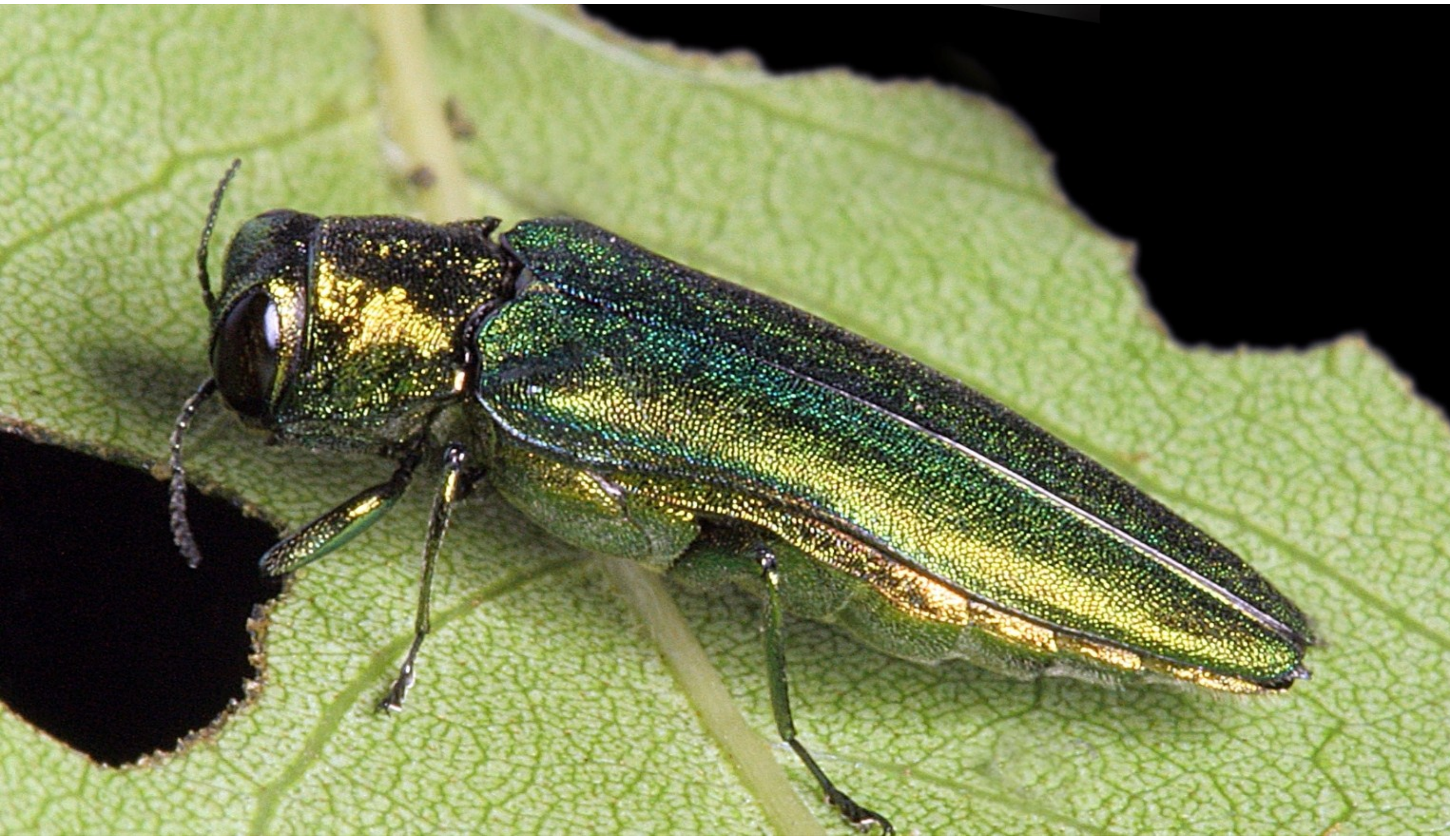
Vitenskapskomiteen for mattrygghet
Norwegian Scientific Committee for Food Safety



VKM Report 2014: 13

The EPPO PRA for *Agrilus planipennis*: assessment for Norway

Opinion of the Panel on Plant Health of the Norwegian Scientific Committee for Food Safety

Report from the Norwegian Scientific Committee for Food Safety (VKM) 2014:13
The EPPO PRA for *Agrilus planipennis*: assessment for Norway

Opinion of the Panel on Plant Health of the Norwegian Scientific Committee for Food Safety
24.11.2014

Cover photo: David Cappaert, Michigan State University, Bugwood.org (UGA 2106098)

ISBN: 978-82-8259-152-2
Norwegian Scientific Committee for Food Safety (VKM)
Po 4404 Nydalen
N – 0403 Oslo
Norway

Phone: +47 21 62 28 00
Email: vkm@vkm.no

www.vkm.no
www.english.vkm.no

Suggested citation: VKM. (2014) Scientific Opinion on the Report from the Norwegian Scientific Committee for Food Safety (VKM) 2014:13.

The EPPO PRA for *Agrilus planipennis*: assessment for Norway. Opinion of the Panel on Plant Health of the Norwegian Scientific Committee for Food Safety, ISBN: 978-82-8259-152-2 Oslo, Norway.

The EPPO PRA for *Agrilus planipennis*: assessment for Norway

Authors preparing the draft opinion

Leif Sundheim (chair), Daniel Flø, Trond Rafoss, Bjørn Økland

Assessed and approved

The opinion has been assessed and approved by the Panel on Plant Health. The members of the Panel are: Trond Rafoss (chair), Guro Brodal, Åshild Ergon, Christer Magnusson, Arild Sletten, Halvor Solheim, Leif Sundheim, May-Guri Sæthre, Anne Marte Tronsmo, Bjørn Økland.

Acknowledgment

The Norwegian Scientific Committee for Food Safety (Vitenskapskomiteen for mattrygghet, VKM) has appointed a working group consisting of both VKM members and external experts to answer the request from the Norwegian Food Safety Authority. Project leaders from the VKM secretariat have been Elin Lid Thingnæs and Juliana Perminow. The members of the working group Leif Sundheim, Trond Rafoss, Bjørn Økland and Daniel Flø (Norwegian Forest and Landscape Institute) are acknowledged for their valuable work on this opinion.

Competence of VKM experts

Persons working for VKM, either as appointed members of the Committee or as external experts, do this by virtue of their scientific expertise, not as representatives for their employers or third party interests. The Civil Services Act instructions on legal competence apply for all work prepared by VKM.

Table of Contents

Summary

Agrilus planipennis (emerald ash borer) is native to eastern Asia. This small beetle has become a major pest on ash (*Fraxinus* spp.) where it has been introduced in USA, Canada, and European Russia. The pest feeds on several species of ash, including the species found in Norway, *Fraxinus excelsior*, also known as common ash or European ash. Ash trees are eventually killed by the feeding damage between the bark and the wood.

Since the first North American record in 2002, *A. planipennis* has spread to 23 states in USA and two provinces of Canada. At the epicenter of its introduction in Michigan, the mortality of ash exceeds 99 %. In European Russia, this pest was first detected in Moscow during 2002-2003. Following yearly range expansions and killing of ash trees, *A. planipennis* has now been recorded 466 km from its European epicenter.

The Norwegian Scientific Committee for Food Safety (VKM) has been asked by the Norwegian Food Safety Authority (NFSA) to assess the probability of: a) entry of *A. planipennis* into Norway through different pathways; b) establishment of *A. planipennis* in Norway; c) the further spread and potential damage of *A. planipennis* on ash trees in Norway. In addition, an evaluation of the effectiveness of the risk-reduction measures described by the European and Mediterranean Plant Protection Organization (EPPO) and the European Union (EU) has been requested.

VKM considers the probability of entry of *A. planipennis* by natural spread low, mainly because of the geographical distance and sea barriers between Norway and the infested areas.

Among the human-assisted pathways of entry, via commodities containing ash wood, the probability of entry is considered to be: moderate for wood chips, wood in the rough and plants for planting; low-to-moderate for fuel wood; and low for waste wood and wood sawn or chipped lengthwise.

VKM is of the opinion that should *A. planipennis* enter the pest risk analysis (PRA) area, there is a high probability of establishment and spread; the environmental conditions are similar to those of its current range area, and ash trees are widely distributed.

The potential damage should *A. planipennis* reach Norway is considered high, since ash trees in forests, parks and urban areas of Norway may be killed within a few years after infestation.

VKM is of the opinion that the risk-reduction measures in the EPPO PRA, as well as in the EU legislation, can be considered safe under Norwegian conditions. Chipping and heat treatment are not regarded as reliable risk-reduction measures due to lack of documented information on efficiency. Squaring of wood, with removal of at least 2.5 cm of the outer sapwood, is regarded as a measure that may be ineffective at preventing entry because prepupae and

pupae could be located more deeply in the wood. VKM suggests that at least 3.5 cm of the outer sapwood should be removed. Ionizing radiation of 1 kGy for disinfestation of wood is proposed in the EPPO standard. VKM assumes that this would be an effective phytosanitary measure, but more specific research on irradiation tolerance of the pest is needed.

Key words: Emerald Ash Borer, Pest Risk Analysis (PRA), pest risk assessment, distribution, spread, establishment, entry, management options, fuel wood, ash, impact, economic and environmental consequences, wood chips, plants for planting, VKM, Norwegian Scientific Committee for Food Safety

Sammendrag på norsk

Agrilus planipennis (asiatisk askepraktbille) er en billeart som har sin naturlige utbredelse i østlige Asia. Billens boringer mellom barken og veden på asketrær (*Fraxinus* spp.) gjør at trærne til slutt dør. *Agrilus planipennis* gjør skade på flere arter av ask, inkludert den vanligste arten i Norge, *Fraxinus excelsior*.

Agrilus planipennis har blitt et stort problem for asketrær der den er introdusert i USA, Canada og europeisk Russland. Siden første nordamerikanske funn av *A. planipennis* i 2002, har den spredt seg til 23 stater i USA og to provinser i Canada. Der arten ble introdusert i Michigan er dødeligheten av ask mer enn 99%. I europeisk Russland ble denne skadegjøreren påvist for første gang i Moskva i 2002-2003. Etter årlige ekspansjoner og dreping av asketrær er *A. planipennis* nå blitt påvist 466 km fra Moskva.

Mattilsynet har spurt Vitenskapskomiteen for mattrygghet (VKM) om å vurdere hvor sannsynlig det er at *A. planipennis* blir introdusertes i Norge via ulike innførselsveier. Videre hvor sannsynlig det er at den etableres og sprer seg i Norge, og hvilken skade *A. planipennis* vil kunne gjøre på ask etter etablering. Mattilsynet har også bedt VKM vurdere effektiviteten av de risikoreduserende tiltakene som anbefales av European and Mediterranean Plant Protection Organization (EPPO)

VKM mener sannsynligheten er lav for at *A. planipennis* sprer seg naturlig til Norge. Grunnen er lang avstand mellom Norge og landene hvor den i dag forekommer og at det finnes hav i mellom.

Blant handelsvarer som inneholder ask, anses sannsynligheten for introduksjon å være moderat for flis, tømmer og levende planter; lav til moderat for ved til brensel; og lav for vedavfall og trelast saget eller kuttet i lengderetningen.

VKM mener at det er stor sannsynlighet for etablering og spredning av *A. planipennis* i Norge, siden de klimatiske forholdene er sammenlignbare med dagens utbredelsesområde, og ask er vidt utbredt her i landet.

Skadepotensialet regnes som stort, siden asketrær i skog, parker og byområder i Norge kan bli drept i løpet av få år etter angrep av *A. planipennis*.

VKM mener at risikoreduserende tiltak beskrevet av EPPO og EU kan regnes som effektive under norske forhold. Oppflising og varmebehandling regnes ikke som pålitelige tiltak på grunn av manglende dokumentasjon om effektivitet. Fjerning av minst 2,5 cm av den ytre veden ved saging av tømmer regnes som et usikkert tiltak fordi prepupper og pupper kan finnes dypere i veden. VKM foreslår derfor at minst 3,5 cm bør fjernes. Ioniserende stråling med styrke 1kGy, er foreslått i EPPO-standarden. VKM antar at dette er et effektivt tiltak, men mer forskning på stråletoleransen hos skadegjøreren er nødvendig.

Background as provided by the Norwegian Food Safety Authority

The Norwegian Food Safety Authority (NFSA) asked The Norwegian Scientific Committee for Food Safety (VKM) in a letter of December 10th 2013, to assess the potential for introduction, establishment and damage of the plant pest *A. planipennis* in Norway, and the effect of the risk reducing measures described in the EPPO PRA and in the EU Council Directive 2000/29 (EU, 2014). The NFSA will use the VKM risk assessment as a basis to determine whether *A. planipennis* should be regulated as a quarantine plant pest in Norway, and if specific phytosanitary actions should be taken to prevent its introduction.

Terms of reference as provided by the Norwegian Food Safety Authority

On the background of what is currently known about trade patterns and distribution and biology of the species, the Norwegian Food Safety Authority requests an assessment of the relevance of the recently revised EPPO PRA for *Agrilus planipennis* related to conditions in Norway. We request that the assessment has a particular focus on:

1. Probability of entry into Norway, including an assessment of which pathways that today represent the highest probability of entry of *A. planipennis* into Norway and an assessment of the likelihood of natural spread into Norway from the areas where this species occurs today.

2. Probability of establishment and of further spread after an establishment in Norway.

3. Potential damage on cultivated plants, public greenery and uncultivated plants in Norway (in particular on *Fraxinus excelsior*)

4. Effectiveness of the risk reduction measures described in EPPO PRA and in EU Council Directive 2000/29 Annex IV Part A, Section I, point 11.4, 2.3, 2.4 and 2.5, related to the import of plants for planting, wood (round wood, sawn wood, firewood and wood chips) and bark.

Assessment

1 Introduction

Agrilus is a genus of flat-headed woodborers with species found in Asia, Australia, Europe and North America. The larvae typically feed on the cambium of trees or on the stems of vines and small woody plants. The adults have striking metallic color, and they are often referred to as jewel beetles. Several species are of economic importance in forestry, arboriculture and agriculture. About 100 *Agrilus* species are native to North America and at least 11 are present in Europe.

The native range of *A. planipennis* Fairmaire, 1888 includes parts of China, Korea, Japan, Taiwan, as well as small areas in the Far East of Russia and Mongolia. It has recently been introduced into USA, Canada and European Russia, where it is now considered a major pest and threatens ash forests. Infested wood packaging material has been suspected as the pathway for import into USA. *Agrilus planipennis* has not been detected in Norway. In Europe, *A. planipennis* is only reported from Russia, where an expanding outbreak started in the Moscow-area. Ash trees attacked by *A. planipennis* may be killed in a short time.

In October 2013 the European and Mediterranean Plant Protection Organization (EPPO) published a PRA on *A. planipennis* (EPPO, 2013b). The main conclusions were that the likelihood of entry is moderate, and the likelihood of establishment is high. Where the pest is introduced, it is likely to cause major losses, negative environmental impacts and some social effects. Long-distance spread may be via human-assisted pathways, although natural spread is also likely to happen, but at a slower rate. Where *A. planipennis* is introduced it will have massive impact, and eradication or containment will be difficult and costly, and very unlikely to be successful. Phytosanitary measures could prevent its introduction into the endangered area.

On the background of these conclusions, the Norwegian Food Safety Authority (NFSA) asked The Norwegian Scientific Committee for Food Safety (VKM) in a letter of December 10th 2013, to assess the potential for introduction, establishment and damage of the plant pest *A. planipennis* in Norway, and the effect of the risk reducing measures described in the EPPO PRA and in the EU Council Directive 2000/29 (EU, 2014). The NFSA will use the VKM risk assessment as a basis to determine whether *A. planipennis* should be regulated as a quarantine plant pest in Norway, and if specific phytosanitary actions should be taken to prevent its introduction.

VKM's Panel on Plant Health has appointed a project group consisting of three members of the panel and one external expert to make a draft assessment answering the request from the NFSA. The draft assessment was mainly conducted as contract work by the Norwegian

Forest and Landscape Institute. The assessment was adopted by the Panel on Plant Health at a meeting 22nd of September 2014.

2 Initiation of assessment

2.1 Identification of the PRA area

The PRA area is Norway.

2.2 Taxonomic position of the pest

Agrilus planipennis Fairmaire, 1888

Common name in Norwegian: asiatisk askepraktbille

Common name in English: emerald ash borer (EAB)

EPPO code: AGRLPL

The pest is an arthropod.

Class: Insecta, Order: Coleoptera, Family: Buprestidae, Genus: *Agrilus*, Species: *planipennis*.

2.3 Is the pest present in the PRA area?

No, the pest is not present in the PRA area.

2.4 Current occurrence of the pest

In addition to its native range in China, Taiwan, Mongolia, Japan, South and North Korea and Russian Far East (Haack, 2002), *A. planipennis* is introduced in the following regions:

Russia:

In Russia, there are currently 11 oblasts of European Russia with infestation records of *A. planipennis*: Moscow, Tver, Smolensk, Kaluga, Tula, Orel, Voronezh, Yaroslavl, Tambov, Ryazan, and Vladimir (Orlova-Bienkowskaja, 2013).

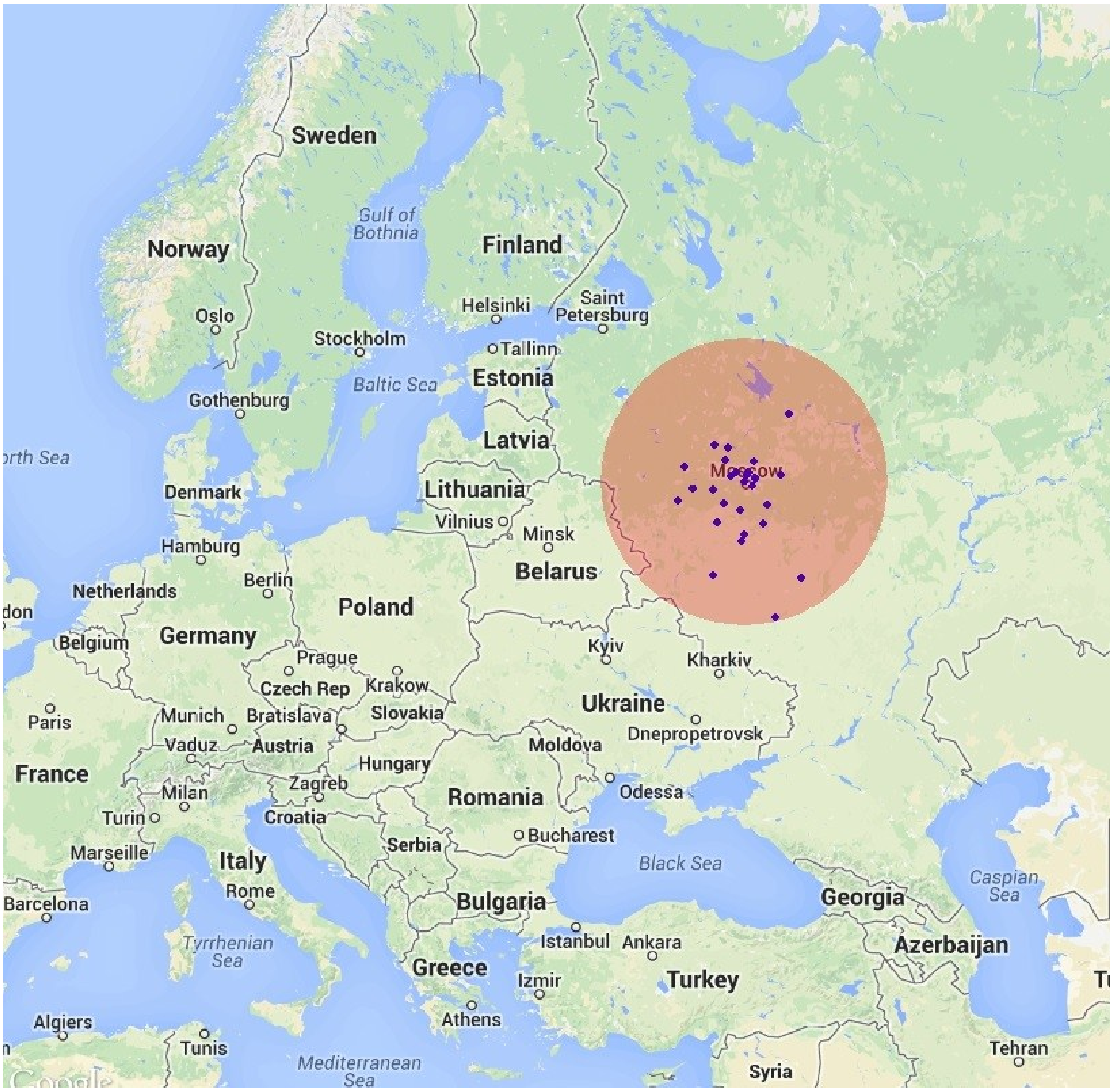


Figure 2.4-1 Confirmed infestations of ash by *A. planipennis* (blue dots) in European parts of Russia. The red circle has a radius of 466 km, and marks the distance between Moscow and Voronezh, the town furthest away from Moscow where *A. planipennis* has been confirmed. Map based on data from (Baranchikov et al., 2009; Orlova-Bienkowskaja 2013; Orlova-Bienkowskaja 2014; Straw et al., 2013)

USA:

In USA, there are confirmed records of *A. planipennis* in 23 states: Colorado, Connecticut, District of Columbia, Georgia, Illinois, Indiana, Iowa, Kansas, Kentucky, Maryland, Massachusetts, Michigan, Minnesota, Missouri, New Hampshire, New Jersey, New York, Ohio, Pennsylvania, Tennessee, Virginia, West Virginia and Wisconsin (EPPO, 2013a).

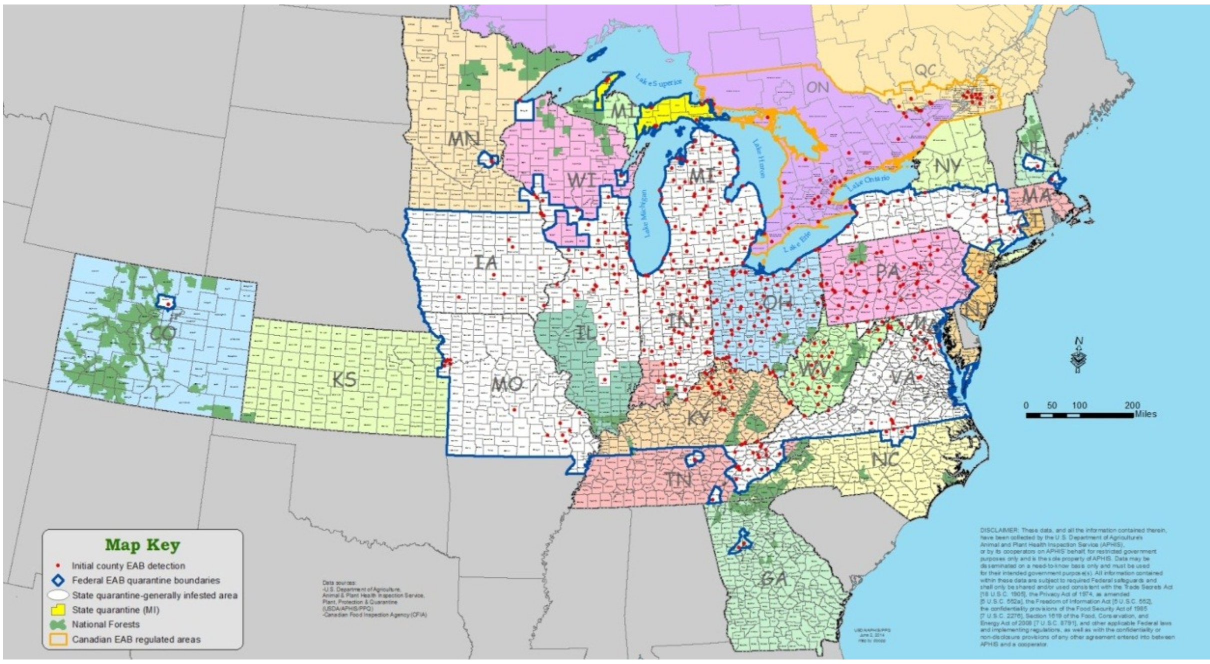


Figure 2.4-2 States in USA and Canadian provinces where *A. planipennis* is registered. Reprinted from www.emeraldashborer.info (2014) the United States Department of Agriculture Animal and Plant Health Inspection Service EAB Program.

Canada:

As of July 2013, *A. planipennis* had been confirmed in 32 Ontario counties and in seven areas in the province of Québec (EPPO, 2013a), see Figure 2.4-2.

2.5 Regulatory status

Agrilus planipennis is currently on the EPPO A2 list and the NAPPO Alert list. The species is regulated in the USA and Canada, and the EU (EU, 2014). There are currently no regulations of *A. planipennis* in Russia and the surrounding countries: Kazakhstan, Uzbekistan, Belarus and Ukraine.

2.6 Biological information

A summary of the biology of *A. planipennis* is presented in the EPPO PRA (EPPO,2013b) and in the *A. planipennis* EPPO datasheets on pests recommended for regulation (EPPO, 2005).

In North America and European Russia, *A. planipennis* exclusively attacks *Fraxinus* species (see table 2.6-1). The attacks start in the canopy of healthy trees, where eggs (length 1mm) are laid on the bark surface, and larvae (length 30–36 mm) tunnel through the bark and feed on the cambium for one or two years, eventually girdling branches and the trunk which leads to canopy dieback or death of the whole tree. The larvae bore into the wood and maximum penetration depth of the beetle is believed to be approximately 3.5 cm (Myers et al., 2009), where they pupate (pupae 13–17.5 mm in length) and spend the winter. Adults

(Imago 13 mm in length) emerge through D-shaped exit holes after accumulation of a temperature sum of 400 - 500 degree-days calculated at base 10°C (USDA, 2013). Depending on temperature and population densities, attacked trees may die within three years. At the *A. planipennis* epicenter in Michigan (USA), mortality of ash exceeds 99 %, the seed banks of ash are rapidly depleted, and ash regeneration has ceased (Klooster et al., 2014). The most common ash species in Europe *F. excelsior*, which is the only naturally occurring ash species in Norway, is attacked and killed by *A. planipennis* (Baranchikov et al., 2009).

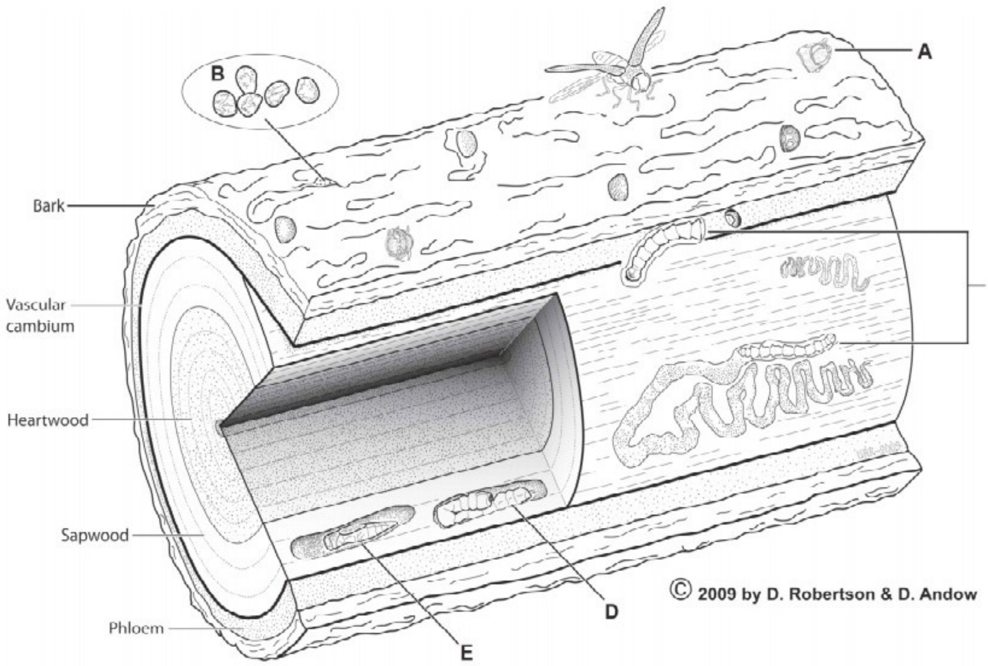


Figure 2.6-1 Cross-section of a log and the different life stages of *A. planipennis*. A: adult beetles typically emerge from ash D-shaped exit holes. B: females lay approximately 50-90 eggs during their lifetime, deposited individually in bark crevices along the phloem trunk and lower portions of major branches. C: serpentine-shaped galleries. D: prepupae about 1 cm deep into the sapwood or outer bark. E: in colder regions, development may occur with young larvae overwintering in the cambial region, completing development the following summer, and then emerging after overwintering for a second time. Fuel wood and whole wood, or logs similar to the illustration are ideal for long distance transport (Robertson et al., 2009).

Table 2.6-1 Host tree species in the native, introduced, and potential range of *A. planipennis*. Only tree hosts that are native to the respective areas are included; however, *A. planipennis* also attacks the non-native species *F. pennsylvanica* in the Moscow region and in the Russian Far East (Haack, 2002; Baranchikov et al., 2009; Rebek et al., 2008).

	Potential range		**Introduced range**		**Native range**			
Host species	**PRA area**	**Europe except Russia**	**European Russia**	**North America**	**China, Taiwan, Mongolia**	**Japan**[1]	**Korea**	**Russia Far East**
F. americana				**x**				
F. angustifolia		**x**						
F. chinensis				**x**	**x**			
F. excelsior	**x**	**x**	**x**	**x**				
F. mandshurica				**x**	**x**			**x**
F. mandshurica var. japonica						**x**		
F. nigra				**x**				
F. ornus		**x**						
F. pennsylvanica		**x**	**x**	**x**				
F. quadrangulata				**x**				
F. rhynchophylla					**x**			**x**
F. velutina					**x**			
Juglans mandshurica						**x**		
Pterocarya rhoifolia						**x**		
Ulmus davidiana						**x**		
U. davidiana var. japonica							**x**	

[1]The difference in host preferences given for Japan compared to other regions is probably reflecting that the Japanese records also include a subspecies of *A. planipennis* (*A. marcopoli ulmi*) and adult feeding on leafs of other trees than ash (EPPO, 2013b).

2.7 Relevance of EPPO's PRA

The PRA for *A. planipennis* performed by EPPO (2013b) is considered highly relevant to Norway. The information given in that PRA corresponds well with Norwegian conditions. Questions that are specific for Norway are discussed in chapter's 3.1 -3.3.of the current document. These chapters present VKM's answers to the Terms of Reference.

3 Answers to the terms of reference

3.1 Probability of entry, establishment and spread of *A. planipennis* in Norway

Question 1 in Terms of Reference: probability of entry into Norway, including an assessment of which pathways that today represent the highest probability of entry of *A. planipennis* into Norway and an assessment of the likelihood of natural spread into Norway from the areas where this species occurs today.

3.1.1 Natural spread

Rating of probability of natural spread: low

Rating of uncertainty: low

Agrilus planipennis is not expected to spread naturally from its current distribution area in Russia to Norway within the next decade. This is due to the long distance (approximately 1650 km from Moscow to Oslo) and the naturally occurring sea barriers separating Norway from continental Europe and Finland from the Scandinavian Peninsula. Within the distribution range of *F. excelsior* there is no continuous deciduous forest containing *Fraxinus* through Finland into Scandinavia, except for the numerous islands in the Åland archipelago, which could serve as stepping stones across the Baltic Sea. The shortest distance across the sea into Scandinavia is over Kattegat from Helsingør (Denmark) to Helsingborg (Sweden), approximately 5 km. According to the EPPO PRA, *A. planipennis* is not likely to spread naturally to most EPPO countries in the next decade (EPPO, 2013b).

The speed at which *A. planipennis* spreads through the land may change over time depending on climate and forest health. Occurrence of stressed or dying ash trees, infected by the ash dieback fungus *Hymenoscyphus fraxinus*, may possibly increase the spread rate of *A. planipennis.* Between Russia and the PRA area the ash dieback disease is present in Russia (Kaliningrad), Belarus, Poland, Germany, Denmark, Sweden and Norway.

3.1.2 Pathways for human-mediated spread

The pathways treated in the EPPO PRA are listed in Table 3.1.2-1, while the pathways considered to represent the highest probability of entry of *A. planipennis* into Norway in the current PRA are presented in Table 3.1.2-2. All the import statistics are listed in Appendix 1. And table 3.1.2-3 contains some terms and definitions mentioned in table 3.1.2-1 and 3.1.2-2.

Table 3.1.2-1 Lists of pathways included in the EPPO PRA, in order of importance:

Pathways considered by EPPO (in order of importance)	EPPO rating	Pest already intercepted on the pathway? Yes/No
Wood with or without bark (Includes; *round wood*, *sawn wood* and *fuel wood*)	Likelihood of entry on the pathway: moderate Uncertainty: moderate	Yes (in USA and Canada, on *Fraxinus*)
Plants for planting	Likelihood of entry on the pathway: moderate Uncertainty: moderate	Yes (in USA and Canada on *Fraxinus*)
Waste wood	Likelihood of entry on the pathway: moderate Uncertainty*:* moderate	no
Hardwood wood chips originating from where the pest occurs	Likelihood of entry on the pathway: low/moderate Uncertainty*:* moderate	Yes (in USA and Canada)
Wood packaging material	Likelihood of entry on the pathway: if treated according to ISPM No. 15 very low; if untreated, high. Uncertainty: low	No
Bark and objects made of bark	Likelihood of entry on the pathway: moderate Uncertainty: high	No
Furniture and other objects made of untreated wood	Likelihood of entry on the pathway: low Uncertainty: moderate	No
Natural spread	Likelihood of entry on the pathway from Russia into other EPPO countries: low (EPPO 2013b) Uncertainty: moderate (distribution in the European part of Russia)	No
Cut branches	Likelihood of entry on the pathway: low Uncertainty*:* moderate	No

Pathways considered by EPPO (in order of importance)	EPPO rating	Pest already intercepted on the pathway? Yes/No
Hitchhiking	Likelihood of entry on the pathway: moderate for Belarus. Uncertainty: moderate	No
Movement of live beetles	Likelihood of entry on the pathway: very low Uncertainty: low	No

Table 3.1.2-2 List of considered pathways of entry for *A. planipennis* into Norway.

HS Nomenclature - World Customs Organization	Norwegian name - Statistics Norway	Commodity code[1]	Commodity in trade	Pest already intercepted on the pathway elsewhere?
Fuel wood, in logs, in billets, in twigs, in faggots or in similar forms	Ved til brensel	44.01.1000	Yes	Yes
Wood in chips or particles: non-coniferous	Treflis el trespon av lauvtrær	44.01.2200	Yes	Yes
Wood waste and scrap, not agglomerated	Treavfall - ellers	44.01.3909	Yes	No
Wood in the rough, whether or not stripped of bark or sapwood, or roughly squared: other	Diverse tømmer, ikke av bartrær, eik, bøk, div tropiske tresorter, også avbarket el grovt tilskåret	44.03.9908	Yes	Yes
Wood sawn or chipped lengthwise, sliced or peeled, whether or not planed, sanded or end-jointed, of a thickness exceeding 6 mm: pf ash (Fraxinus spp.)	Trelast av ask, saget/kuttet i lengderetn: også høvlet/pusset/endeskjøtt, tykkelse > 6 mm	44.07.9500	Yes	No
Other live plants (including their roots), cuttings and slips; mushroom spawn: Other	Levende planter, uten klump av jord eller annet vekstmedium, i.e.n.	06.02.9010	Yes	Yes

[1] The Norwegian commodity codes (eight digits) based on the harmonized commodity description and coding system where the first six digits are incorporated in the harmonized system. These are mandatory for all countries using this system as a basis for their customs tariffs. In most cases, the seventh digit reflects national customs duty rate, and the eighth digit is used to cover e.g. national statistics.

Table 3.1.2-3 Definition and explanation of terms used in the assessment.

Definition and explanation of terms	
Commodity	a type of plant, plant product, or other article being moved for trade or other purpose
Establishment	perpetuation, for the foreseeable future, of a pest within an area after entry
Hitchhiking	pest that is carried by a commodity, but does not infest the product
Non-squared wood and bark	wood that retains some natural rounded surface. Bark may remain on the wood
Ionizing radiation	charged particles and electromagnetic waves that as a result of physical interaction create ions by either primary or secondary processes
Irradiation	treatment with any type of ionizing radiation
Other non-squared wood and bark	logs with bark, debarked logs, fire wood, sawn wood containing some natural rounded surface, isolated bark
Particle wood	chips, particles
Pathway	any means that allows the entry or spread of a pest
Plants for planting	plants intended to remain planted, to be planted or replanted
Round wood	wood not sawn longitudinally, carrying its natural rounded surface, with or without bark
Sawn wood	wood sawn longitudinally, with or without its natural rounded surface with or without bark
Squared Wood	wood from which all natural rounded surface has been removed: no wane, no bark
Waste wood	off-cuts from sawing, sawdust and shavings, scrap
Wood packaging material	wood or wood products (excluding paper products) used in supporting, protecting or carrying a commodity (includes dunnage)

Wood packing material (WPM) (including dunnage) is not included here, since this pathway is covered by the International Standards for Phytosanitary Measures No. 15 (IPPC, 2013). There are no reported interceptions of *A. planipennis* on wood packing material. With low uncertainty, EPPO rated the likelihood of entry on the pathway WPM as very low if treated according to ISPM No. 15, and high if untreated. The pathway for introduction of *A. planipennis* into USA is believed to be WPM from China, but this is not known for certain (Herms & McCullough, 2014). The standard ISPM no.15 includes rules for heat treatment of all WPM at 56°C for 30 min, which will kill most insects (IPPC, 2013). A recent review has shown that *A. planipennis* can survive at temperatures exceeding 56°C for 30 min, and EFSA recommends at least 70°C for 60 min (EFSA, 2012).

According to Izhevskii and Mozolevskaya (2010), *A. planipennis* was most probably brought to Moscow at the beginning of the 1990s with planting material from North America. The ongoing spread across North America has largely been facilitated by movement of fuel wood and plants for planting (Haack, 2006; Haack et al., 2010). Other potential pathways, as for example bark and bark products, furniture, and cut branches, will not be considered here due to absence of interceptions globally, and a low-moderate probability of association of the pest with the pathway in the EPPO PRA.

In Canada, regulated import commodities include ash nursery stock, ash trees, ash logs, ash wood, rough lumber (including pallets and other wood packaging materials containing ash, wood, bark, wood chips or bark chips from ash trees), and fuel wood of all tree species (CFIA, 2013). The most high-risk commodities for import of *A. planipennis* into Norway are wood where bark is still present, like fuel wood, wood chips, plants for planting, wood in the rough and saw logs.

3.1.2.1 Fuel wood

Likelihood of entry on the pathway: low-moderate

Rating of uncertainty: low

Mixed fuel wood may consist of a variety of tree species, including ash wood that can be infested by *A. planipennis*. Therefore, import of mixed fuel wood from Russia is not safe. *Agrilus planipennis* is found in a large area of European Russia and is expected to reach Belarus within the next decade and may spread further to surrounding countries.

Apparently, little or no mixed fuel wood containing ash was imported into the PRA area in the past ten years. The two largest importers of fuel wood from Russia, "ABG Varme AS" and "UMAS Ulf Mediaas AS" only import fuel wood of birch. Summarized approximate statistics collected from the two above mentioned importers indicate that they account for the majority of the bulk import the past few years. According to "UMAS Ulf Mediaas AS", their yearly import has been approximately 3000 metric tons of birch wood from Russia on average during the past five years, but the import has been as high as 5000 metric tons for individual years. The average import for "ABG Varme AS" has been approximately 10000 metric tons per year, but in 2012 and 2013 the numbers exceeded 11000 metric tons. According to the official statistics of Norway the average yearly import during the past five years was 12052 metric tons, indicating that few other than the two companies referred to above contributed to the import of fuel wood to Norway.

It has been a considerable import of fuel wood from Russia, and this import showed a strong growth from 2004 until 2011 (Figure 3.1.2.1-1). The commodity code of fuel wood does not distinguish between tree species. According to the distributors, the current import of fuel wood from Russia contains only birch. However, as demonstrated in analyses of international trade of timber import and other wooden products, the volume and type of wooden commodities is a question of offer and demand in the market and may quickly change (Piel et al., 2007; Økland et al., 2012). Therefore, it cannot be excluded that future imports of fuel wood may contain mixed fuel wood. Furthermore, it is feasible to distinguish birch wood from other tree species due to its characteristic bark color pattern.

Import of fuel wood including host species of *A. planipennis* represents an efficient mechanism for introduction and spread of *A. planipennis* in the PRA area. Fuel wood is widely distributed by end users, and fuel wood is often stored outdoors, where the pest easily can spread to neighboring forests. Most of the evidence suggests that the major pathway for movement of *A. planipennis* within North America has been fuel wood (Robertson & Andow, 2009). The risk associated with imports of fuel wood of birch from Russia is unknown, but there is a considerable risk associated with the import of fuel wood of birch from North America due to the possible introduction of the bronze birch borer, *Agrilus anxius* (VKM, 2012). There are only small amounts of fuel wood being imported from North America (Appendix I), and it is unknown if this is pure birch fuel wood or mixed fuel wood, possibly containing ash.

The likelihood of entry of *A. planipennis* on the pathway of fuel wood is set as low based on the import statistics for the past ten years, but this may quickly change from low to moderate if the import of ash or mixed fuel wood increases.

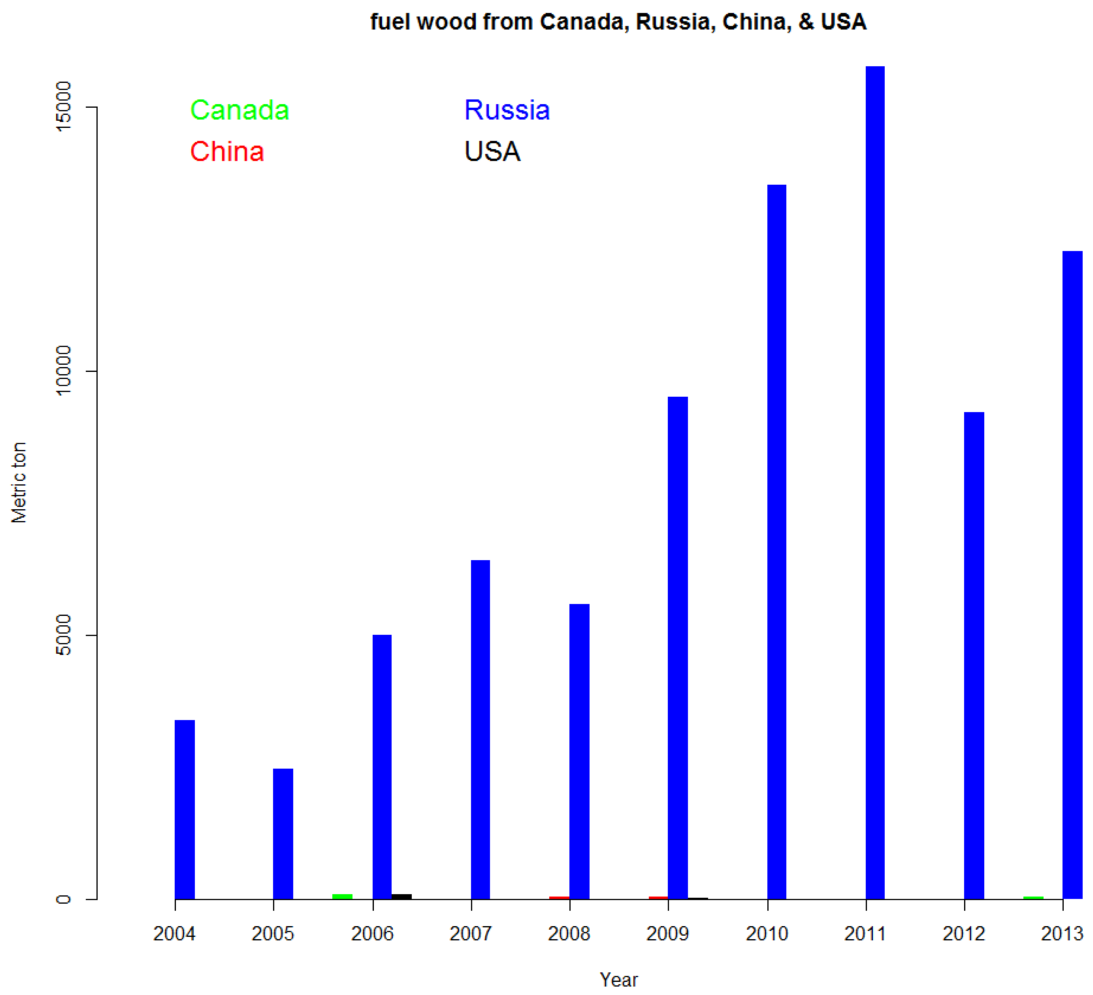


Figure 3.1.2.1-1 Fuel wood (44.01.1000) imported during the past ten years from Canada, China, Russia and USA. Data from Statistics Norway (www.ssb.no).

3.1.2.2 Wood chips

Likelihood of entry on the pathway: moderate

Uncertainty: moderate

Wood chips of ash is a pathway for *A. planipennis*, since this insect has been demonstrated to survive wood-chipping (McCullough et al., 2007), and the import volumes of deciduous wood chips may be large. The frequency of *A. planipennis* in this pathway is expected to vary with the particle size due to the survival rate during the chipping process. Also, decreasing quality of the raw material used for chipping is expected to result in a higher frequency of *A. planipennis* in the pathway.

Hardwood wood chips have been imported to Norway in the recent years. According to Appendix 1 (Trade of wood waste, scrap wood, and hardwood wood chips from countries where *A. planipennis* occurs) 66.280 metric tons of hardwood wood chips were imported to Norway from Canada in 2010 and ambitions of increased bioenergy production may lead to large import volumes of hardwood wood chips in the future. The ambition of the Norwegian Government is to double the bioenergy production during the period 2008-2020. Also *Fraxinus* wood was included in this mixture of hardwood wood (VKM, 2013 and references therein).

There is an uncertainty about the proportion of ash in the volumes of imported hard wood chips and wood waste. There is also a lack of information about the quality of the imported wood chips. If the imports contain much wood waste from the range area of *A. planipennis*, the low quality wood may potentially contain a high concentration of *A. planipennis*. Volume and frequency of imports throughout the year may be relevant for timing with the phenology of *A. planipennis*, but also this information is lacking in the statistics. The statistics do not inform about storage time before export, which may affect the risk of *A. planipennis* import. Furthermore, changes of names and commodity code have added to uncertainty in the import statistics of these commodities* (* see Table 3.1.2-2 above).

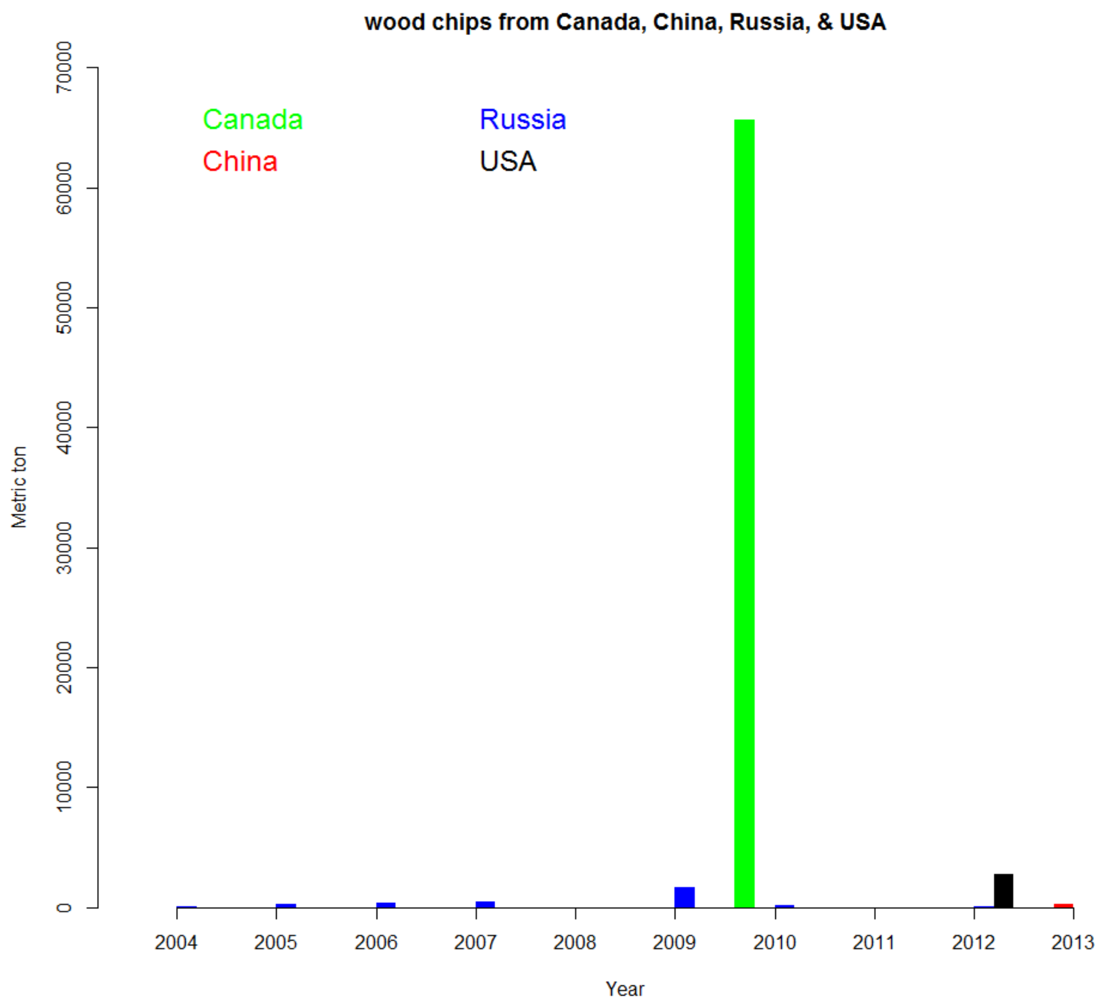


Figure 3.1.2.2-1 Wood chips (44.01.2200) imported during the past 10 years from Canada, China, Russia, and USA. Data from Statistics Norway (www.ssb.no).

3.1.2.3 Waste wood - Other

Likelihood of entry on the pathway: low

Uncertainty: moderate

The commodity code 44.01 includes a variety of wooden items, i.e. "wood in chips or particles; sawdust and wood waste and scrap, whether or not agglomerated in logs, briquettes, pellets or similar forms". Under this code, the sub number 3909 ("other") comprises waste and scrap of conifers and deciduous trees not suitable for timber.

This commodity code may include ash wood with bark and other wooden items that can host *A. planipennis*. Figure 3.1.2.3-1 shows that the import of waste wood (44.01.3909) from countries where *A. planipennis* is present has been large in most years during the last ten years. However, the uncertainty is set as moderate due to lack of knowledge about the actual content of the items listed under this commodity code.

Particles of waste wood are much bigger in size than wood chips and could therefore pose an even higher risk than wood chips. Waste may be of lower quality than wood chips and includes wood chunks for use in wood industry. Waste is usually not screened and is not reported under the custom codes for trade. Earlier attempts to trace wood chunks have failed, but the industry confirms to have imported wood chunks from unknown origins.

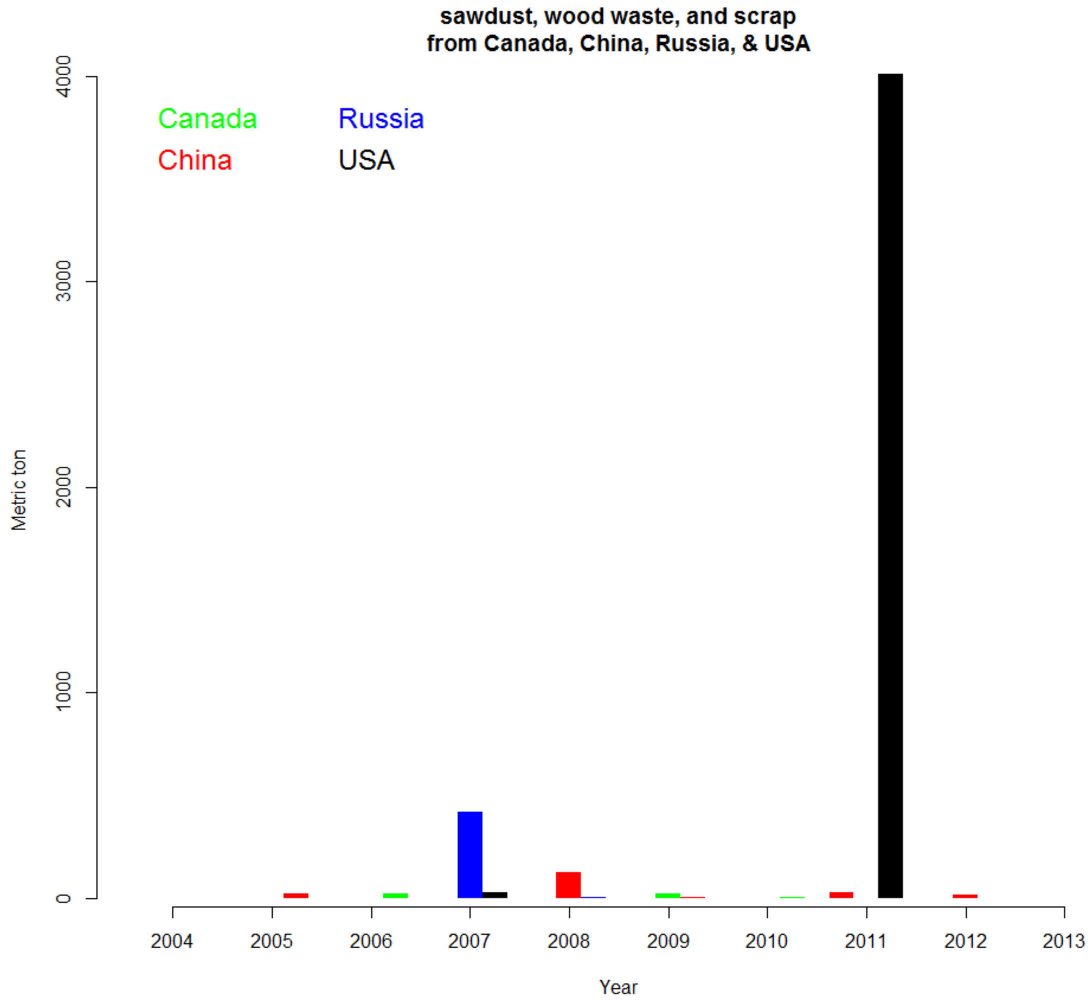


Figure 3.1.2.3-1 Sawdust, wood waste, and scrap (44.01.3909) imported during the past ten years from Canada, China, Russia, and USA. Data from Statistics Norway (www.ssb.no).

3.1.2.4 Wood in the rough

Likelihood of entry on the pathway: moderate

Uncertainty: moderate

Wood in the rough (commodity code 44.03) is defined as wood, whether or not stripped of bark or sapwood, or roughly squared, and ash that could contain *A. planipennis* would fall in the sub category "other" (commodity code 44.03.9908). This sub category may contain ash, but the custom statistics does not reveal the proportional content of ash in this commodity category. Furthermore, the custom statistics do not reveal whether the commodity comes from a pest-free area or not within the respective countries.

Wood in the rough of deciduous trees has been imported almost annually from Russia and the United States to the PRA-area during the past ten years. Whole ash logs with bark would be an ideal substrate for *A. planipennis*, and one log with bark could contain hundreds of beetles (McCullough et al., 2009). Also roughly cut logs without bark may pose a threat when the outer sapwood is not removed, and especially when the wood includes edges with strips of bark. The import statistics of wood in the rough (44.03.9908) from Russia and the United States shows significant changes between years. Trade of timber and other wood commodities is known to be particularly dynamic in space and time (Piel et al., 2007; Økland et al., 2012). Large volumes of ash under this commodity code may be imported from Russia in the future, since this country is one of the leading exporters of timber in the world.

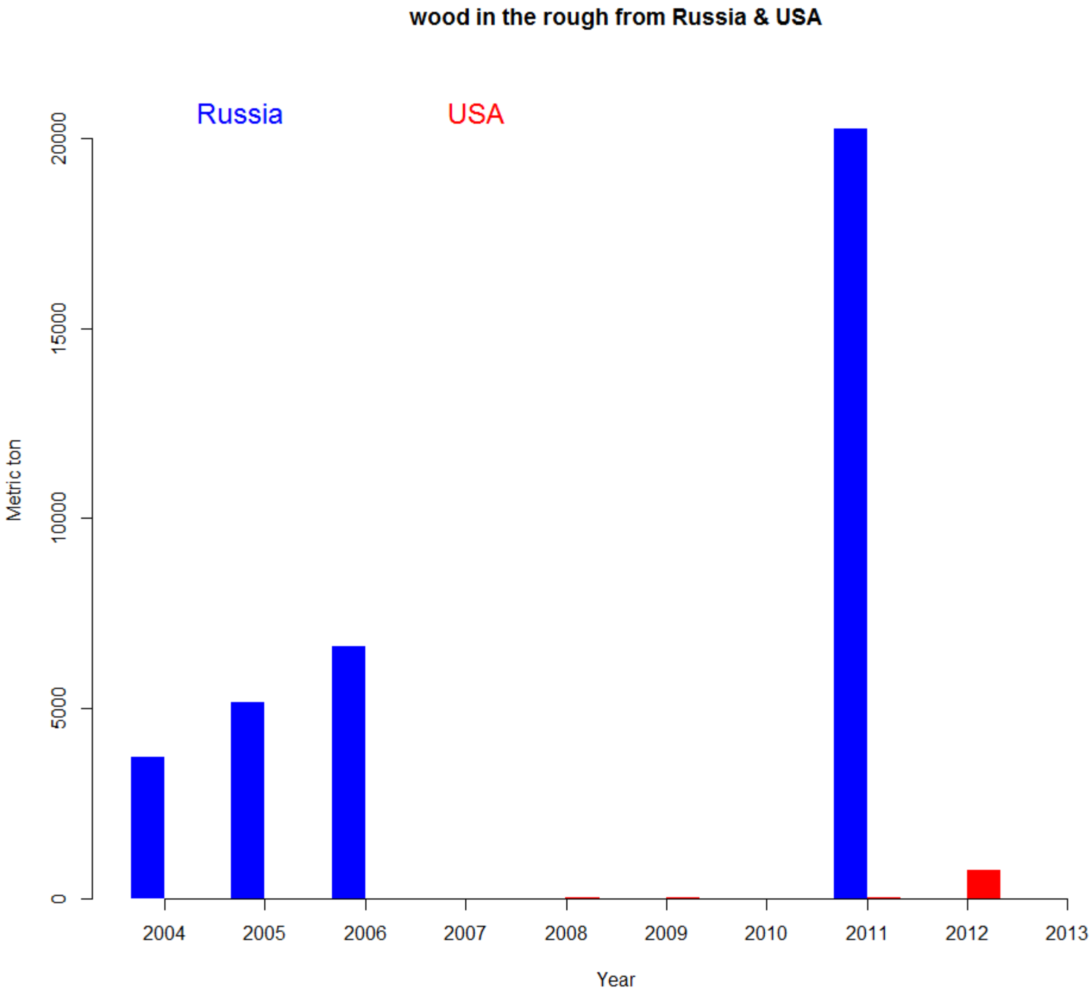


Figure 3.1.2.4-1 Wood in the rough imported during the past ten years from Russia and USA. Data from Statistics Norway (www.ssb.no).

3.1.2.5 Wood sawn or chipped lengthwise; of ash

Likelihood of entry on the pathway: low

Uncertainty: moderate

Wood sawn or chipped lengthwise, sliced or peeled, whether or not planed, sanded or end-jointed, of a thickness exceeding 6 mm; of ash, contains beams, planks, furring strip, etc. as well as items equivalent to sawn timber, and which is prepared by use of chipping machines. All products exceed 6 mm in width, can be very long, and are sawn or chipped, sliced or peeled along the fiber direction.

We assume that most of these products have accurate dimensions, and their surfaces are smoother than products fabricated only by sawing. This commodity code also includes wood and parquet flooring.

All products under this commodity code are processed; however, it is uncertain how much bark and phloem they could contain. It cannot be excluded that some commodities contain pieces of phloem and sapwood suitable for pupae of *A. planipennis* despite the requirements of surface treatment. In general, the description of this commodity code makes it hard to know the exact content and treatments included. Harmonized System (HS) nomenclature descriptions (World Customs Organization, 2014) giving extended descriptions are supposed to give more information; however, these are not available for free on the internet. From areas where *A. planipennis* occurs, the largest import was from USA in 2011, while smaller amounts arrived the PRA area in the other years (Figure 3.1.2.5-1).

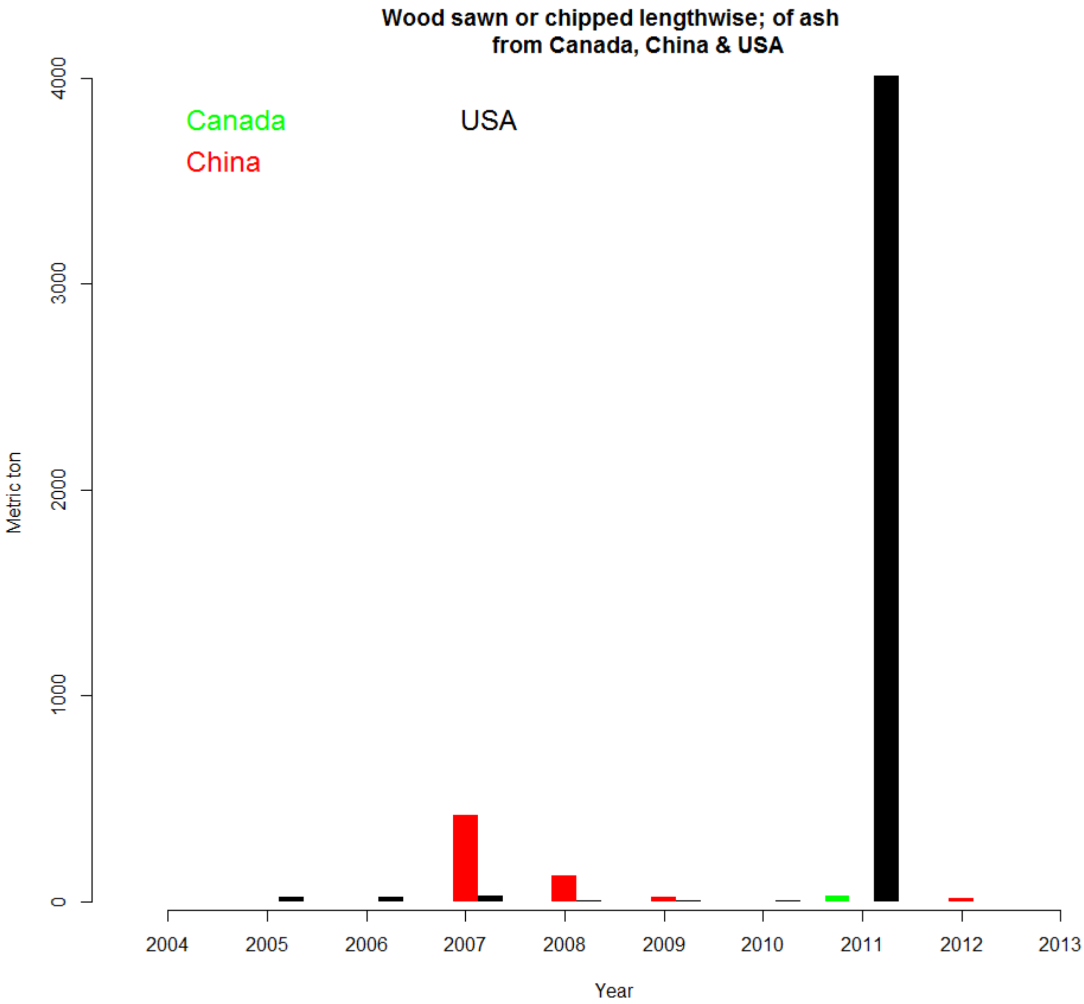


Figure 3.1.2.5-1 Ash wood sawn or chipped lengthwise (44.07.9500) during the past ten years, from countries where *A. planipennis* is present. Data from Statistics Norway (www.ssb.no).

3.1.2.6 Plants for planting

Likelihood of entry on the pathway: moderate

Uncertainty: moderate

The imports of *Fraxinus* spp. plants for planting (commodity code 06.02.9010) from areas where *A. planipennis* occurs is partly limited by the current regulations on ash dieback "Forskrift om tiltak mot askeskuddsopp" (Mattilsynet, 2008).

Section two in the Norwegian Customs Tariff deals with organic material and chapter 06.01 covers only live trees and goods including seedling vegetables (Sic.) of a kind commonly supplied by nursery gardeners or florists for planting or for ornamental use. In chapter six, commodity code 06.02.9010 plants for planting, live trees (Levende planter, uten klump av jord eller annet vekstmedium) contains trees that have been stored outdoors in the country of origin. These are perennial trees or bushes imported without balled roots or other culture media or with balled roots or other culture media, including stocks. As there is no further resolution in the codes it is impossible to separate tree species.

An assessment of import statistics on plants for planting (Commodity code 06.02.9021 (The commodity codes containing living trees have changed names several times the past years)) from 1997 until 2011 shows that 99% of the imports came from five countries: The Netherlands, Germany, Denmark, Belgium and Great Britain. In the same period only 2.1 metric tons came from the USA, 0.9 tons from China and 0.4 tons from Canada (Hagen et al., 2012). If any of the above mentioned shipments contained *Fraxinus* spp. is unknown. From 2004 to 2013 there was only one shipment of plants for planting from countries where *A. planipennis* occurs. This was a consignment from USA in 2013, which did not contain *Fraxinus* spp. According to data from NFSA, since 2011 there have been 20 imported consignments of *Fraxinus* for planting from five European countries (Table 3.1.2.6-1)

Table 3.1.2.6-1 Imports containing *Fraxinus* spp. in the period 01.01.2011- 29.8.2013 (data NFSA personal communication)

Land of origin	Number of shipments
Belgium	1
Denmark	3
Sweden	5
Netherlands	11
Total	20

3.2 Probability of establishment and of further spread after an establishment in Norway

Question 2 in Terms of Reference: probability of establishment and of further spread after an establishment in Norway.

3.2.1 Probability of establishment in the PRA area

Likelihood of establishment: high

Uncertainty: low

Agrilus planipennis is already established in North America and in the European part of Russia, and the pest is spreading. In European Russia this species has been recorded 466 km from its epicenter in Moscow (Baranchikov et al., 2009; Orlova-Bienkowskaja, 2013; Orlova-Bienkowskaja, 2014; Straw et al., 2013). According Straw et al. (2013), *A. planipennis* is believed to be a short distance from the border with Ukraine. There is a large trade of wood from countries in this region to Western Europe. Such trade may also include waste, wood chunks, and commodities potentially infested by *A. planipennis*.

The PRA area has the host plants, suitable habitats and climatic conditions to support establishment of the pest. Intrinsic biological features such as a two-year development time, high fecundity and the potential for long distance dispersal will increase the probability of establishment in the PRA area. Competition, natural enemies, the lack of alternate hosts, and the managed environment are not considered being factors that will significantly influence establishment in the PRA area. In managed areas like central Oslo *F. excelsior* is the dominant ash species. Existing management practices in urban areas such as parks, urban forests and gardens will not prevent establishment of *A. planipennis*.

3.2.2 Probability of spread after establishment in the PRA area

Likelihood of spread: high

Uncertainty: moderate

Flight distance of *A. planipennis* is dependent on availability and densities of host trees. When ash trees are available, the spread is minimal, and most adults would fly less than 100 m. Mercader et al. (2009) found that spread pattern follows a negative exponential function with 100% and 97.8% of females ovipositing on trees within 300 meters within the two emergence points. However, when ash trees are scarce, the flight distance is expected to be longer. *Agrilus planipennis* is a strong flyer, and a flight mill experiment by Taylor et al. (2010) showed that average flight distance was >3km, with 20% of mated females able to fly >10 km in 24 h, and 1% > 20 km. In addition to biological spread, movement of fuel wood and logs may aid long-distance spread of *A. planipennis* after establishment. In Russia

A. planipennis has moved on average 30-40 km per year in a four year period, which cannot be explained by flight activity alone (Straw et al., 2013).

Delayed detection may favour spread of *A. planipennis*. Upper portions of the canopy of large trees are typically colonized before the main trunk, which makes it difficult to detect early infestations (Herms & McCullough, 2014).

3.2.3 Host plants and suitable habitats

Fraxinus excelsior is wide-spread in Norway. It is most common in eastern Norway, in the counties of Østfold, Akershus, Oslo, Hedmark, Oppland, Buskerud, Vestfold, and Telemark, up to 720 masl. This host species is also naturally occurring along the cost, north to Nærøy, Nord- Trøndelag County, and it is planted as far north as Steigen, Nordland County (Lid et al., 2005).

We may expect that weakened ash tree may be more susceptible to attack by *A. planipennis* than healthy ashes. Ash dieback (*H. fraxineus*) is currently a widespread pathogen on *F. excelsior* in Norway (Hietala et al., 2013). At present ash dieback has reached Ørskog in Sunnmøre and Rauma in Romsdal (H. Solheim, pers. comm.). Presence of this pathogen may possibly increase the spread rate of *A. planipennis.*

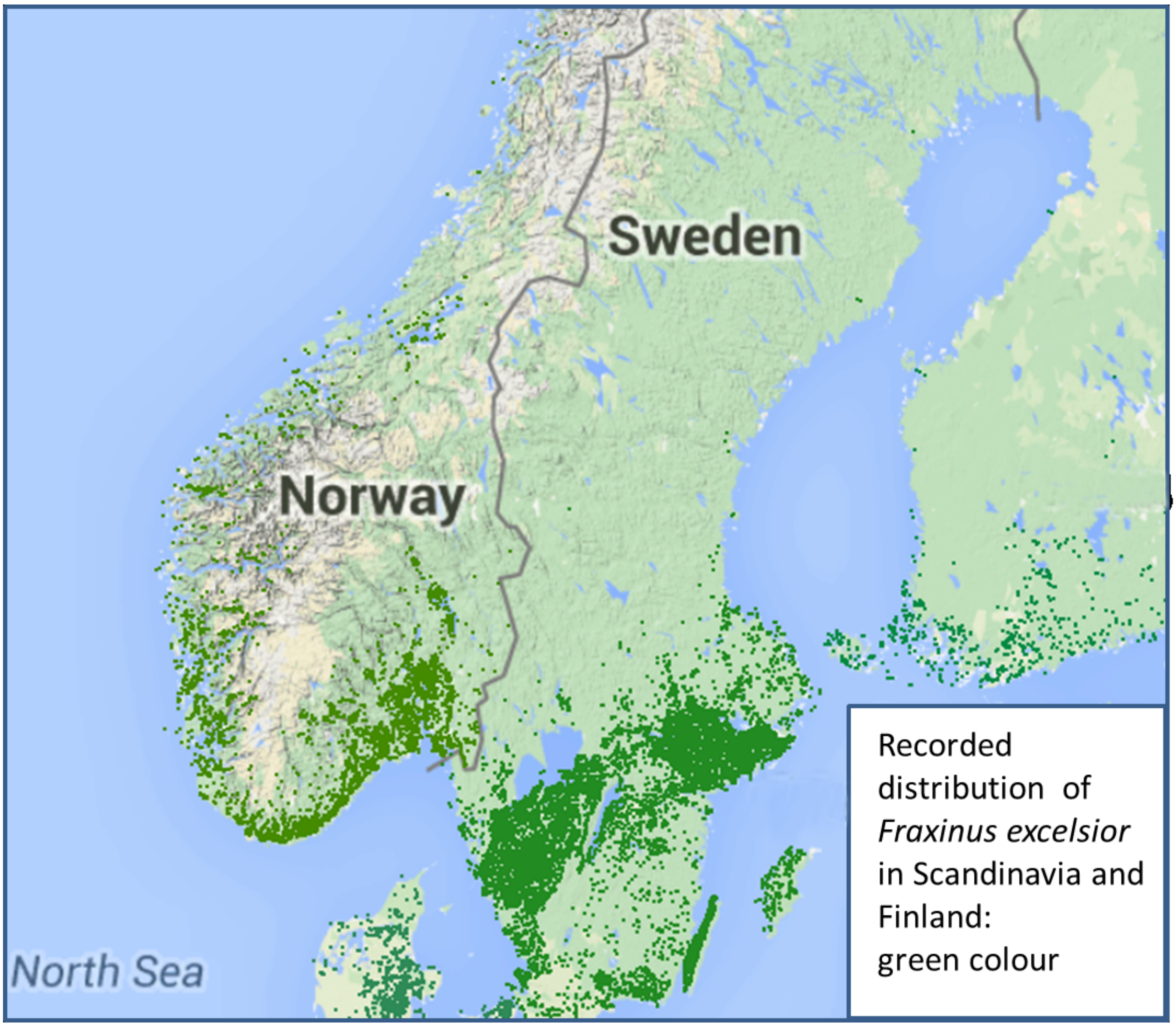


Figure 3.2.3-1 Distribution of *Fraxinus excelsior* (green dots) in Scandinavia and Finland (Data from GBIF, 2014).

3.2.4 Hosts and other essential species

Other species of *Fraxinus*, such as *F. pennsylvanica*, and *F. americana*, are found only as single trees in some parks in Norway (e.g. at the Norwegian University of Life Sciences (NMBU) in Ås www.nmbu.no). These few alternate host trees are not expected to have any significant influence on the establishment of *A. planipennis* in Norway.

3.2.5 Climate suitability

Likelihood of suitability: moderate

Uncertainty: moderate

There are areas of suitable climate within the PRA-area (Figure 3.2.5-1). The most important abiotic factor is temperature. *Agrilus planipennis* prepupae are freeze-intolerant, but accumulate glycerol and other antifreeze agents in the hemolymph and have a low supercooling point at -30°C (Crosthwaite et al., 2011). They can, therefore, survive ambient winter temperatures beneath -30°C. The coldest temperatures in Norway occur in January, when *A. planipennis* is overwintering beneath the bark. Some areas where *F. excelsior* occurs can probably have periods below -30°C, but these events will be rare and are unlikely to last for prolonged periods. Since the pupae overwinter under the bark at any part of the tree, this species has the possibility of surviving during cold winters by being located in a trunk section where the bark is protected by a snow cover. In accordance with the EPPO PRA (EPPO, 2013b), *A. planipennis* is assumed to be limited by the distribution of its host in Norway rather than by climate conditions.

In USA, *A. planipennis* adults begin emerging after the accumulation of 400-500 degree days above 10°C (USDA, 2013; USDA, 2014). In Ann Arbor, Michigan, peak emergence was between June 13th -19th 2003 within the degree-day range of 471-584 with a base temperature of 10°C (Brown-Rytlewski & Wilson, 2004) As an example, degree days basal temperature of 10°C at the NMBU, Ås in the period 15.06.2012 to 31.05.2013 was 509 degree days. Total degree days in 2012, 2011 and 2010 were 516, 618 and 559 respectively. The map in Figure 3.2.5-1 is displaying areas with DD10 above and below 450 degree-days based on average climate data from the 1961-1990.

In the northern part of the distribution of *F. excelsior* in the PRA-area, *A. planipennis* will probably be limited by low summer temperatures rather than mortality during cold winters. The development of *A. planipennis* at high latitudes and altitudes would require a two-year life cycle due to low average temperatures require.

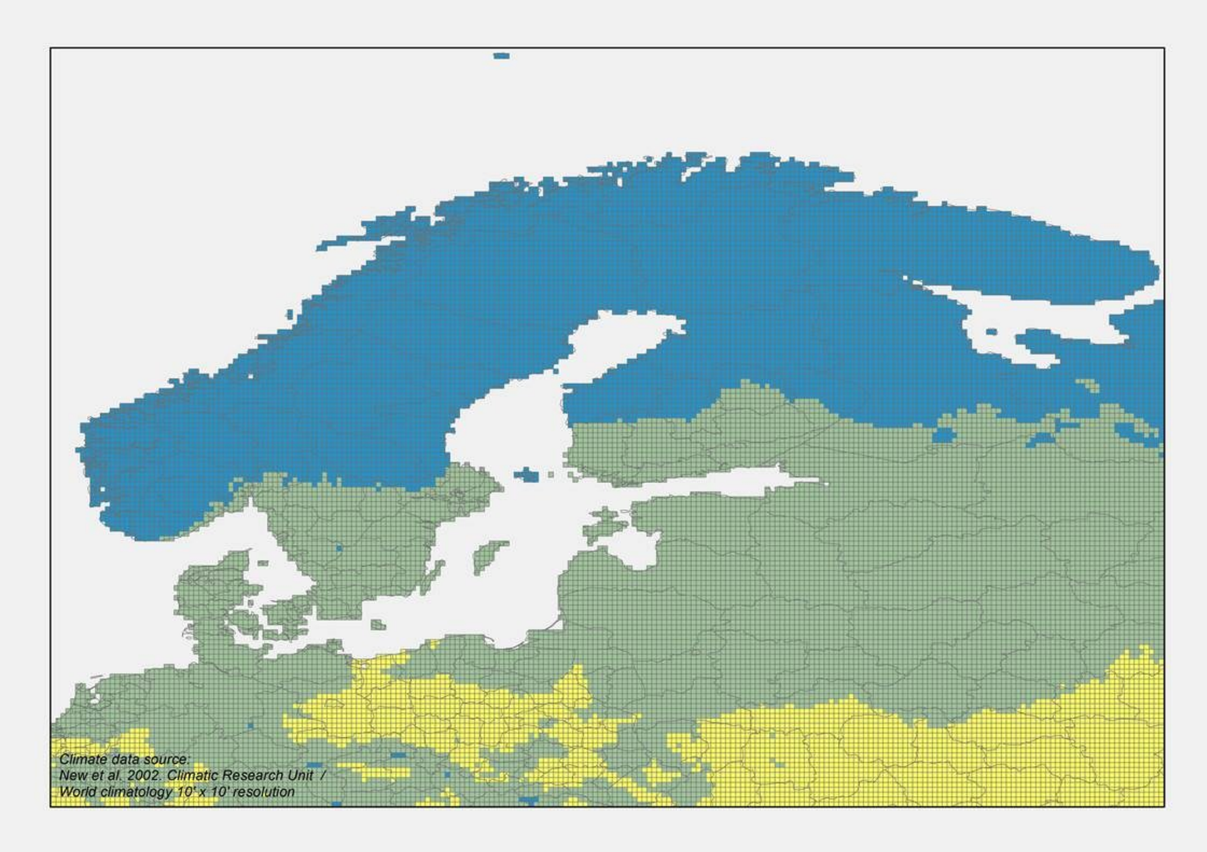


Figure 3.2.5-1 Map of degree days above 10°C in Scandinavia and neighbouring countries in Northern Europe. Blue colour show areas below 450 degree days above 10°C, green and yellow colour present areas above 450 degree days where *A. planipennis* will develop. Green colour shows areas with 450 – 933 degree days, and yellow shows 933 – 1407 degree days.

Comparison of the calculated degree day map for *A. planipennis* in Figure 3.2.5-1, with the actual distribution of *F. excelsior* in Figure 3.2.3-1, reveals that the distribution of *F. excelsior* approximately follows the green areas with 450 – 933 degree days through Finland and Sweden, but not in Norway. The degree day map is based on data from New et al. (2002), global 10-minute resolution climate database 1961-90 average, equaling 18.6 km x 18.6 km tiles. These tiles are however too large to show the large variations between local temperatures within a grid cell due to the highly complex topography along the west coast of Norway (Storlie et al., 2014). There are localities with warmer local climate than the average of each tile where *F. excelsior* is present. It is therefore likely that the distribution of *F. excelsior* is a more useful predictor for the potential spatial distribution of *A. planipennis* in Norway.

Considering both precipitation and temperature, they are not expected to be factors preventing establishment. The interaction between photoperiod and decreasing temperature which determines the phenology of ash could be more critical for establishment further north. The climate within the range areas of *A. planipennis* is slightly different from the PRA area (Figure 3.2.5-2). In the Tianjin Municipality (China), where *A. planipennis* occurs naturally, the annual average temperature is 12.1°C (max 40.3°C, min –20.3°C) and annual rainfall of 500-700 mm. *Agrilus planipennis* has expanded its ranges vastly within the continental climate zones. The two areas where *A. planipennis* first established in North America (Michigan) and Europe (Moscow region) have similar climates (precipitation and temperature). Detroit, Michigan has a humid continental climate with severe winters, no dry season, hot summers and strong seasonality (Köppen-Geiger classification: Dfa Appendix 2) (Peel et al., 2007). The annual average temperature is 9.2°C and total annual precipitation averages 828.5 mm. Moscow has a humid continental climate with severe winters, no dry season, warm summers and strong seasonality (Köppen-Geiger classification: Dfb Appendix 3) (Peel et al., 2007). The annual average temperature is 5°C and the total annual precipitation averages 689.2 mm. Oslo has a humid continental climate with severe winters, no dry season, warm summers and strong seasonality (Köppen-Geiger classification: Dfb Appendix 3) (Peel et al., 2007). The average annual temperature is 5.7°C. and total annual precipitation averages 763 mm. The three areras are similar, Oslo has the warmest winters and the coldest summers, and a somewhat lower precipitation than Detroit.

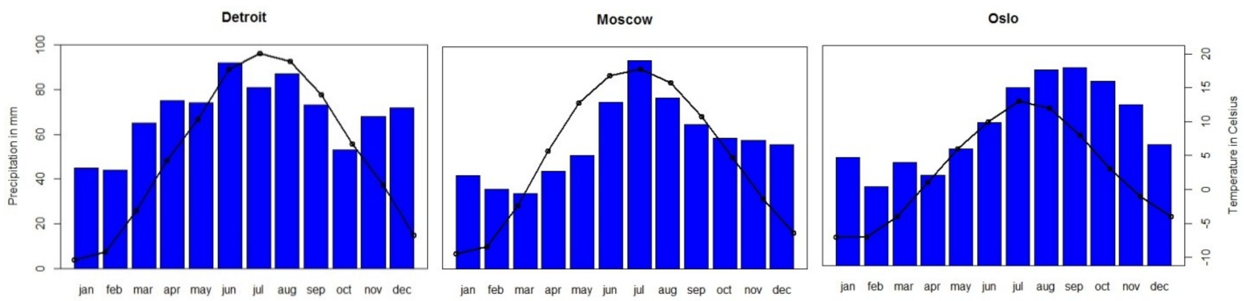


Figure 3.2.5-2 Weather charts comparing precipitation and temperatures from two of the cities where *A. planipennis* first established and Oslo. Bars show average precipitation per month in mm and lines show average temperature in Celsius (data from www.climatemps.com)

3.2.6 Other abiotic factors

It could be speculated that photoperiod at the high latitudes in Norway could affect life cycle synchrony and thus be a limiting factor for establishment of *A. planipennis*. This is however unlikely when we consider the distribution of this species. The broad distribution of *A. planipennis* suggests that it may be adapted to colonize a wide geographic range in Europe, as long as suitable host species are present. Norway lies further north than all of the source areas in North America, but the latitudes of the northernmost spreading points to the north of Moscow (Figure 2.4-1) are comparable to those of the southern part of Norway. The influence of the photoperiod on the phenology of its host, *F. excelsior,* is not expected to be important. The life cycle of *A. planipennis* is not dependent on the flowering time of its host tree.

3.2.7 Competition and natural enemies

Likelihood of effect: low

Uncertainty: low

Competition and natural enemies are not expected to stop establishment or spread of *A. planipennis* in the PRA-area. Two wood-boring beetles, larch elm bark beetle (*Hylesinus crenatus* Fabricius, 1787: Norwegian: stor askebarkbille), and ash bark beetle (*Hylesinus varius* Fabricius, 1804; flekket askebarkbille), and one defoliating wasp ash sawfly (*Tomostethus nigritus* Fabricius, 1804; askebladveps) feed on *F. excelsior* in Norway. These three species are of little or no economic importance. To what extent these species will have an effect on *A. planipennis* is unknown. If they should have any effect due to interactions, it is not expected to prevent establishment or spread of *A. planipennis*. There are no known parasitoids on *A. planipennis* present in Norway. In its native range in Asia, *A. planipennis* has several known potential competitors (e.g. the bark beetles *Hylesinus holodkovskyi*, *H. laticollis* and *H. fraxini*) and parasitoids (e.g. *Oobius agrili*, *Tetrastichus planipennisi*, *Spathius depressithorax*, *S. generosus, S. agrili, Sclerodermus pupariae and Deuteroxorides orientalis*) (Liu et al., 2007; Yang et al., 2014), whereas in North America it has only one known parasitoid, *Atanycolus cappaerti* (McCullough et al., 2009) and in the European part of Russia there are so far no known parasites. Generalist predators like woodpeckers are known to forage for *A. planipennis*, but are probably not efficient enough to stop establishment. An extensive amount of work in classical bio control has been done in North America on mass-rearing and release of parasitoids to reduce the populations of *A. planipennis*, but the impact of these species on the populations of *A. planipennis* is not yet known (EPPO, 2013b). These parasitoids are not present or have been tested for in Norway.

3.2.8 Endangered area within the PRA area

The whole area where *Fraxinus excelsior* is distributed in Norway (Østfold, Akershus, Oslo, Hedmark, Oppland, Buskerud, Vestfold, Telemark, Aust-Agder, Vest-Agder, Rogaland, Hordaland, Sogn og Fjordane, Møre og Romsdal and Sør-Trøndelag) is an endangered area. The distribution of F. *excelsior* in Norway (Figure 3.2.3-1) is expected to be the limiting factor for *A. planipennis*, and not the temperature.

Potential damage is expected to be high in the endangered area of uncultivated plants, since *Fraxinus excelsior* is widely occurring in Norway.

3.2.9 Potential impacts of an establishment of *A. planipennis* in Norway

Magnitude of impact: high

Uncertainty: low

Agrilus planipennis kills *F. excelsior* within a few years after infestation. The ecological impact of the tree mortality of wild ashes (*F. excelsior*) is expected to be significant, while the economic cost of such mortality is unknown for the PRA area. The costs of the invasion of *A. planipennis* in USA, including monitoring and control measures, are estimated as high (Kovacs et al., 2010). There is also expected to be a cost due to attacks on cultivated ashes, but an estimate of total cost is not available. In US, the highest costs due to *A. planipennis* are associated with removal and replanting of urban trees (Kovacs et al., 2010).

It is expected that *H. fraxinus* (ash dieback) will favor tree-killing by *A. planipennis.*

3.3 Potential damage

Question 3 in Terms of Reference: Potential damage on cultivated plants, public greenery and uncultivated plants in Norway (in particular on Fraxinus excelsior).

The questions of potential damages are overlapping with the ISPM 11 questions of probability of establishment and of further spread.

The answers of the 3rd question under the terms of reference are therefore placed in the previous section.

3.4 Efficiency of the risk reducing measures

Question 4 in Terms of Reference: Effectiveness of the risk reducing measures described in EPPO PRA and in EU Council Directive 2000/29 Annex IV Part A, Section I, point 11.4, 2.3, 2.4 and 2.5, related to the import of plants for planting, wood (round wood, sawn wood, firewood and wood chips) and bark.

Risk-reducing measures related to import of plants for planting, wood (round wood, sawn wood, firewood and wood chips) and bark are given both in the EPPO PRA for *A. planipennis* and in Annex IV Part A, Section I, point 11.4, 2.3, 2.4 and 2.5 of the EU Council Directive 2000/29. The measures given by these documents are to a large extent overlapping, and they apply for plants, plant products and other objects from wood of *Fraxinus* L., *Juglans ailantifolia* Carr., *Juglans mandshurica* Maxim., *Ulmus davidiana* Planch. and *Pterocarya rhoifolia* Siebold & Zucc originating from where *A. planipennis* occurs (see Appendix 1).

These measures are with only few exceptions applicable for the PRA area of Norway. The applicable measures are not repeated here, and the following text is focused on measures that are not regarded as reliable in the current PRA, or may need further discussions and modifications.

3.4.1 Squaring of wood

Conclusion: removing 2.5 cm of the outer sapwood is regarded as an uncertain measure and an extension to at least 3.5 cm is suggested

Uncertainty: moderate

Both the EPPO PRA (EPPO 2013b) and the new EU Council directive (EU, 2014) state the same requirement about removing sapwood during squaring of wood: "the bark and at least 2.5 cm of the outer sapwood are removed in a facility authorized and supervised by the national plant protection organization". This is regarded as a better measure against *A. planipennis* than the former formulation: "is squared so as to remove entirely the round surface" (EU, 2000), because beetles pupating into the wood may possibly survive in squared corners close to the log surface, especially when remnants of bark near corners are left after squaring. It is therefore recommended to remove all bark and most of the outer sap wood of *Fraxinus* (Haack & Petrice, 2009).

According to McCullough et al., (2007) and CABI (2014), most larvae overwinter as prepupae about 1 cm deep in the sapwood or outer bark. However, the maximum penetration depth of *A. planipennis* is uncertain. A depth of 3.5 cm may be necessary to ensure complete freedom from prepupae and pupae of *A. planipennis*. Thus, due to the uncertainty about penetration depth, the safest option for a regulation of the import of squared wood for the PRA area would be 3.5 cm (Myers et al., 2009).

3.4.2 Ionizing radiation

Conclusion: disinfestation of wood with ionizing radiation is regarded as a safe measure when this treatment is retained with a minimum absorbed dose of 1 kGy throughout the wood.

Uncertainty: high

Hallman (2011) recommended a minimum generic dose of 350-400 Gy for sterilization of adults. And EPPOs PM 10/8 recommends an absorbed dose of 1 kGy for all insects (EPPO, 2009a). The same level is also considered by EU as a sufficient level in phytosanitary irradiation *A. anxius* (EPPO, 2013b). There is no research on the effect of irradiation *on A. planipennis*, but we assume that this level will be sufficient to prevent development of eggs, larvae or sterilization of adult *A. planipennis* as well.

It is necessary to ensure that the minimum absorption dose (1 kGy) is achieved throughout the whole commodity. This may represent a practical challenge in a large bulk of a certain *Fraxinus* commodity, e.g. wood chips or round wood. To ensure that the center of a bulk absorbs 1 kGy, a greater dose than the minimum is needed for the whole bulk, and the edges of the commodity may receive at least twice of what is received in the center (Hallman, 2011).

More specific research on irradiation tolerance among various pest species is needed. It is it not known exactly what effect 1 kGy would have on *A. planipennis*; whether it will inhibit development, cause sterility, or kill the specimen. It is also unknown whether mortality will occur within days or weeks after the treatment.

3.4.3 Chipping

Conclusion: chipping down to a certain size is not regarded as a safe measure.

Uncertainty: low

Chipping down to a certain size (with screen smaller than 2.5 cm) has been discussed as safe measure in the EPPO (2013b) without giving a final recomandation about chip size.

The problem with this measure is twofold, (1) the true chip dimensions appear to be highly variable and differ from the dimensions specified by producers and regulators, and (2) there are uncertainties about the survival of pests in the actual chip sizes.

Even if the screen size is defined, a large variety of chip dimensions are produced in chipping (Kopinga et al., 2010; Roberts & Kuchera, 2006). According to a representative for Bandit Industries, Inc. in Norway (producer of the "Beast" chipper); 96 % of the chips produced with a 2.5 cm screen will be less than 8 mm in size and the remaining 4 % can be as big as 30mm (J. Olö, 2014; pers. comm., 22. May), but published complete tests of size distributions of chips produced by the various screen sizes are not known. Furthermore, it is not known whether similar small chip size would be obtained in other types of chippers and grinders. It is also uncertain how wide-scale commercial production of wood chips can comply with size requirements for wood chips specified by regulations. Significant deviations from specified chip measures have been observed during field observations (Kopinga et al. 2010; Roberts & Kuchera 2006). For example, Roberts and Kuchera (2006) compared two wood chips produced by 1-inch (~2.5 cm) screen, finding that one was about one inch square and the other was more than 20 cm long.

Even when the true chip sizes are given, the survival of *A. planipennis* in various chips sizes is uncertain. The frequently cited experiment behind the regulations of chip size against this species was performed by McCullough et al. (2007). In this experiment based on eight ash trunks, some *A. planipennis* prepupae survived chipping by 4-inch screen, while no survivors were found in in the chips processed by 1-inch screen. The true size distribution of the chips in this experiment is not clear, and it is not known which sizes within these size distributions that contained survivors or not. Furthermore, the sample size of this experiment is too small to be conclusive about "1-inch chips" being safe or not.

A simulation experiment was used to test the probability of overlooking prepupae being present in "1-inch chips" in a shipload (300 liters of chips per trunk × 150000 trunks) by repeated sampling of a volume corresponding to eight trunks (300 liters per trunk × 8 trunks) (Økland et al., 2011). The rate of true survival was based on the experiment of McCullough et al. (2007), and it was tested for true survival ranging from 1 % to 10 % of the survival for "4-inch chips". For 1 %, the probability of not detecting living prepupae was 0.9 in a sample volume corresponding to eight trunks, while the total number of prepupae in the shipload would be about 1500. For 10 %, the probability of not being detected was about 0.4 in a sample volume corresponding to eight trunks, while the whole shipload would contain about 15000 living prepupae. Thus, an experiment to determine a reliable estimate of survival would require a much larger sample, and even a small true survival rate would result in large numbers of imported living prepupae in a realistic import volume like a ship load.

It is possible that prepupae of *A. planipennis* are killed due to mechanical injuries during the process that are not a direct effect of intersection of prepupae, or that prepupae die due to drought in the processed chips. However, the size threshold for such mortality of *A. planipennis* is not known. A full intersection of all prepupae may be considered as safe. A model simulation demonstrated that there was complete survival of prepupae for chip thicknesses as low as 7 mm (even when including a buffer of 1 mm in each end of the prepupae), implying that chips without survivors required thicknesses of 6 mm or less (Økland et al., 2011). Most likely, it will be difficult to guarantee such small dimension for all chips in the process. Thus, chipping to down to a certain size represents an unfeasible measure in practice.

Chipping may increase the efficiency of other measures, such as ionization and heat treatment. Especially, reaching a sufficient core temperature may be facilitated by small units. It is however the requirements of ionization and heat treatment that should be fullfilled, and it is difficult to specify what chip sizes the users should apply for meeting these requirements.

3.4.4 Heat treatment

Conclusion: heat treatment is not regarded as a safe measure before reliable temperature/exposure levels have been tested and found lethal for *A. planipennis*.

Uncertainty: moderate.

According to PM 10/6 (EPPO, 2009b) and ISPM No. 15 (IPPC, 2013), round and sawn wood (with or without bark) should be treated to a minimum core temperature of 56°C for a minimum of 30 minutes (56/30). However, in tests by McCullough et al. (2007), *A. planipennis* survived heat treatment of chips of 55°C for both 30 and 60 min, and Myers et al. (2009) observed survival at 60°C for 30 min measured at 3.5 cm depth, and Goebel et al. (2010) observed survival at 56°C for 60 min measured at 2.54 cm depth. In 2011, the Brown Panel on Plant Health (EFSA, 2011) reviewed Myers et al. (2009) and other literature and concluded that *A. planipennis* is likely to survive the proposed heat treatment of 60°C for 60 minutes. According to ISPM15, the required core temperature is 56°C for 30 minutes, which would mean the temperature at depth used in the above mentioned experiments (3.5 and 2.54 cm) would exceed 56°C or would be at 56°C for a time longer than 30 minutes in industrial scaled treatment. Therefore this cannot be interoperated as failure or success in regards to ISPM No. 15 since none of the papers actually followed ISPM No. 15 protocol by measuring the core temperature (56/30) of the wood. After implementation of ISPM No. 15, infestation rates of WPM has declined by 36–52% (Haack et al., 2014), which could indicate that the 56/30 treatment is insufficient. In USA, it has been proposed the use of 71.1°C for 60 minutes, but this has not been evaluated due to lack of data (EFSA 2012). However, to our knowledge *A. planipennis* has never been intercepted in WPM, except being suggested as the pathway for introduction to USA. To date, test data are inconclusive about heat treatment of firewood, logs and lumber of *Fraxinus* originating from where *A. planipennis* occurs.

4 Conclusion

VKM considers the probability of entry of *A. planipennis* by natural spread low, mainly because of the geographical distance and sea barriers between Norway and the infested areas.

Among the human-assisted pathways of entry, via commodities containing ash wood, the probability of entry is considered to be: moderate for wood chips, wood in the rough and plants for planting; low-to-moderate for fuel wood; and low for waste wood and wood sawn or chipped lengthwise.

VKM is of the opinion that should *A. planipennis* enter the pest risk analysis (PRA) area, there is a high probability of establishment and spread; the environmental conditions are similar to those of its current range area, and ash trees are widely distributed.

The potential damage should *A. planipennis* reach Norway is considered high, since ash trees in forests, parks and urban areas of Norway may be killed within a few years after infestation.

VKM is of the opinion that the risk-reduction measures in the EPPO PRA, as well as in the EU legislation, can be considered safe under Norwegian conditions. Chipping and heat treatment are not regarded as reliable risk-reduction measures due to lack of documented information on efficiency. Squaring of wood, with removal of at least 2.5 cm of the outer sapwood, is regarded as a measure that may be ineffective at preventing entry because prepupae and pupae could be located more deeply in the wood. VKM suggests that at least 3.5 cm of the outer sapwood should be removed. Ionizing radiation of 1 kGy for disinfestation of wood is proposed in the EPPO standard. VKM assumes that this would be an effective phytosanitary measure, but more specific research on irradiation tolerance of the pest is needed.

5 Datagaps

Data from Statistics Norway (www.ssb.no) and EUROSTAT (www.ec.europa.eu/eurostat) are aggregated in coarse categories, which make it impossible to separate relevant commodity categories for *A. planipennis*. Furthermore, the data miss information about time of the year, exact origin within countries, and transits. There is also a discrepancy in translations of the HS Nomenclature between Norwegian Custom authorities and Statistics Norway. And unfortunately, the original English HS Nomenclature descriptions must be purchased through the World Customs Organization (2014).

6 Literature

The EPPO PRA reference list was used as the main source of information on relevant literature (EPPO 2013b). In addition electronic searches were performed containing the species name "*Agrilus planipennis*" in various combinations with other relevant words, with default settings, in the following scientific databases CAB Direct (2014), JSTOR (2014), Science Direct (2014), Springer Link (2014) and Web of Knowledge (2014). The references in these sources were screened for additional relevant publications.

7 References

Baranchikov Y., Gninenko Y., Klyukin M. , Yurchenko G. (2009) Survey of emerald ash borer distribution in Russia, in: Lance D., Buck J., Binion D., Reardon, R., Mastro V. (Eds), Emerald ash borer reasarch and technology development meeting, pp. 8-10.

Brown-Rytlewski D. E. , Wilson M. A. (2004) Tracking the emergence of emerald ash borer a dults. Emerald Ash Borer Research and Technology Development Meeting, pp. 13-14.

CAB Direct (2014) CAB Direct [Internet] http://www.cabdirect.org/.

CABI (2014) Cabi crop protection compendium report - *Agrilus planipennis* (emerald ash borer) [Internet] http://www.cabi.org/isc/datasheet/3780.

CFIA (2013) Canadian Food Inspection Agency [Internet] http://inspection.gc.ca/eng/1297964599443/1297965645317.

Crosthwaite J. C., Sobek S., Lyons D. B., Bernards M. A., Sinclair, B. J. (2011) The overwintering physiology of the emerald ash borer, *Agrilus planipennis* Fairmaire (Coleoptera: Buprestidae). Journal of Insect Physiology 57 (1): 166-73.

EFSA (2011) European Food Safety Authority Panel on Plant Health (PLH), Scientific Opinion on a technical file submitted by the US Authorities to support a request to list a new option among the EU import requirements for wood of *Agrilus planipennis* host plants. EFSA Journal (7).

EFSA (2012) European Food Safety Authority Panel on Plant Health (PLH), Statement on a heat treatment to control *Agrilus planipennis*. EFSA Journal 10 (4).

Emeraldashborer.info. (2014) [Internet] http://www.emeraldashborer.info/.

EPPO (2005) Data sheets on quarantine pests *Agrilus planipennis*. EPPO Bulletin 35 (3): 436-438.

EPPO (2009a) Disinfestation of wood with ionizing radiation. EPPO Bulletin 39 (1): 34-35.

EPPO (2009b) Heat treatment of wood to control insects and wood-borne nematodes. EPPO Bulletin 39 (1): 31-31.

EPPO (2013a) EPPO Reporting Service NO. 08 PARIS, 2013-08-01. Paris.

EPPO (2013b) Pest Risk Analysis for *Agrilus planipennis*. [Internet] http://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRA_intro.htm.

EU (2000) COUNCIL DIRECTIVE 2000/29/EC - on protective measures against the introduction into the Community of organisms harmful to plants or plant products and against their spread within the Community. Official Journal of the European Union [Internet] http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32000L0029.

EU (2014) COMMISSION IMPLEMENTING DIRECTIVE 2014/78/EU - amending Annexes I, II, III, IV and V to Council Directive 2000/29/EC on protective measures against the introduction into the Community of organisms harmful to plants or plant products and against their spread within the Community. Official Journal of the European Union. [Internet] http://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1413375617765&uri=CELEX:32014L0078.

GBIF (2014) Global Biodiversity Information Facility Data Portal [Internet] http://www.gbif.org/.

Goebel P. C., Bumgardner M. S., Herms D. A. , Sabula, A. (2010) Failure to phytosanitize ash firewood infested with emerald ash borer in a small dry kiln using ISPM-15 standards. Journal of Economic Entomology 103 (3): 597-602.

Haack R. A. (2002) Intercepted Bark- and Wood-Boring Insects in the United States: 1985-2000 Michigan Entomological Society 47 (3 & 4): 14-15.

Haack R. A., Eduard J., Houping L., Kenneth R., Toby R. P., Therese M. P. , Hui Y. (2002) The emerald ash borer: a new exotic pest in North America. Michigan Entomological Society, 47 (3-4):1-5.

Haack R. A. (2006) Exotic bark- and wood-boring Coleoptera in the United States: recent establishments and interceptions. Canadian Journal of Forest Research-Revue Canadienne De Recherche Forestiere 36 (2): 269-288.

Haack R. A., Petrice T. R. (2009) Bark- and Wood-Borer Colonization of Logs and Lumber After Heat Treatment to ISPM 15 Specifications: The Role of Residual Bark. Journal of Economic Entomology 102 (3): 1075-1084.

Haack R. A., Petrice T. R. , Wiedenhoeft A. C. (2010) Incidence of Bark- and Wood-Boring Insects in Firewood: A Survey at Michigan's Mackinac Bridge. Journal of Economic Entomology 103 (5): 1682-1692.

Haack R. A., Britton K. O., Brockerhoff E. G., Cavey J. F., Garrett L. J., Kimberley M., Lowenstein F., Nuding A., Olson L. J., Turner J. (2014) Effectiveness of the International Phytosanitary Standard ISPM No. 15 on Reducing Wood Borer Infestation Rates in Wood Packaging Material Entering the United States. PLoS ONE 9 (5): e96611.

Hagen D., Endrestøl A., Hanssen, O., Often A., Skarpaas O., Staverløkk A., Ødegaard, F. (2012) Fremmede arter. Kartlegging og overvåking av spredningsvegen «import av planteprodukter», in: NINA Rapport 915 Trondheim. Norsk institutt for naturforskning (NINA) 76 pp.

Hallman G. J. (2011) Phytosanitary Applications of Irradiation. Comprehensive Reviews in Food Science and Food Safety 10 (2): 143-151.

Herms D. A. , McCullough D. G. (2014) Emerald ash borer invasion of north america: history, biology, ecology, impacts, and management. Annual Review of Entomology 59: 13-30.

Hietala A. M., Timmermann V., Borja I. , Solheim H. (2013) The invasive ash dieback pathogen *Hymenoscyphus pseudoalbidus* exerts maximal infection pressure prior to the onset of host leaf senescence. Fungal Ecology 6 (4): 302-308.

IPPC (2003) International standards for phytosanitary measures: ISPM no. 18 Guidelines for the use of irradiation as a phytosanitary measure. Food and Agriculture Organization of the United Nations. [Internet] https://www.ippc.int/publications/guidelines-use-irradiation-phytosanitary-measure.

IPPC (2013) International standards for phytosanitary measures: ISPM no. 15 Regulation of wood packaging material in international trade. Food and Agriculture Organization of the United Nations. [Internet] https://www.ippc.int/publications/regulation-wood-packaging-material-international-trade-0.

Izhevskii S. S., Mozolevskaya E. G. (2010) *Agrilus planipennis* Fairmaire in Moscow ash trees. Russian Journal of Biological Invasions 1 (3): 153-155.

JSTOR (2014) JSTOR [Internet] http://www.jstor.org/.

Klooster W. S., Herms D. A., Knight K. S., Herms C. P., McCullough D. G., Smith A., Gandhi J. K., Cardina J. (2014) Ash (*Fraxinus* spp.) mortality, regeneration, and seed bank dynamics in mixed hardwood forests following invasion by emerald ash borer (Agrilus planipennis). Biological Invasions 16 (4): 859-873.

Kopinga J., Moraal L. G., Verwer C. C. , Clerkx A. P. P. M. (2010) Phytosanitary risks of wood chips. Wageningen, NL, Alterra-report (ISSN 1566-7197 ; 2059) 80pp.- Research Institute for the Green World 80. Retrieved November 3, 2011.

Kovacs K. F., Haight R. G., McCullough D. G., Mercader R. J., Siegert N. W. & Liebhold A. M. (2010) Cost of potential emerald ash borer damage in U.S. communities 2009–2019. Ecological Economics 69 (3): 569-578.

Lid J., Lid D. T., Elven R. , Alm T. (2005) Norsk flora. Oslo: Samlaget. 1230 pp.

Liu H. P., Bauer L. S., Miller D. L., Zhao T. H., Gao R. T., Song L. W., Luan Q. S., Jin R. Z., Gao C. Q. (2007) Seasonal abundance of *Agrilus planipennis* (Coleoptera: Buprestidae) and its natural enemies *Oobius agrili* (Hymenoptera: Encyrtidae) and *Tetrastichus planipennisi* (Hymenoptera: Eulophidae) in China. Biological Control 42 (1): 61-71.

Mattilsynet. (2008). Forskrift om tiltak mot askeskuddsopp (*Chalara fraxinea*). [Internet] http://lovdata.no/dokument/SF/forskrift/2008-09-08-1005.

McCullough D. G., Poland T. M., Cappaert D., Clark E. L., Fraser I., Mastro V., Smith S., Pell C. (2007) Effects of chipping, grinding, and heat on survival of emerald ash borer, *Agrilus planipennis* (Coleoptera: Buprestidae), in chips. Journal of Economic Entomology 100 (4): 1304-15.

McCullough D. G., Poland T. M., Anulewicz A. C., Cappaert D. (2009) Emerald ash borer (Coleoptera: Buprestidae) attraction to stressed or baited ash trees. Environonmental Entomolology 38(6): 1668-79.

Mercader R. J., Siegert N. W., Liebhold A. M., McCullough D. G. (2009) Dispersal of the emerald ash borer, *Agrilus planipennis*, in newly-colonized sites. Agricultural and Forest Entomology 11 (4): 421-424.

Myers S. W., Fraser I., Mastro V. C. (2009) Evaluation of Heat Treatment Schedules for Emerald Ash Borer (Coleoptera: Buprestidae). Journal of Economic Entomology 102 (6): 2048-2055.

New M., Lister D., Hulme M., Makin I. (2002) A high-resolution data set of surface climate over global land areas. Climate Research 21: 1-25.

Orlova-Bienkowskaja M. J. (2013) Ashes in Europe are in danger: the invasive range of *Agrilus planipennis* in European Russia is expanding. Biological Invasions 16 (7): 1345-1349.

Orlova-Bienkowskaja M. J. (2014) European range of the emerald ash borer *Agrilus planipennis* (Coleoptera: Buprestidae) is expanding: The pest destroys ashes in the northwest of Moscow oblast and in part of Tver oblast. Russian Journal of Biological Invasions 5 (1): 32-37.

Økland B., Haack R. A., Wilhelmsen G. (2011) Detection probability of forest pests in current inspection protocols – A case study of the bronze birch borer. Scandinavian Journal of Forest Research 27 (3): 285-297.

Økland B., Børja I., Often A., Solheim H., Flø, D. (2012) Import av tømmer og andre treprodukter som innførselvei for fremmede insekter, sopp og planter - trendanalyse av importstatistikk ISBN: 978-82-311-0162-8. Ås: Norsk institutt for skog og landskap. 140 pp.

Peel M. C., Finlayson B. L., McMahon T. A. (2007) Updated world map of the Köppen-Geiger climate classification. Hydrology and Earth System Sciences 11 (5): 1633-1644.

Piel F., Gilbert M., De Cannière C., Grégoire J.-C. (2007) Coniferous round wood imports from Russia and Baltic countries to Belgium. A pathway analysis for assessing risks of exotic pest insect introductions. Diversity and Distributions 14 (2): 318-328.

Rebek E. J., Herms D. A., Smitley D. R. (2008) Interspecific variation in resistance to emerald ash borer (Coleoptera: Buprestidae) among North American and Asian ash (*Fraxinus* spp.). Environmental Entomology 37 (1): 242-6.

Roberts D., Kuchera J. (2006) The Survival of EAB in Wood Chips: Does Size Matter? The Landsculptor: 19-21.

Robertson D. R., Andow D. A. (2009) Human-mediated dispersal of emerald ash borer: Significance of the firewood pathway. [Internet] http://www.entomology.umn.edu/prod/groups/cfans/@pub/@cfans/@ento/documents/asset/cfans_asset_139871.pdf.

Science Direct (2014) Science Direct [Internet] http://www.sciencedirect.com/.

Springer Link (2014) Springer Link [Internet] http://link.springer.com/.

Storlie C., Merino-Viteri A., Phillips B.,VanDerWal J., Welbergen J., Williams S. (2014) Stepping inside the niche: microclimate data are critical for accurate assessment of species' vulnerability to climate change. Biology Letters 10 (9).

Straw N. A., Williams D. T., Kulinich O., Gninenko Y. I. (2013) Distribution, impact and rate of spread of emerald ash borer *Agrilus planipennis* (Coleoptera: Buprestidae) in the Moscow region of Russia. Forestry 86 (5): 515-522.

Taylor R. A. J., Bauer L. S., Poland T. M., Windell K. N. (2010) Flight performance of *Agrilus planipennis* (Coleoptera: Buprestidae) on a flight mill and in free flight. Journal of Insect Behavior 23 (2): 128-148.

USDA (2013) Emerald Ash Borer Biological Control Release and Recovery Guidelines. Riverdale, Maryland: USDA-APHIS-ARS-FS. [Internet] http://www.aphis.usda.gov/plant_health/plant_pest_info/emerald_ash_b/downloads/EAB-FieldRelease-Guidelines.pdf.

USDA (2014) USDA APHIS PPQ 2014 Emerald Ash Borer Survey Guidelines. [Internet]

http://www.aphis.usda.gov/plant_health/plant_pest_info/emerald_ash_b/downloads/survey_guidelines.pdf.

VKM (2012) The EPPO PRA for *Agrilus anxius*: Assessment for Norwegian conditions - Opinion of the Panel on Plant Health of the Norwegian Scientific Committee for Food Safety Oslo: VKM. 1-35 pp. [Internet] http://www.vkm.no/dav/8dbdcd2120.pdf.

VKM (2013) Import of deciduous wood chips from eastern North America – pathway-initiated risk characterizations of relevant plant pests. [Internet] http://www.vkm.no/dav/c211b61647.pdf.

Web of Knowledge (2014) Web of Knowledge [Internet] http://webofknowledge.com.

World Customs Organization (2014) [Internet] http://www.wcoomd.org/.

Yang Z. Q., Wang X. Y., Zhang Y. N. (2014) Recent advances in biological control of important native and invasive forest pests in China. Biological Control 68: 117-128.

Appendix I

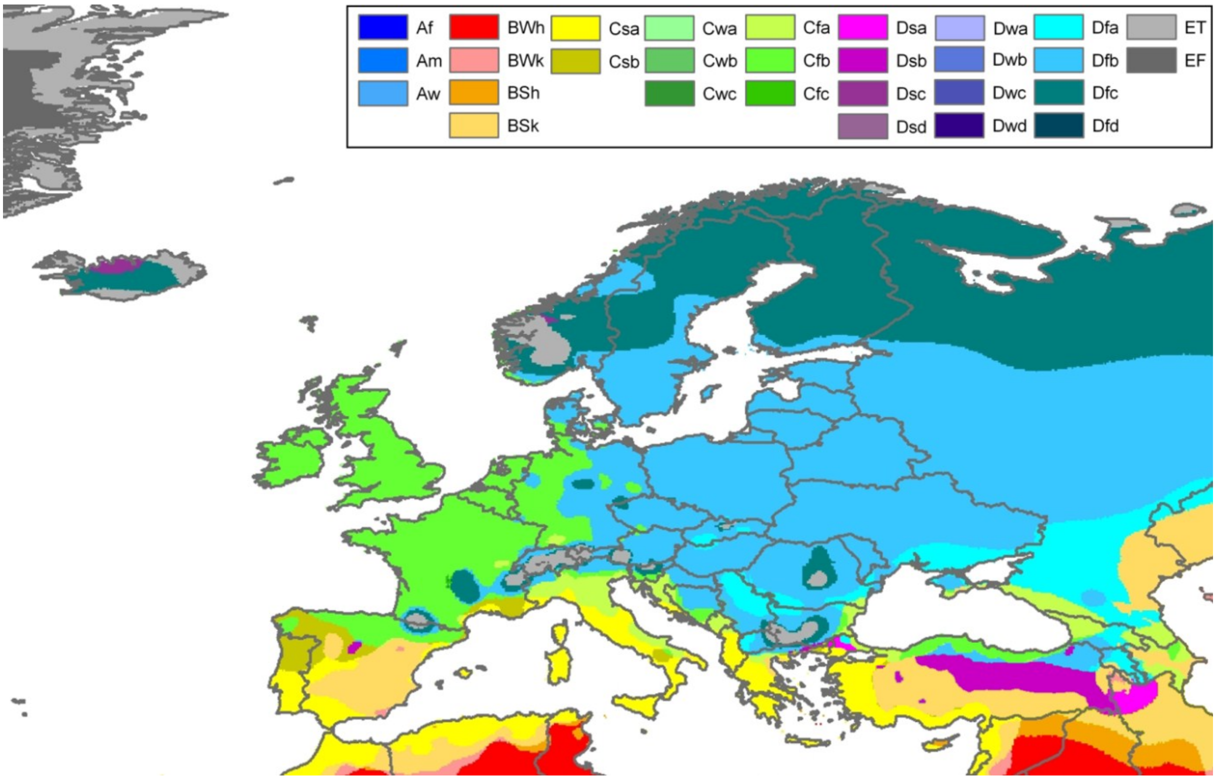
Table A I-1 Summarized yearly import statistics for all presented pathways (Figure 3.1.2.1-1, 3.1.2.2-1, 3.1.2.3-1, 3.1.2.4-1, and 3.1.2.5-1) the past ten years (numbers in tons), countries with zero imports has been omitted. Data from Statistics Norway (www.ssb.no).

Heading	Code	Country	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Fuel wood, in logs, in billets, in twings, in faggots or in similar forms; wood in chips or particles; sawdust and wood waste and scrap, whether or not agglomerated in logs, briquettes, pellets or similar forms.	**44.01.1000**	**Canada**	0	0	82.6	0	0	0	0	0	0	0.03
		China	0	0	0	0	42.1	34.1	0	0	0.04	0
		Russia	3388.5	2456.2	5002.9	6409.2	5573.6	9497.0	13513.7	15761.3	9212.2	12276.2
		USA	0	0	78.8	0	0	5.2	0	0	0.2	0
Wood in chips or particles Non-coniferous	**44.01.2200**	**Canada**	0	0	0	0	0	0	65622.5	0	0	0
		China	0	0	0	0	0	0	0	0	0	0.2
		Russia	23.8	234.5	381.5	427.1	0	1616.9	126.7	0	16.1	0
		USA	0	0	1.6	0	0	0	0	0	2.7	3.1
Sawdust and wood waste and scrap, whether or not agglomerated in logs, briquettes, pellets or similar forms.	**44.01.3909**	**Canada**	0	0	0	0	0	0	0	0	0.06	0
		China	0	0	0	0	0	0	0	0	0.02	0
		Russia	0	0	0	0	0	0	0	0	365.8	1101.5
		USA	0	0	0	0	0	0	0	0	0.6	0.1
Terminated (Sawdust and wood waste and scrap, whether or not agglomerated in logs, briquettes, pellets or similar forms.	**44.01.3008**	**Canada**	0	0	0	0	0	0	0.04	24.6	0	0
		China	0	0	0	0	0	21	0	0	0	0
		Russia	0	0	0	0	0	967.9	6335.6	4650.9	0	0
		USA	0	0	0	0	0	4.5	6	4	0	0

Heading	Code	Country	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Terminated (Sawdust and wood waste and scrap, whether or not agglomerated in logs, briquettes, pellets or similar forms).	**44.01.3009**	**China**	0	0	0	416.5	126.4	0	0	0	0	0
		Russia	219.6	90	27	1287.9	1873.1	0	0	0	0	0
		USA	0	19.7	22.9	27.2	4.3	0	0	0	0	0
Wood in the rough, whether or not stripped of bark or sapwood, or roughly squared	**44.03.9908**	**Russia**	3708.6	5140.4	6631.7	0	0	0	0	20247.4	0	0
		USA	0	0	0	0	19.9	18.9	0	21.6	741.1	0
Wood sawn or chipped lenghtwise, sliced or peeled, whether or not planed, sanded or end-jointed, of a thickness exceeding 6 mm Of ash (*Fraxinus* spp.)	**44.07.9500**	**Canada**	0	0	0	0	28.9	23.5	0	0	0	17.9
		China	0	0	0	0	0	0	1	0	18	0
		USA	0	0	0	59.7	149.6	270.3	245.1	268.4	168.4	127.2
Wood sawn or chipped lenghtwise, sliced or peeled, whether or not planed, sanded or end-jointed, of a thickness exceeding 6 mm Other than ash.	**44.07.9900**	**Canada**	0	0	0	0	28.9	23.5	0	0	0	17.9
		China	0	0	0	0	0	0	1	0	18	0
		Russia	399.7	446.3	446.0	169.5	67.4	84.3	39.9	14.8	105.6	23.9
		USA	0	0	0	59.7	149.6	270.3	245.1	268.4	168.4	127.2
Other live plants (including their roots), cuttings and slips; mushroom spawn. **Without balled roots or other culture media, including stocks (except those classified in commodity number 06.02.2000 or 06.02.4002)**	**06.02.9010**	**USA**	0	0	0	0	0	0	0	0	0	0.1

Appendix II

Figure A II-1 Köppen-Geiger climate classification map of Europe (Peel et al. 2007)



Appendix III

Figure A III-1 Köppen-Geiger climate classification map of North America (Peel et al. 2007)