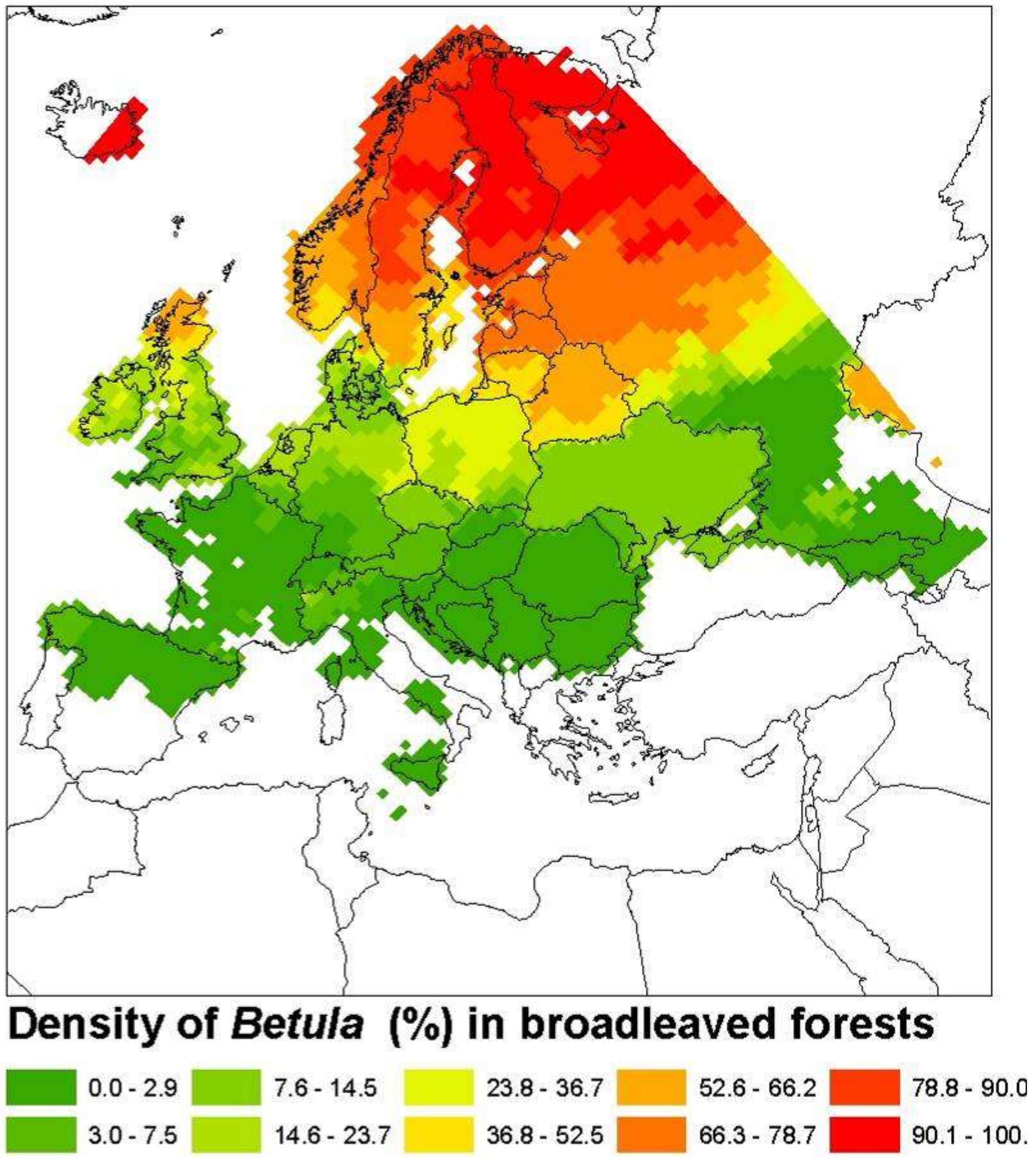

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