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Pest risk assessment of *Dendrolimus sibiricus* and *Dendrolimus superans*

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

Report from the Norwegian Scientific Committee for Food and Environment (VKM) 2018:08
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Pest risk assessment of *Dendrolimus sibiricus* and *Dendrolimus superans*

Preparation of the opinion

The Norwegian Scientific Committee for Food and Environment (Vitenskapskomiteen for mat og miljø, VKM) appointed a project group to answer the request from the Norwegian Food Safety Authority. The project group consisted of two VKM members from the Panel on Plant Health and one two project managers from the VKM secretariat. Three external referees commented on and reviewed the manuscript. The VKM Panel on Plant Health evaluated and approved the final opinion drafted by the project group.

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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

The two lappet moths, *Dendrolimus sibiricus* and *D. superans*, are largely native to Russia and restricted parts of Northern China, Mongolia, Kazakhstan and Japan. The pests feed on several native conifer species (Pinaceae), including species found in Norway; Norway spruce (*Picea abies*) and Scots pine (*Pinus sylvestris*). In Russia, these moths can be major pests, where reoccurring defoliation of Coniferous trees under drought conditions eventually lead to death.

An article published in 2001 on *D. sibircus*, stated that the species had spread west to Moscow from its natural area of distribution east of the 60th meridian. This article sparked an interest in the species and generated a concern that the species soon could reach Europe with potentially devastating consequences for the conifer forests in Europe.

Historically, Russian scientists have considered *D. superans* as a single species with two subspecies; *D. superans sibiricus* and *D. superans albolineatus.* However, recent genetic analyses have indicated that they are two distinct species, *D. sibiricus* and *D. superans*.

The Norwegian Scientific Committee for Food and Environment (VKM) has been asked by the Norwegian Food Safety Authority (NFSA) to: 1) Summarize current knowledge about taxonomy of *D. sibiricus* and *D. superans* and closely related lappet moths as background for identifying their current distribution areas. 2) Summarize current knowledge of spread of the species and their host plants, including natural spread. Is there a risk that *D. sibiricus* can be spread naturally from Russia to Norway? 3) List countries where the status of the pests should be considered as present. 4) Identify possible pathways for introduction of the two species into Norway. 5) Assess the probability of the pests entering Norway from countries listed in (3) through the pathways listed in (4). 6) Estimate the potential of establishment and further spread of the species in the Norwegian environment if they are introduced, also regarding climatic changes in the future. 7) Assess the potential consequences in Norway (environmental, economic and social effects) if they are introduced and established. VKM was asked to look at these effects in two scenarios: a) No regulations for these insects (no measures taken). b) The insects are regulated as quarantine pests with certain specific requirements. 8. Identify relevant risk reduction measures and evaluate their effectiveness

and feasibility. For wood packing material, also consider if ISPM 15 is effective enough to prevent introduction of the pests.

VKM considers the probability of entry of *D. sibiricus* and *D. superans* by natural spread as unlikely and very unlikely, respectively mainly because of the geographical distance and partial sea barriers between Norway and the infested areas.

The overall probability of entry by human mediated pathways for *D. superans* and *D. sibiricus* is considered as unlikely with a medium level of uncertainty.

VKM is of the opinion that , should *D. sibiricus* enter the pest risk analysis (PRA) area, the probability of establishment and spread are considered as unlikely, due to the combination of suboptimal environmental conditions and the fact that the two potential host trees, Norway spruce (*P. abies*) and Scots pine (*P. sylvestris*), are intermediate and poor hosts, respectively.

The potential damage, if *D. sibiricus* should enter Norway, is considered low, again due to the combination of suboptimal environmental conditions and the fact that the two potential host trees, Norway spruce (*P. abies*) and Scots pine (*P. sylvestris*), are intermediate and poor hosts, respectively.

It is forbidden to import into Norway Coniferales of plants, wood with bark and chips of wood with bark, isolated bark and wood waste of Coniferales from Non-European countries and Portugal are prohibited according to "Regulations of 1 December 2000 no. 1333 relating to plants and measures against pests" (Ministry of Agriculture and Food, 2017).

Furthermore, VKM is of the opinion that the risk-reduction measures in the EPPO Commodity-specific phytosanitary measures PM 8/2 (2) Coniferae, can be considered satisfactory under Norwegian conditions.

Treatments of wood packing materials, which are regulated under ISPM 15, are regarded as effective measures to prevent introduction of the pests to the PRA-area.

Key words: Pest Risk Analysis (PRA), pest risk assessment, distribution, spread, entry, establishment, management options, impact, economic and environmental consequences, VKM, Norwegian Scientific Committee for Food and Environment, Norwegian Food Safety Authority.

Sammendrag på norsk

De to møll-artene *Dendrolimus sibiricus* og *Dendrolimus superans,* har sin naturlige utbredelse hovedsakelig i Russland, men de finnes også i avgrensede deler av nordlige Kina, Mongolia, Kasakhstan og Japan. Møllartene spiser nålene til en rekke bartrær (Coniferae), inkludert gran (*Picea abies*) og furu (*Pinus sylvestris*). Begge bartrærne er utbredt i Norge. I tørkeperioder kan de to møllartene gjøre stor skade på skog i Russland. Trær som har vært utsatt for tørke og som også blir utsatt for flerårige angrep av disse nålespisende insektene, kan dø. I Russland har *D. superans* vært ansett som en art, med to underarter; *D. superans sibiricus* og *D. superans albolineatus*, siden disse to er svært like. Nye genetiske analyser har vist at dette er to ulike arter som heter henholdsvis *D. sibiricus* og *D. superans*.

En Russisk artikkel som ble publisert i 2001 (Gninenko and Orlinskii, 2002), beskrev at *D. sibiricus* hadde spredt seg vestover fra sitt naturlige utbredelsesområde i Uralfjellene rundt den sekstiende breddegrad til Moskva. Artikkelen har skapt interesse for arten og bekymring for at den kan spre seg til Europa og kanskje gjøre stor skade på europeiske barskoger.

Mattilsynet har bedt Vitenskapskomiteen for mattrygghet (VKM) om å utføre en risikoanalyse i henhold til ISPM nr. 11 for *Dendrolimus sibiricus* og *Dendrolimus superans* i Norge, og om å spesifikt svare på følgende spørsmål: 1) Å gi en sammendrag på dagens kunnskap på taksonomi av *D. sibiricus* og *D. superans* samt nært beslektede arter som bakgrunn for å kartlegge dagens utbredelse. 2) Gi en sammendrag på dagens kunnskap angående utbredelse av artene og deres vertsplanter, inkludert naturlig spredning av *D. sibiricus* og om det er en risiko for at *D. sibiricus* kan spre seg naturlig fra Russland til Norge. 3) Gi en sammendrag på land hvor arten er etablert. 4) Oppsummer mulige smitteveier for introduksjon for de to artene til Norge. 5) Vurder sannsynligheten for at artene kan introduseres I Norge fra land som r identifisert I punkt tre, fra smitteveier oppsummert I punkt fire. 6) Estimer potensialet for etablering og videre spredning av de to artene i Norge om de blir introduserte Norge under dagens klima og framtidig klima scenario. 7) Vurder potensielle konsekvenser for Norge (Miljømessige, økonomiske og sosiale effekter) om artene etableres. Vurder to scenario: a) artene reguleres ikke (ingen tiltak iverksettes), eller B) artene reguleres som karanteneskadegjørere med påfølgende krav. 8) Oppsummer relevante risikoreduserende tiltak og evaluer effekten og gjennomførbarhet. Vurder også om den Internasjonal standard for treemballasje ISPM nr. 15 er tilstrekkelig for forhindre introduksjon av artene.

VKM mener at sannsynligheten for at *D. sibiricus* og *D. superans* sprer seg naturlig til Norge er lav. Årsaken er at det er lang avstand mellom Norge og områdene hvor disse artene forekommer i dag, og at insektene må krysse hav eller passere rundt Bottenviken. VKM mener at det er lav sannsynlighet for at de to *Dendrolimus*-artene kan introduseres via handelsvarer som inneholder bartrær, «planter og plantemateriale» og «tømmer», og kategorien «Lauvverk, blad, greiner og andre plantedeler».

VKM mener at det er lav sannsynlighet for etablering og spredning av *D. sibiricus* i Norge. Årsaken er kombinasjonen av sub-optimale klimatiske forhold og at de to vertstrærne gran (*P. abies*) og furu (*P. sylvestris*) er ansett for å være henholdsvis medium og dårlige vertstrær. Skadepotensialet regnes også av den grunn som lite.

VKM mener at det norske importforbudet, fra ikke-europeiske land og Portugal, som gjelder planter og plantedeler, tre med bark og flis av tømmer med bark, isolert bark og treavfall fra bartrær slikt beskrevet i vedlegg 3 av forskrift om planter og tiltak mot planteskadegjørere (FOR-200-12-01-1333) (Ministry of Agriculture and Food, 2017) er effektive. VKM mener i tillegg at risikoreduserende tiltak beskrevet i EPPO`s «Commodity-specific phytosanitary measures PM 8/2 (2) Coniferae» kan regnes som effektive under norske forhold.

Abbreviations and/or glossary

Table 1. Definition and explanation of terms used in the assessment. The current opinion is mainly according to the ISPM No.5 Glossary of phytosanitary terms by FAO (2015).

Definition and explanation of term	
CABI	Centre for Agriculture and Biosciences International
Commodity	A type of plant, plant product, or other article being moved for trade or other purpose
EFSA	European Food Safety Authority
Endangered area	An area where ecological factors favour the establishment of a pest whose presence in the area will result in economically important loss
Entry	Movement of a pest into an area where it is not yet present, or present but not widely distributed
EPPO	European Plant Protection Organization
EPPO PQR	EPPO Plant Quarantine Data Retrieval system
Establishment	Perpetuation, for the foreseeable future, of a pest within an area after entry
FAO	Food and Agricultural Organization
Introduction	The entry of a pest resulting in its establishment
Non-squared wood and bark	Wood that retains some natural rounded surface. Bark may remain on the wood
NFSA	The Norwegian Food Safety Authority
NIBIO	Norwegian Institute of Bioeconomy Research
Other non-squared wood and bark	Logs with bark, debarked logs, fire wood, sawn wood containing some natural rounded surface, isolated bark
Pathway	Any means that allows the entry or spread of a pest
Pest	Any species, strain or biotype of plant, animal or pathogenic agent injurious to plants or plant products
Plants for planting	Plants intended to remain planted, to be planted or replanted
PRA	Pest Risk Analysis
PRA area	Area in relation to which a pest risk analysis is conducted
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

Definition and explanation of term	
Spread	Expansion of the geographical distribution of a pest within an area
Squared Wood	Wood from which all natural rounded surface has been removed: no wane, no bark
Tariff codes	Customs codes according to the World Customs Organization's internationally agreed Harmonized System.
VKM	The Norwegian Scientific Committee for Food and Environment
Wood packaging material	Wood or wood products (excluding paper products) used in supporting, protecting or carrying a commodity (includes dunnage)

Background as provided by the Norwegian Food Safety Authority

The two lappet moths, *Dendrolimus sibiricus* and *Dendrolimus superans,* which are closely related to the pine-tree lappet moth (*Dendrolimus pini*), have the potential to damage a wide range of different conifers. During a period of 25 years (1932-1957) *D. sibiricus* damaged 7 million ha of forest in West Siberia and Chita Oblast (EPPO, 2005). The two species naturally occur in Asia, and *D. sibiricus* is known to have spread into the European parts of Russia. Neither of the two species are known to be present in Norway. However, it is suggested that the moths can enter with a presumed pathway by wood and wood products. Lappet moths are generally good flyers, and both these *Dendrolimus* species may naturally spread by a rate of 100 km per year (EPPO, 2005).

EPPO conducted a Pest Risk Assessment for *D. sibiricus* in 2000 (EPPO, 2000a) and for *D. superans* in 2003 (EPPO, 2003). However, there has been no complete Pest Risk Analysis, including both a Pest Risk Assessment and a Pest Risk Management, for any of the two *Dendrolimus* species.

Both species are listed on the «EPPO A2 list». Furthermore, *D. sibiricus* is on the EU list of «Pest forbidden to introduce or spread».

Today, the two *Dendrolimus* species are not regulated as quarantine pests for Norway.

Considering the supposed damage potential for the Norwegian conifer forests, the Norwegian Food Safety Authority (NFSA) asked the Norwegian Scientific Committee for Food and Environment (VKM) to carry out an assessment of the potential for entry, establishment and damage of the two plant pests *D. sibiricus* and *D. superans* in Norway. The NFSA will use the VKM risk assessment as a basis to determine whether *D. sibiricus* and *D. superans* should be regulated as quarantine plant pests for Norway and if specific phytosanitary actions should be taken to prevent their introduction.

Terms of reference as provided by the Norwegian Food Safety Authority

VKM is requested to carry out a pest risk analysis according to ISPM 11 for *Dendrolimus sibiricus* and *Dendrolimus superans* in Norway, including special information on:

1. Summarize current knowledge about the taxonomy of *D. sibiricus* and *D. superans* and closely allied lappet moths as background for identifying their current distribution areas.

2. Summarize current knowledge about spread of the species and their host plants, including natural spread. Is there a risk that *D. sibiricus* can be spread naturally from Russia to Norway?

3. List countries where the status of the pests should be considered as present.

4. Identify possible pathways for introduction of the two species into Norway.

5. Assess the probability of the pests entering Norway from countries listed in (3) through the pathways listed in (4.).

6. Estimate the potential for establishment and further spread of the species in the Norwegian environment if they are introduced, also regarding climatic change in the future.

7. Assess the potential consequences for Norway (environmental, economic and social effects) if they are introduced and established. We would like you to look at these effects in two scenarios: a) No regulations for these insects (no measures taken). b) The insects are regulated as quarantine pests with certain specific requirements.

8. Identify relevant risk reduction measures and evaluate their effectiveness and feasibility. For wood packing material, also consider if ISPM 15 is effective enough to prevent introduction of the pests.

Assessment

1 Introduction

1.1 Purpose and scope

This document presents a scientific opinion prepared by the VKM Panel on Plant Health (hereafter referred to as the Panel), in response to a request from the Norwegian Food Safety Authority. The opinion is a risk assessment of the two closely related lappet moths *D. sibiricus* and *D. superans* for Norway. Furthermore, the opinion identifies and evaluates risk reduction options in terms of their effectiveness in reducing the plant health risk posed by these moths.

The PRA (Pest Risk Analysis) area of this risk assessment is Norway.

1.2 Information collection

1.2.1 Previous pest risk assessments

The previous pest risk assessments of *D. sibircus* and *D. superans* are listed below:

EPPO (1998). Pest risk analysis to decide immediate action to be taken on interception of a pest in an EPPO country: *Dendrolimus sibiricus*.

EPPO (2000a). Pest risk assessment scheme (00/8481): *Dendrolimus sibiricus* Tschetverikov (Lepidoptera: Lasiocampidae)**:** 16.

EPPO (2000b). Report of a Pest Risk Assessment: *Dendrolimus sibiricus***:** 3.

EPPO (2003). Report of a Pest Risk Management: *Dendrolimus superans* (05-11895): 3.

Kubasik et al. (2017) Analizy Zagrożenia Agrofagiem (Ekspres PRA) dla *Dendrolimus sibiricus*, Rzeczpospolita Polska, Institute of Plant Protection-NRI Poznan, Poland

1.2.2 List of conclusions from previous PRA's:

EPPO (1998) concluded that *D. sibiricus* threatens large areas of conifer forests in Europe, with the potential to cause serious and destructive epidemics in European conifer forests.

EPPO (2000a) concluded that the entry of the *D. sibiricus* into the EPPO region is more likely to occur by natural spread and import of untreated wood with bark, dunnage or packing material, and less likely to occur by import of host plants for planting and cut branches. It was also concluded that the probability of establishment was considered to be high in the EPPO region, including Norway. The potential impact within the EPPO region was also considered to be high, including both the direct damage to coniferous plantations and forests (mainly *Abies* spp., *Pinus* spp., *Larix* spp., and *Picea* spp.) resulting in wood losses, environmental damage to natural forests, including deforestation over large areas, and social damage to people living in damaged areas.

EPPO (2003) concluded that the main pathways for *D. superans* are, in order of descending importance: 1) Plants for planting of host trees that may carry eggs, larvae and cocoons of the pest on bark and branches. Management options: Plants free from soil, visual inspection, harvesting in restricted periods, pest free areas and protected areas. 2) Cut branches (including Christmas trees) that may carry eggs, larvae and cocoons of the pest. Management options: Fumigation, visual inspection, harvesting in restricted periods, and pest free areas. 3) Wood with bark of host plants that may carry eggs and larvae of the pest. 4) Isolated bark of host plants that may carry eggs and larvae of the pest. 5) Natural spread has been identified as a pathway, but the EPPO Panel did not consider this possibility because of the long distance between the actual area of distribution of the pest and the endangered area.

Kubasik et al. (2017) concluded that *D. sibiricus* poses a potentially very high threat to the forests of Poland, because the high proportion of coniferous trees, and that suitable climatic conditions facilitate establishment of this species, if it enters into Poland. However, due to low imports of relevant conifer commodities to Poland, the probability of introduction was considered low.

1.2.3 Literature search strategy

This section describes the literature search conducted for retrieving the scientific documentation available for this opinion.

A literature search was conducted in September 2017 and was last updated in March 2018. with the species names "*Dendrolimus sibiricus*" and "*Dendrolimus superans*" with default settings, in JSTOR (2017), ScienceDirect (2017), Springer Link (2017) and Web of Knowledge (2017). The reference lists in identified publications were screened for additional relevant publications. Publications of all ages in English were included.

If additional relevant references were discovered (e.g. in publication reference lists), these were included. Additional literature was also retrieved by the members of the project group, due to their expertise on the subject. Furthermore, literature was also obtained from collaboration with the Russian scientists Oleg Kulinich and Yuri Baranchikov.

1.2.4 Data collection

Data on import statistics for relevant commodities into Norway were downloaded from Statistics Norway (SSB, 2017), using StatBank Open data API (Application Programming Interface) in R (R Core Team, 2017) using the packages httr (Wickham, 2017) and rjstat (Schumacher and Malmedal, 2016).

Data for import of relevant commodities into Sweden and Finland were manually downloaded from the Eurostat (2017) CN8 database.

1.3 Ratings of probabilities and uncertainties

The conclusions for probability of entry and establishment of the pests are presented and rated separately, following a fixed scale: Very unlikely, unlikely, moderately likely, likely, very likely. The descriptors for these qualitative ratings are shown in Appendix 2

For the conclusions on entry and establishment, the levels of uncertainty are rated separately, following a fixed scale: Low, medium, high. The descriptors for these qualitative ratings of uncertainty are presented in Appendix 2

2 Pest identity, biology, occurrence, hosts and regulatory status

2.1 Pest identification, name and taxonomic position

Dendrolimus sibiricus is the most destructive pest of conifers in Russia. In the period between 1994 and 1996, *D. sibiricus* damaged 700.000 ha of forest in Krasnoyarsk krai (Zhirin et al., 2016), between 1954 and 1957 the pest killed over 1.5 million ha of pine near the Ket- and Chulym rivers (Kharuk et al., 2016), and between 1932 and 1957, the pest damaged 7 million hectares of forest and killed 50% of the trees in western Siberia and in the Chita Oblast (Baranchikov and Montgomery, 2014). *Dendrolimus sibiricus* inhabits an area stretching from the Pacific Ocean across Russia past the Ural Mountains (Figure 1). However, there are ambiguities in the historic records of the distribution of these pests. The exact geographical distribution remains obscure, as the alleged expansion westwards towards Moscow (Gninenko and Orlinskii, 2002) has been questioned (Mikkola and Stahls, 2008), and thought to be based on a misidentification of *D. pini as D. sibiricus* (Baranchikov et al., 2006).

The closely related *D. superans* is restricted to the Sakhalin and the Kurile Islands, Sakhalin Oblast Russia, and northern Japan (EPPO, 2005). *Dendrolimus superans* is reported not to extend its range or attacking European conifer species. However, little information is available in English on this species.

2.1.1 Biological information

The biology of *D. sibiricus* and *D. superans* is very similar and described in detail by (EPPO, 2005).

2.1.1.1 Dendrolimus sibiricus

In Russia, *D. sibiricus* can attack a wide range of host species (as described in chapter 2.1.3). Adults fly from the end of June to the beginning of August, and each female can lay up to 800 eggs (EPPO, 2005). Eggs (1.9-2.2 mm in length) are laid on the bark of stems, needles or branches of host trees, where larvae (length 60-82 mm) hatch after 13 to 22 days and start feeding on the needles. Afterwards, larvae that have overwintered make cocoons in June to late July and pupate (pupae 50-110 mm in length) in the trees. The life cycle typically takes from one to two years depending on population density and temperature. Larvae can have between six and eight instars, and diapausing larvae overwinter once or twice in the ground, in litter or underneath moss. However, parts of the population (larvae) can enter summer diapause (a period of slow development of the third- to fifth-instar larvae), if food availability is low or abiotic conditions are unfavourable, prolonging their life cycle up to four years (Kirichenko et al., 2011). Due to this prolonged diapause, parts of the population can have a life cycle of either two, three or four years, which contributes to the population persistence during unfavourable conditions.

2.1.1.2 Dendrolimus superans

Dendrolimus superans can attack a wide range of host species (EPPO, 2005). Typically, its life cycle takes one to two years, depending on food availability and temperature. *Dendrolimus superans* is active in the period from June to August, and prefers forests older than 50 years (EPPO, 2005).

2.1.2 Taxonomic position

Both *D. sibiricus* and *D. superans* are arthropods, and the taxonomic positions of the pests are presented in Table 2. Historically, many researchers have considered *D. superans* to be a single species with two subspecies; *D. superans sibiricus* Tschetverikov and *D. superans albolineatus* Butler (Kononov et al., 2016). Both of these species are closely related to the pine-tree lappet moth (*Dendrolimus pini*) which is present in Norway and the rest of Europe. According to Kononov et al. (2016) there are about 30 species in the genus Dendrolimus, but only eight species in Eurasia, most of which are native to Far East Asia.

Table 2. Taxonomic position of the pests.

	Dendrolimus sibiricus	***Dendrolimus superans***
Name	*Dendrolimus sibiricus* (Chetverikov, 1908)	*Dendrolimus superans* (Butler, 1877)
Synonyms	*Dendrolimus superans sibiricus* (Chetverikov, 1908) *Dendrolimus laricis* (Chetverikov, 1903)	*Dendrolimus superans albolineatus* (Butler, 1877) *Dendrolimus albolineatus* (Matsumura, 1921) *Dendrolimus yezoensis* (Matsumura) *Odonestis superans* (Butler, 1877)
Common name in English and Russian	Siberian silk moth Larch caterpillar Sibirskiy shelkopryad	Sakhalin silk moth Siberian conifer silk moth
The pest is an arthropod	Class: Insecta, Order: Lepidoptera, Family: Lasiocampidae, Genus: *Dendrolimus*, Species: *D. sibiricus*	Class: Insecta, Order: Lepidoptera, Family: Lasiocampidae, Genus: *Dendrolimus*, Species: *D. superans*

2.1.3 Host plant species

The larvae of species in the genus *Dendrolimus* only infest conifer trees. Hardin and Suazo (2012) presents an extensive list of reported hosts plant species for *D. sibiricus* and *D. superans*. Several of the host plant species presented by Hardin and Suazo (2012) can be found as ornamental landscape trees in Norway. However, since these host trees are sparsely used and rarely planted in small forest patches, the Panel do not consider these host plants of interest for further investigation within this PRA.

2.1.3.1 *Dendrolimus sibiricus*

The main hosts for *D. sibiricus* are the Siberian larch (*Larix sibirica*), Siberian pine (*Pinus sibirica*), Siberian fir (*Abies sibirica*), and Siberian spruce (*Picea obovata*). However, the pest is reported to damage more than 20 different species of Pinaceae (EPPO, 2005).

Two potential hosts are present in Norway, the Norway spruce (*Picea abies*) and the Scots pine (*Pinus sylvestris*). Kirichenko et al. (2009) showed, in a larval host plant bioassay-experiment with European tree species, that *Picea abies* and *Pinus sylvestris* were intermediate and poor hosts, respectively, for *D. sibiricus* larvae. However, *P. abies* was preferred over *P. sylvestris.* For larvae feeding on *P. sylvestris* and *P. abies,* the developmental time increased, and larvae mortality reached 66.7% and 14.5%, respectively, compared to 3.2% mortality for the larvae fed on *Larix decudia*, which provided the lowest larvae mortality in the same period. Kirichenko et al. (2009) concluded that *D. sibiricus* will be able to develop on the main European conifer hosts mentioned above, resulting in severe damage to large forest areas.

2.1.3.2 *Dendrolimus superans*

The main hosts for *D. superans* are *Larix kamtschatica, Pinus pumila*, *Picea ajanensis* and *Abies sachalinensis* (EPPO, 2005), all of which are absent from Norway –or only used sparsely as landscape trees-, and they are mostly growing in the far eastern federal districts of Russia. According to EPPO (2005) there are no specific reports concerning the suitability of European conifers as hosts for *D. superans*. To the knowledge of the Panel, there are no data indicating that any Norwegian tree species is a suitable host of *D. superans.* On the other hand, there are no data showing that Norwegian tree species cannot be suitable hosts of *D. superans*.

2.1.4 Geographical distribution

2.1.4.1 *Dendrolimus sibiricus*

Dendrolimus sibiricus is native to Russia, and restricted parts of northern Kazakhstan, Mongolia and China (EPPO, 2005).

Dendrolimus sibiricus is present west of the 60th meridian east in European Russia (Figure 1). However, the exact western border of the geographical distribution of *D. sibiricus,* is disputed among experts (Gninenko and Orlinskii, 2002; Kirichenko et al., 2009; Kononov et al., 2016). The geographical distribution of the species are presented in figure 1 and 2.

Also, the northern limit of *D. sibirucus* is uncertain, but according to (Rozhkov, 1963) (printed in EPPO, 2005), the city of Yakutsk is the northernmost record of the species (Figure 2). However, this area is sparsely populated, and there are uncertainties as to which data Rozhkov (1963) used to draw his map. Therefore, *D. sibiricus* could be more widespread in Northern Russia than previously reported (Flament et al., 2017). Also, there are uncertainties as to the southern limits of the distribution of the pest in China, Mongolia and Kazakhstan. Therefore, the distribution of the main hosts may be the best indicator of the historic distribution of *D. sibiricus*, even though the northern limits in this case could be overestimated.

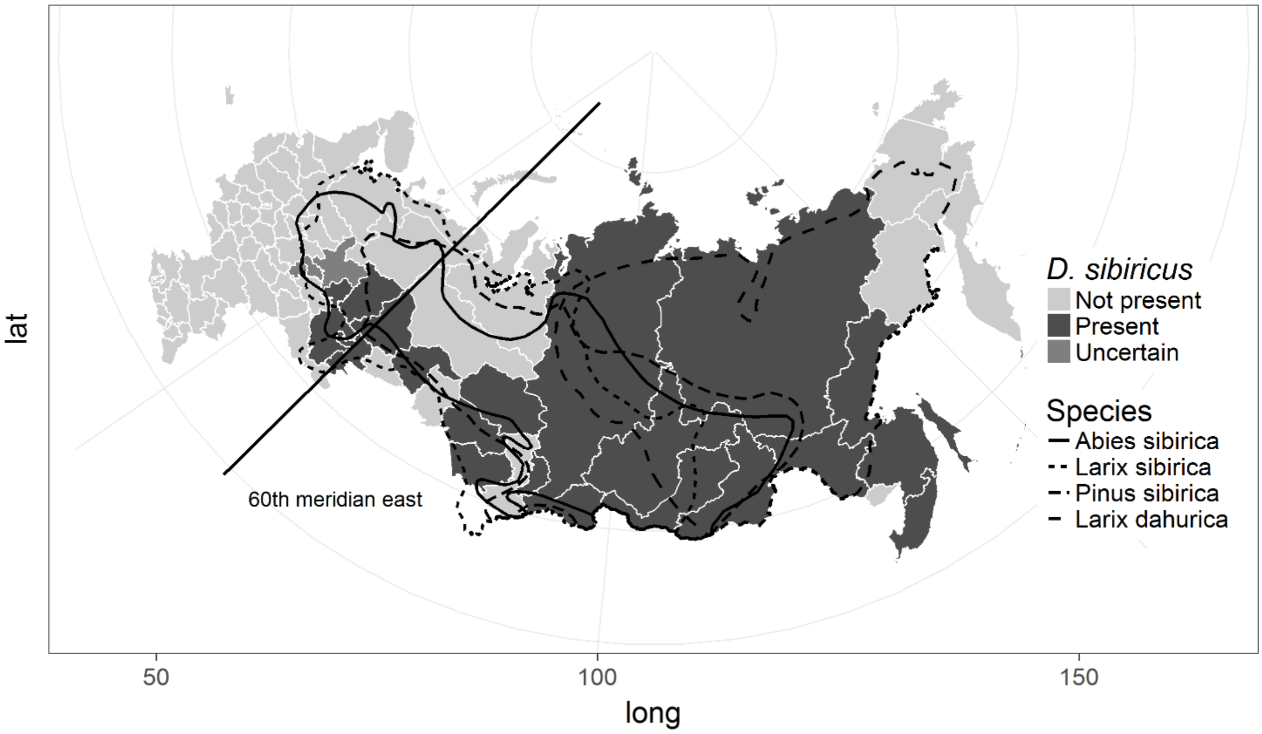

Figure 1. Map of Russia showing the federal subjects, where *Dendrolimus sibiricus* is present (dark gray areas) and not present (light gray areas). The distribution of *D. sibiricus* is uncertain for some of the federal subjects in European Russia (gray areas). The black lines represent the distribution for some of the main host species for *D. sibiricus*. The 60th meridian east represents the border between Europe and Asia. The map was compiled from literature and personal communication, see appendix I for full references. Data on the distribution of *Picea obovata* were unavailable.

Figure 2. Map of the geographical distribution of *Dendrolimus sibiricus* by Rozhkov (1963), Reprinted from EPPO Bulletin Volume 35, Issue 3, pages 390-395 (EPPO, 2005)

2.1.4.2 Dendrolimus superans

Dendrolimus superans is native to Japan, China and Far East Russia (Primorsky krai, Sakhalin- and Kurile Islands, Sakhalin Oblast) (Figure 3).

Figure 3. Map of Russia showing the federal subjects, where *Dendrolimus superans* is present (black areas) and not present (gray areas) (EPPO, 2005; Kononov et al., 2016).

2.1.4.3 Occurrence of the pests in the PRA area

The pests are not present in the PRA area.

2.2 Regulatory status

Dendrolimus sibiricus and *D. superans* are currently not regulated in the PRA-area. However, *D. sibiricus* and *D. superans* are on the «EPPO A2 List of pests recommended for regulation as quarantine pests» (Table 3). *Dendrolimus sibiricus* is also included in the EU Plant Health Legislation by EU Directive 2000/29 Annex I/AI, requiring a phytosanitary certificate issued by Russia, ensuring that plants and plant products are inspected and free from *D. sibiricus* (Council Directive 2000/29/EC, 2000). See Table 3 for further information regarding regulation of *D. sibiricus* and *D. superans*. Furthermore, it is forbidden to import into Norway Coniferales of plants, wood with bark and chips of wood with bark, isolated bark and wood waste of Coniferales from Non-European countries and Portugal are prohibited according to“Regulations of 1 December 2000 no. 1333 relating to plants and measures against pests” (Ministry of Agriculture and Food, 2017).

Table 3. Regulatory status of *Dendrolimus sibiricus* and *D. superans*. EAEU – Eurasian Economic Union, EU – European Union, EPPO – European and Mediterranean Plant Protection Organization.

Species	Country/Organization	List category	Year regulated
Dendrolimus sibiricus	EPPO	A2 List	2002
	EU	Annex I/AI/A1 List	2009
	EAEU	A2 list	2016
	Ukraine	A1 list	2010
	Turkey	A1 list	2007
	Russia	A2 list	2014
	Kazakhstan	A1 list	2009
	EPPO	A2 List	2005

3 Assessment of the probability of introduction and spread

Dendrolimus sibiricus has never been intercepted outside its main area of distribution, and in Russia there is no, or very slow spread westwards. In addition, there are currently no imports of commodities that would support entry to the PRA-area. To the best of the Panels knowledge *D. superans* has never been intercepted outside its main area of distribution, and in Russia there is no report of a westward spread. Furthermore, it is forbidden to import into Norway Coniferales of plants, wood with bark and chips of wood with bark, isolated bark and wood waste of Coniferales from Non-European countries and Portugal are prohibited according to "Regulations of 1 December 2000 no. 1333 relating to plants and measures against pests" (Ministry of Agriculture and Food, 2017).

3.1 Probability of entry of the pest

The special event, when a species crosses a country border, is in a PRA context classified as an "entry" event, while further spread inside the actual country or administrative unit, is denominated as spread (see glossary).

3.1.1 Identification of pathways for entry

The pathways are separated into natural spread and human mediated spread as pathways for entry. Three human mediated pathways are considered as possible entries of the *D. sibiricus* and *D. superans* into Norway; Living trees, coniferous wood in the rough and import of foliage and branches (Table 4).

Table 4. List of human mediated pathways of entry of *Dendrolimus sibiricus* and *D. superans* into Norway (SSB 2017).

Possible Pathways	Tariff codes	Short description	Pathway regulated in Norway? (Yes/No)	Pest already intercepted on the pathway? (Yes/No)
Living trees imported from countries where *D. sibirucus* and *D. superans* are present	06.02	There has been no import to Norway from Russia, Kazakhstan, China, Democratic People's Republic of Korea, Republic of Korea, Mongolia or Japan during the past 20 years.	Yes, from countries outside Europe, as well as Portugal. From the European part of Russia import of plants needs a phytosanitary document.	No
Import of branches and foliage.	06.04	There has been no import to Norway from Russia, Kazakhstan, China, Democratic People's Republic of Korea, Republic of Korea, Mongolia or Japan during the past 20 years.	Yes, from countries outside Europe, as well as Portugal. From the European part of Russia import of plants needs a phytosanitary document.	No
Coniferous wood in the rough	44.03	There have been substantial imports of the category "Coniferous wood in the rough" from Russia to Norway during the past 30 years, but these imports have declined since 2000.	Yes, from countries outside Europe, as well as Portugal. From the European part of Russia import of plants needs a phytosanitary document.	No

3.1.1.1 *Human mediated spread as an entry of the pest*

Living trees

The probability of entry of *D. sibiricus* and *D. superans* to Norway is considered as unlikely with a medium level of uncertainty.

During the past 30 years, there has been no import of living trees of *Larix* spp., *Abies* spp., *Pinus* spp. or *Picea* spp. from Russia to Norway. However, during the past 20 years there have been small numbers of living plants (unknown species) shipped to Norway from China (trade codes 06.02.90 Live plants and 06.02.99 Live plants) shown in Figure 3. There have been no other imports of living plants from countries where *D. sibiricus* is present. Furthermore, since 2001 it is forbidden to import into Norway Coniferales of plants, wood with bark and chips of wood with bark, isolated bark and wood waste of Coniferales from Non-European countries and Portugal are prohibited according to "Regulations of 1 December 2000 no. 1333 relating to plants and measures against pests" (Ministry of Agriculture and Food, 2017).

There has not been any import of living trees from Russia to Sweden, and only 12.4 metric tons of trees have been exported from Russia to Finland (Eurostat, 2017).

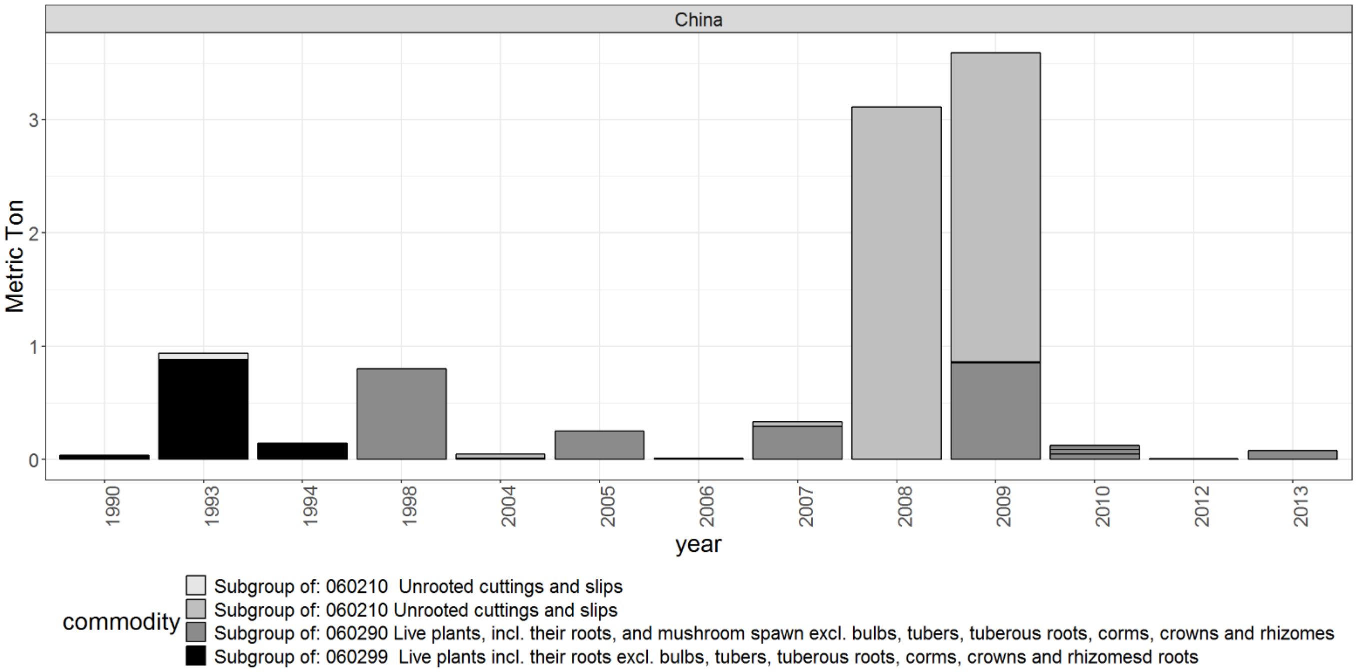

Figure 3. Amounts (metric tons) of Live plants (06.02) imported during the past 30 years from China. Data from Statistics Norway (SSB, 2017)

Coniferous wood in the rough

The probability of entry of *D. sibiricus* and *D. superans* to Norway is considered as unlikely with a medium level of uncertainty.

There have been substantial imports of the category "Coniferous wood in the rough" (trade code 44.03) from Russia to Norway during the past 30 years, but these imports have declined since 2000 and from 2016 there has been no import (Figure 4). All of these products, if containing bark, could contain eggs, larvae and imago. The category with the highest volume, "Wood for pulping of spruce or other coniferous species" (trade code 44.03.2006) sums up to 1.508.417 metric tons over 16 out of 20 years and peaked in 1999 (Figure 4). The next category, "Coniferous sawn wood" (trade code 44.03.2001) sums up to 1.136.599 metric tons over 16 out of 20 years and peaked in 2000. Category "Wood for pulping" (trade code 44.03.2009) sums up to 127.687 metric tons over 12 out of 20 years and peaked in 2000, and "Wood for pulping of pine" (trade code 44.03.2005) sums up to 80.068 metric tons over 12 out of 20 years and peaked in 1994 (Figure 4). There were only 0.67 metric tons of "Coniferous Sawn wood" (trade code 44.03.2001) imported from Japan to Norway in 1992 (not shown in Figure).

Some of the sub-categories (of trade code 44.03) may contain *Larix* spp., *Abies* spp., *Pinus* spp. or *Picea* spp., although the custom statistics do not reveal the proportional content of the respective species. Furthermore, the Custom statistics do not reveal the origin of the respective commodities within Russia.

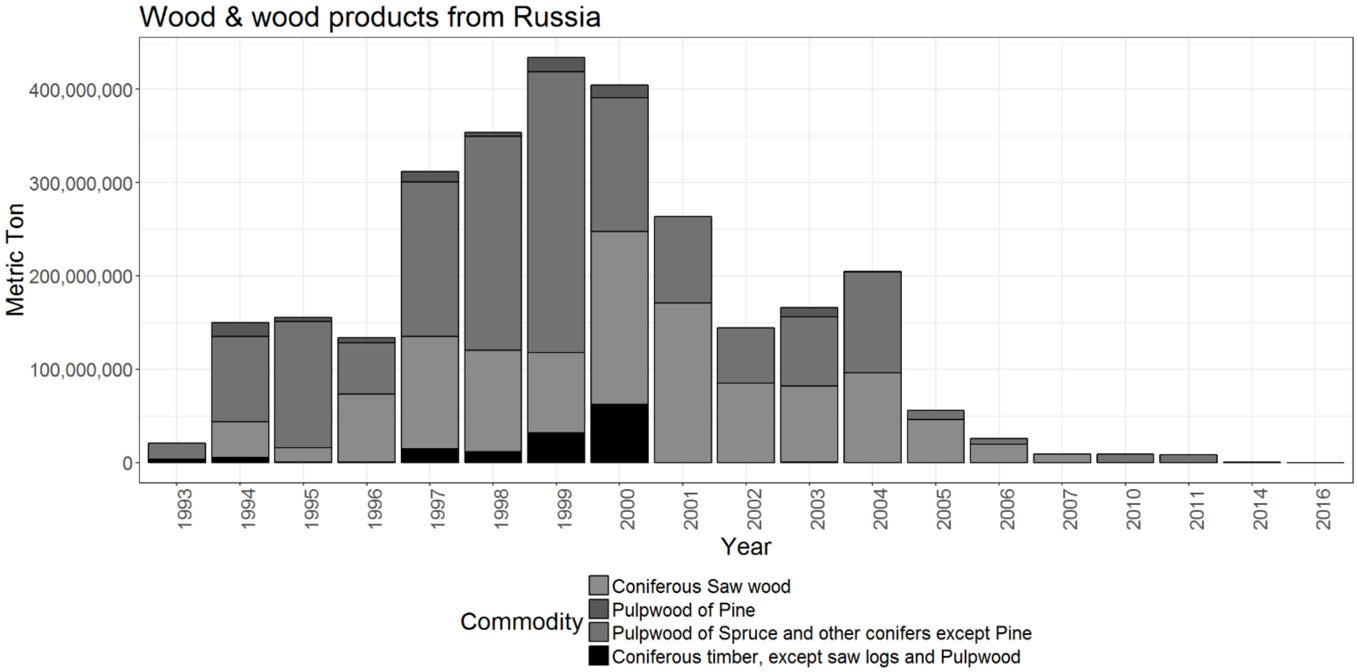

Figure 4. Amounts (metric tons) of coniferous wood and wood products in the rough (trade code 44.03) imported during the past 30 years from Russia. Data from Statistics Norway (SSB, 2017).

Trade in conifer products with bark from European Russia is not regulated in the same way as trade from countries outside of Europe. This is of concern, since European Russia includes several climate types and ecoregions, potentially harbouring a number of unwanted species. Especially, the import of coniferous wood with bark originating from the east of the Ural Mountains (approximately 60th meridian east), represents a considerable risk for the entry of alien *Dendrolimus* species.

Generally, the imports of relevant commodities have shown high variability in the past. The volume of a commodity has, in some cases, changed more than 100% from one year to the next (Økland et al., 2012). This large temporal variation in imports from Russia has also been observed in other European countries, where timber imports from Russia had a dramatic increase in the 1990s, but since the turn of the century imports changed quickly in time and in area of origin (Piel et al., 2008). The decline and cessation of timber imports from Russia during the last decade may reflect a declining paper and pulp industry in Norway. Even though this trend indicates a cessation in import along relevant pathways, attention should be focused on further development of the import by monitoring import statistics.

Foliage and branches

The probability of entry of *D. sibiricus* and *D. superans* to Norway is considered as unlikely with a high level of uncertainty.

It is uncertain which of the commodities under the heading Foliage, branches and other parts of plants (trade code 0604) include coniferous products. This commodity code may include coniferous wood with bark and other coniferous items that can host *D. sibiricus*. However, there was only a small volume of foliage, branches and other parts of plants (<0.5 metric ton) of "Subgroup off: 060491 Foliage, branches and other parts of plants" entering the PRA-area from Russia in 1998 (Figure 5).

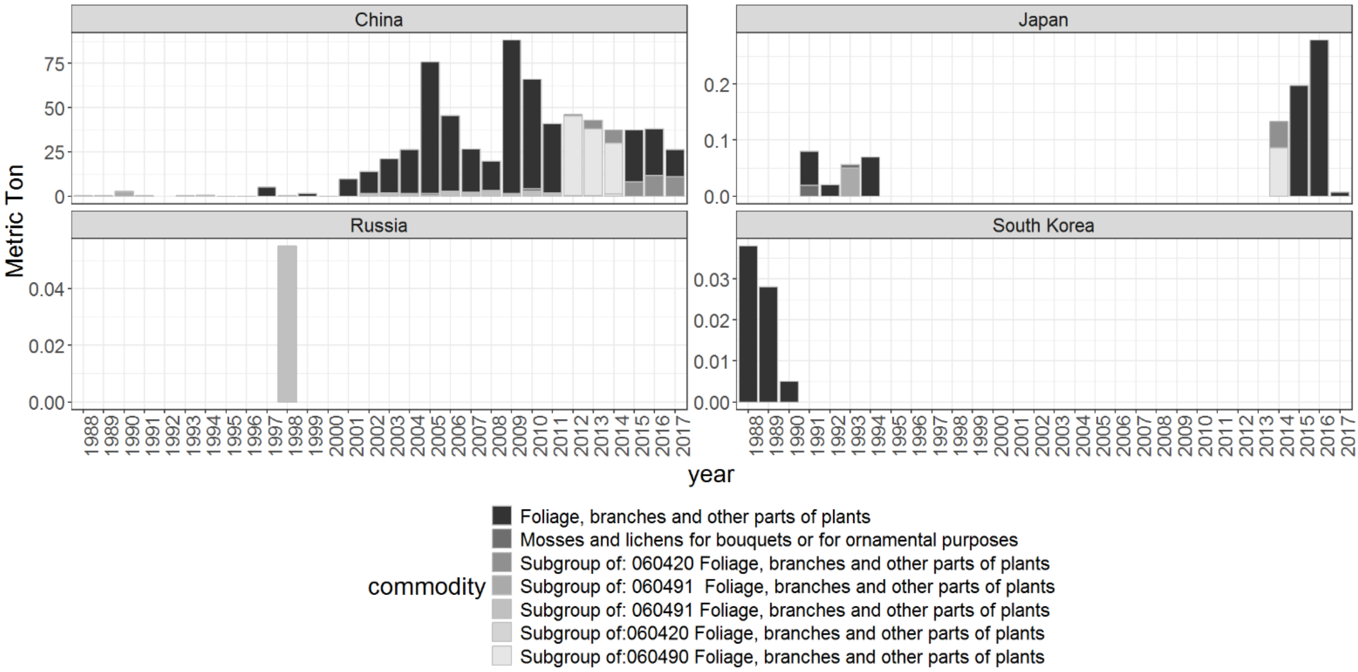

Figure 5. Amounts (metric tons) of foliage, branches and other parts of plants (06.04) imported during the past 30 years from China, Japan, Russia and South Korea. Data from Statistics Norway (SSB, 2017).

3.1.1.2 Natural spread as an entry of the pest.

Dendrolimus sibiricus

The probability of natural spread as an entry is considered as unlikely with a medium level of uncertainty.

The panel assesses that *D. sibiricus* cannot be expected to spread naturally from its current Western distribution limit in Russia (Figure 1) to Norway within the next couple of decades. In a worst case scenario, where *D. sibiricus* spreads westwards from Moscow at a rate of 50 km per year (EPPO, 2005), it would take more than 30 years for the species to reach Norway. In a situation of natural spread of *D. sibiricus* from the Moscow region to Norway the insects would probably need to fly north of the Gulf of Bothnia.

Based on the current data, it is difficult to conclude, with very high certainty, that there is no westward movement of the species. However, historical observations indicate that the westward spread may be very slow or non-existent. *Dendrolimus sibiricus* has probably been present in the Urals since the late 19^{th} century or early 20^{th} century without expanding westwards (Mikkola and Stahls, 2008 and references therein). Petersen W (1909) judged the western limit of distribution of *D. sibiricus* to be at the 59^{th} meridian east, while Mikkola and Stahls (2008) and Eversmann (1844) reported it to be at the 56^{th} and 58^{th} meridian east, respectively. According to Gninenko and Orlinskii (2002) *D. sibiricus* is found in an area around the 52^{th} meridian east, in the regions of Perm and Udmurtiya. Also, Rozhkov (1963) and Koltunov EV et al. (1997) judged the western limits of *D. sibiricus* to be at approximately at the 52^{th} meridian east. However, Okunev PP (1955) reported *D. sibiricus* as far west as the 38^{th} meridian east.

In 2001 a few specimens of *D. sibiricus* were reported as pheromone-trapped close to Moscow (Gninenko Y.U and Kryukov V.Y.U, 2007). Baranchikov et al. (2006) rejected this observation and considered it as a possible misidentification of *D. pini* as *D. sibiricus*. *Dendrolimus sibiricus* has not been recaptured in the Moscow, approximately 37^{th} meridian east, or west of Moscow since 2001.

The trappings of these alleged *D. sibiricus* specimens close to Moscow back in 2001, triggered new studies and risk analyses predicting the risk of this species, e.g. to European forests (EPPO, 2005), to Finland by Möykkynen and Pukkala (2014) and to Poland (Kubasik et al., 2017). The Panel consider these studies as important precautionary reactions to what possibly could be signals of rapid spread. On the other hand, the Panel is of the opinion that such findings could also be a case of temporary presence, or spread, of the species. If subsequent surveillance shows that the species either is not causing any damage, or the surveillance does not recapture the species, indicating that the species has not been able to persist, the risk assessment should be updated and balanced with these results. In case it is suspected that the finding is due to an event of misclassification or otherwise cannot be confirmed, the studies and the risk assessments, which have been based on such data, should be revised.

The estimated westward spread of 50 km/year, reported by EPPO (2005) and by (Möykkynen and Pukkala, 2014), was probably based on the assumption that *D. sibiricus* was present in the Moscow area, which is not considered as a valid basis for the present assessment. There were no citations or calculations given for the statement of 50 km/year spread by EPPO (2005) or by Möykkynen and Pukkala (2014).

In addition, Baranchikov et al. (2006) maintained that *D. sibiricus* is not present in the Republic of Mari El. However, according to Oleg A. Kulinich (personal commutation), Russian NPPO registered *D. sibiricus* in the Republic of Mari El (approximately 47th meridian), Republic of Chuvash (approximately 46th meridian) and Kirov region (approximately 50th meridian) in 2016 (Figure 1, blue regions).

In agreement with Mikkola and Stahls (2008) and Baranchikov et al. (2006), the conclusion is that the westward spread of *D. sibiricus* is very slow or non-existent.

Dendrolimus superans

The probability of natural spread as an entry is considered as very unlikely with a low level of uncertainty.

To the best of the Panels knowledge *D. superans* has never been intercepted outside its natural habitat in the Far East Russia, Japan and Northern China. The moth is not expected to spread naturally from its current area of distribution in the Sakhalin- and Kurile Island (Sakhalin Oblast) in Russia, and from Hokkaido and the North of Honshu in Japan, to Norway.

3.1.2 Probability of the pest being associated with the pathways

The overall probability of the pest being associated with the pathways are considered as very likely with high uncertainty.

Regarding the commodity "Wood in the rough", it is probable that under non-outbreak conditions the pest occurrence has a low density throughout the area of distribution during the summer. Therefore, during logging, it is impossible to distinguish between trees infested with *D. sibiricus* larvae and trees not infested by *D. sibiricus* larvae. However, imago, larvae and cocoons will not be present when logging during the winter. This since, overwintering larvae hibernate in the ground, in the soil or under litter.

Regarding the commodity living trees and foliage and branches, one may make the same assumption that the pest occurrence may be at a low density throughout the area of distribution during the summer. In addition, the pest could be present in the soil during the winter in immediate proximity to the trees, i.e. nursery pots.

3.1.3 Probability of survival during transport or storage

The overall probability of the pest to survive during transport and storage are considered as moderately likely with a high uncertainty.

The Panel considers that for the commodity "Wood in the rough", eggs, larvae, cocoons and imago would be vulnerable to physical stress and other external forces and environmental stresses during transport and storage. Because eggs, larvae, cocoons as well as imago live on needles and branches of the trees, these stages may easily be crushed during transport and storage. Furthermore, the commodity "Wood in the rough" are cut trees without any needles and branches and, therefore, might be less suitable for survival of the larvae and imago.

The Panel concludes that the highest probability of survival of *Dendrolimus* spp. exists in the commodities "Living trees" and "Foliage, branches and other parts of plants", because they may be handled more carefully and are transported in protected consignments.

To the knowledge of the Panel, there are no commercial procedures applied to any of the above-mentioned commodities that would decrease the probability of survival during transport or storage, if phytosanitary measures are not applied.

3.1.4 Probability of the pest surviving existing pest management procedures

The overall probability of the pest to survive existing pest management procedures are estimated to be unlikely with medium uncertaincy.

It is forbidden to import into Norway Coniferales of plants, wood with bark and chips of wood with bark, isolated bark and wood waste of Coniferales from Non-European countries and Portugal are prohibited according to "Regulations of 1 December 2000 no. 1333 relating to plants and measures against pests" (Ministry of Agriculture and Food, 2017). Furthermore, *D. sibiricus* is also included in the EU Plant Health Legislation by EU Directive 2000/29 Annex I/AI, requiring a phytosanitary certificate issued by Russia, ensuring that plants and plant products are inspected and free from *D. sibiricus* (Council Directive 2000/29/EC, 2000).

3.1.5 Probability of transfer to a host

The probability for the pest to transfer to a host is considered to be likely with a low uncertainty.

In most cases, both wood in the rough and plants for planting arrive all year round, and these commodities are usually stored outdoors. Therefore, taking *D. sibiricus* flight ability into consideration, the species will generally have no problems reaching hosts.

3.1.6 Conclusions on the probability of entry

In conclusion the probability of entry of *D. sibiricus* and *D. superans*, from areas outside of the PRA area to a suitable habitat within the PRA area are considered as unlikely with a medium level of uncertainty.

The overall assessment behind of this conclusion is that the overall probability of entry by human mediated pathways for *D. superans* and *D. sibiricus* is considered as unlikely with a medium level of uncertainty. The probability of natural spread as an entry of *D. sibiricus* to the PRA area is rated as unlikely with medium uncertainty, while the rating of the probability of natural spread as an entry of *D. superans* to the PRA-area is considered as very unlikely with low uncertainty.

3.2 Probability of establishment

3.2.1 Climatic suitability

Rating of climate suitability: Moderately likely

Rating of uncertainty: High

Möykkynen and Pukkala (2014) studied the climate suitability in Europe for *D. sibiricus,* and they concluded that the climate in central and northern Europe is favourable for establishment. The basis for this analysis was a CLIMEX model originally parameterised by Flament et al. (2017). However, in the latter study, the authors stated that they based the parameter fitting partly on the map "Siberian moth distribution and areas of injuries", drawn by Rozhkov (1963), except for the mapped western distribution limit. The latter fact seems to be a key assumption with respect to the results of Flament et al. (2017) for the projected distribution for *D. sibiricus* in regard to the risk of establishment in the PRA area of Norway. It should also be noted that, while the "Rozhkov distribution" focused on areas of injuries, Flament et al. (2017) were more focused on the potential geographical distribution of the organism.
The CLIMEX model does not take into account the effect of snow cover. In the case of a species having a strategy of overwintering on the ground, or below ground, the CLIMEX model will have important shortcomings with respect to predicting the actual climate conditions that a ground dwelling, or below ground dwelling species, experience in areas with regular snow cover during winter. Therefore, the Panel has the opinion that the CLIMEX model by Flament et al. (2017) is not able to predict winter survival for *D. sibiricus* outside is current distribution. Baranchikov et al. (2010) also assessed the potential distribution of *D. sibiricus* by applying a bioclimatic model (unspecified), and they concluded that the potential for distribution is more constrained than the Flament et al. (2017) study suggested. Milder winter conditions in European Russia than in Siberia may be a limiting factor, as successful overwintering of larvae requires continuous continental-type winters. A large part of Siberia was found to be climatically suitable by Baranchikov et al. (2010) , and the potential distribution closely matches the existing distribution of the pest there. However, for both of these studies the supporting information on presence/absence data is very sparse. Baranchikov et al. (2006) questioned the theory that the distribution of *D. sibiricus* to the

west of the Ural Mountains is due to mild winters. The current distribution areas of *D. sibiricus* have more continental climate, with higher summer temperatures, lower winter temperatures (Figures 6 and 7) and less precipitation (Figure 8) than the PRA-area (Kharuk and Antamoshkina, 2017). Even when looking to the east of Russia, where *D. sibiricus* is said to be present all the way to the pacific coast, e.g. the coastal city of Vladivostok, the climate is still dominated by cold dry winters and warm summers with low perciptation.
Dendrolimus sibiricus outbreaks are associated with high summer temperatures (Figure 6) and low precipitation, (Figure 8) i.e. drought. This is similar to the climate requirements of the European species *D. pini* (Haynes et al., 2014). Generally, drought stress has been shown to lower the quantity of defensive compounds in the host trees, which make the trees more susceptible to attack (Netherer et al., 2015). In proximity to the oceans, trees experience a more humid climate with less extreme temperature fluctuations, i.e. there is less drought than in continental climates with milder winters. In addition, successful overwintering of *D. sibiricus* larvae requires continuous winters of a continental type with no autumn thaws, as they are fatal for the larvae (Baranchikov 2009). Therefore, stable sub-zero winter temperatures are probably important for the *D. sibiricus* larvae (Figure 7).

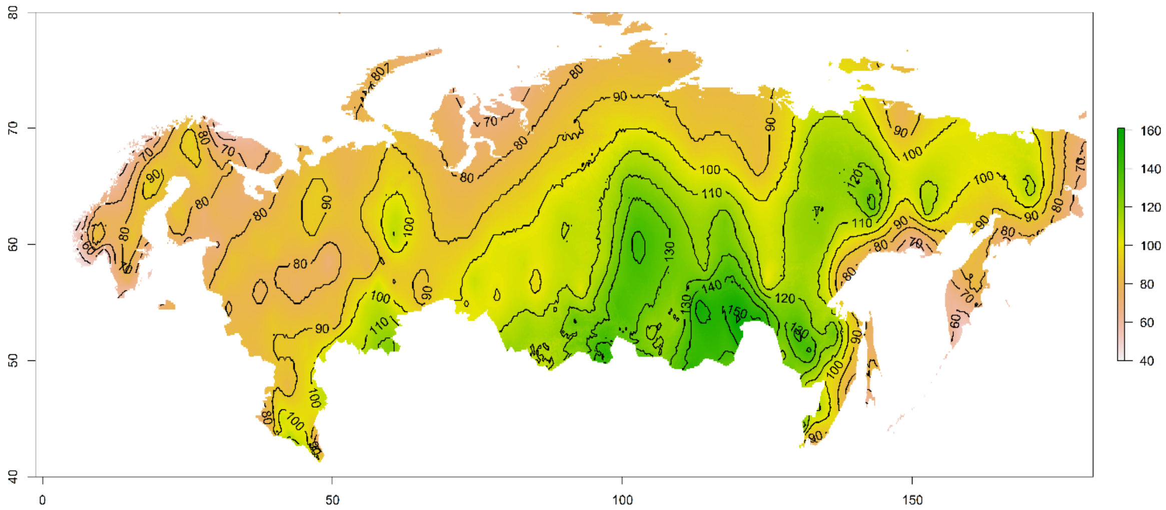

Figure 6. A map of Russia, Finland, Sweden and Norway showing continentally (monthly maximum temperature minus monthly minimum temperature (°C *10)).

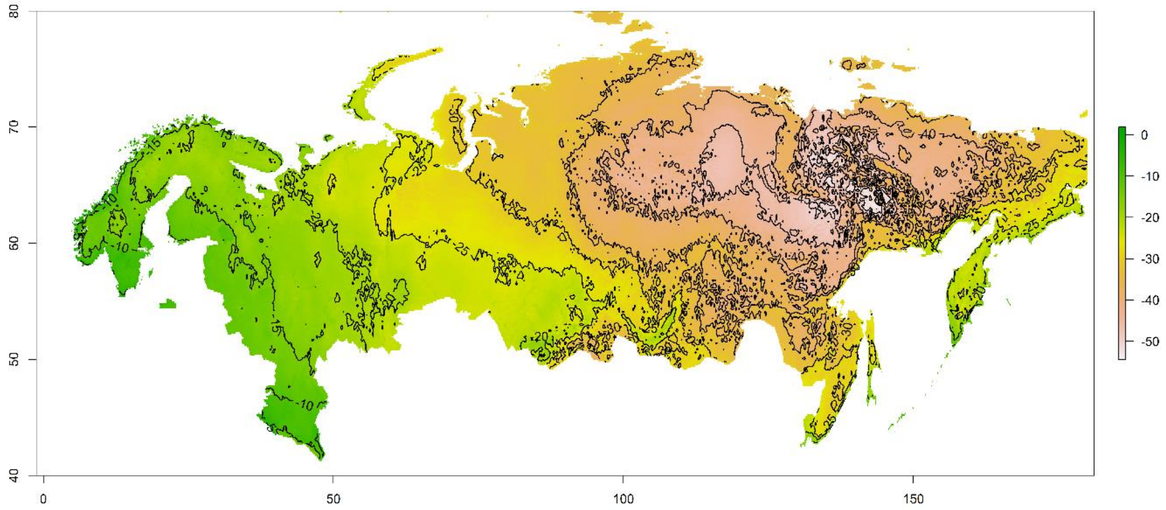

Figure 7. The minimum temperatures (°C) of January, the coldest month (30 year normal), are generally lower, where *Dendrolimus sibiricus* is present, than in the PRA-area.

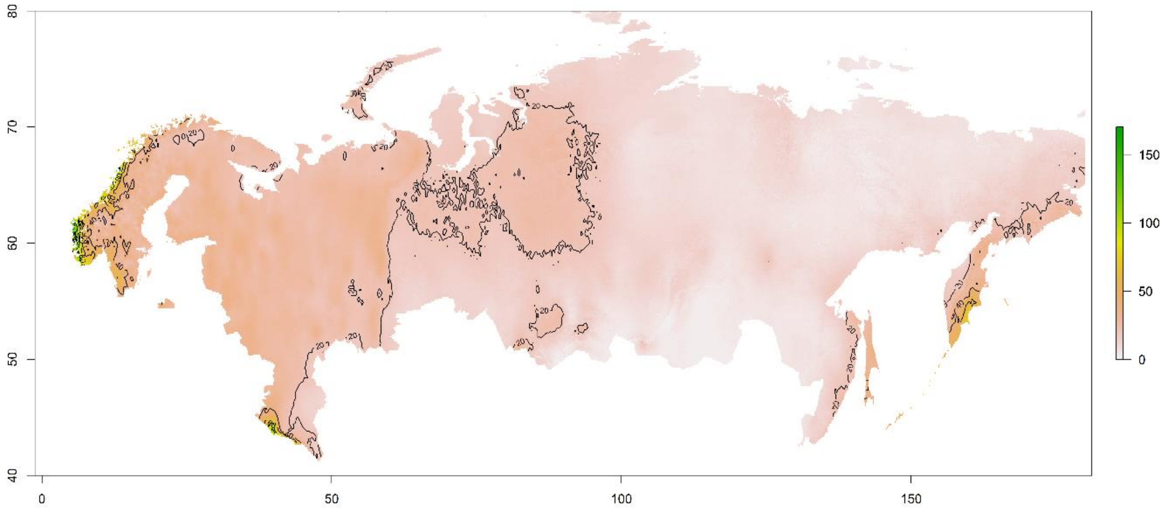

Figure 8. Precipitation during the driest month of the year (August) shows that the total precipitation (millimetres), is lower East of the 60th meridian, and that precipitation is much higher in parts of the PRA-area.

3.2.2 Natural enemies

Telenomus tetratomus is an important insect egg parasitoid, which regulates the population densities of several insect species in Russia under non-outbreak conditions (EPPO, 2005). This species is also present in Norway, where it attacks *D. pini* eggs (Adolfsson, 1984). There are large numbers of parasites attacking *D. sibiricus and D. superans* in Russia (EPPO, 2005), and some of these may also be present in Norway. In Scandinavia, there are several other species of parasitoids on *D. pini* (Adolfsson, 1984), some of which may also attack *D. sibiricus*.

3.2.3 Conclusion of the probability of establishment

Rating of probability of establishment: Unlikely

Rating of uncertainty: Medium

The PRA-area has two potential hosts, *Picea abies* and *Pinus sylvestris*, both of which are widely distributed within the area. However, these species are considered as intermediate and poor hosts, respectively (see chapter 2.1.3). In addition, most of the PRA-area has a suboptimal environmental suitability (chapter 3.2.1), with winter temperatures that are not sufficiently cold and with too much precipitation in the summer to allow establishment. The potential of the pests to adapt to new environments is unknown. However, the pest's life cycle is dynamic, which may be beneficial for adaption to new and adverse conditions.

Dendrolimus sibiricus has never been intercepted outside its main area of distribution, and in Russia there is no, or very slow spread westwards. In addition, there are currently no imports of commodities that would support entry to the PRA-area.

3.3 Probability of spread after establishment

Rating of probability of spread: Likely
Rating of uncertainty: High

The exact flight capacities of *D. sibiricus* and *D. superans* are unknown, but their behaviour probably depend on the density of suitable host trees, where the species will seek out the nearest suitable host. However, lappet moths are strong flyers, and *D. sibiricus* is reported to fly up to 100 km per year (EPPO, 2005 and references therein). This flight behaviour is not unlikely, since other tree killing moths e.g. the Spruce budworm (*Choristoneura fumiferana*), are known to mass migrate up to 200 km per year (Boulanger et al., 2017).

Wind direction and wind strength will strongly affect the spread of the moths. In addition, the movement of the commodities: Plants for planting (chapter 3.1.1.4), Wood products (chapter 3.1.1.5) and Foliage or branches (chapter 3.1.1.6), may further aid long-distance spread after establishment.

3.4 Endangered area within the PRA area

The part of the PRA area, where ecological factors may be favourable for establishment, would be the areas with the coldest continuous winters, and the warmest and driest summers. This would probably be the counties furthest from the moderating effects of the Atlantic Ocean, e.g. the counties of Akershus, Hedmark, Oppland, and possibly inner parts of Finnmark.

3.5 Assessment of impact

Dendrolimus sibiricus and *D. superans* are considered the most important defoliators and the most destructive pests of conifers in their natural habitat in Russia. In the period from 1994–1996, *D. sibiricus* damaged 700.000 hectares of forest in the Krasnoyarsk krai (Zhirin et al., 2016), and between 1954 and 1957 *D. sibiricus* killed over 1.5 million hectares of pine near the Ket and Chulym rivers (Kharuk et al., 2016). During a period of 25 years, between 1932 and 1957, *D. sibiricus* damaged 7 million hectares of forest and killed 50% of the trees in West Siberia and Chita Oblast (Baranchikov and Montgomery, 2014; EPPO, 2005). Furthermore, in China, *D. sibiricus* is considered a major defoliator of the Dahurian larch, *Larix gmelinii* (EPPO, 2005). For *D. superans* the pattern of damage is similar. During the period from 1959 to 1964, *D. superans* caused severe damage to approximately 15.000 hectares of larch-pine forests on the Sakhalin island, Russia (EPPO, 2005). More recently (1986 to 1989), *D superans* caused the death of 1.800 hectares of forest in Russia(EPPO, 2005).

Continuous defoliation by *D. siiricus* and *D. superans* may cause death of forests over large areas, either directly or by leaving forests prone to subsequent attacks by other forest pests, such as woodborers e.g. Scolytidae spp., Cerambycidae spp. (EPPO, 2005). In addition, outbreaks may make the forests more predisposed to forest fires (EPPO, 2005).

Furthermore, the reestablishment of forests after an outbreak is complicated (EPPO, 2005), consequently the attack may lead to major changes in the environment and biodiversity.

In bioassay experiments with *D. sibiricus* and *D. superans,* the two Norwegian hosts *Picea abies* and *Pinus sylvestris* were described as intermediate and poor hosts, respectively (Kirichenko et al., 2011). However, it is unknown how severe the impact would be under Norwegian climatic conditions, which are regarded as suboptimal. Severe damage caused by outbreaks of *D. sibiricus* and *D. superans* in Norway would probably require several years of drought stressed host trees, similar to the circumstances observed during the latest outbreaks of *D. pini* in Elverum and Løten, Hedmark County, Norway in 1812-1816 and in 1902-1904. However, interactions between *D. sibiricus* and *D. pini* could possibly result in more severe outbreaks than those caused by *D. pini* alone.

3.6 Conclusion of the impact

The panel concludes that it is unlikely that the pests will have an impact in the foreseeable future within the PRA area. Therefore, the panel concludes that there will be no economic impact from an introduction of the pests. However, this is an assessment with a high uncertainty.

4 Identification and evaluation of risk reduction options

4.1 Risk reduction options to prevent entry and establishment

Existing phytosanitary requirements, as stated in the commodity-specific phytosanitary measures "PM 8/2 (2) Coniferae" (EPPO, 2014), are regarded as highly applicable for Norway to reduce the risk of introduction of *D. sibiricus* and *D. superans*.

The option "Pest-free area for *D. sibiricus* and *D. superans*" is problematic, since the true distribution of the species is uncertain in the European part of Russia (west of the 60 latitude). However, ISPM NO 4. "Requirements for the establishment of pest free areas" could be implemented.

EPPO (2005) recommended that to prevent the introduction of *D. sibiricus* and *D. superans* through international movement of commodities, plants for planting and cut branches of host plants from the infested areas should be free from soil. Alternatively, such commodities could originate in a pest free area, be produced in protected houses, fumigated or imported during the winter. Wood should be debarked or heat-treated, originate in a pest free area or be imported during the winter, and isolated bark should be treated to destroy contaminating insects.

Any import of *Larix* spp., *Abies* spp., *Pinus* spp. and *Picea* spp., genera which the pest is strongly associated with, from areas in Russia where the pests are present, may result in a high probability of entry of *D. sibiricus* and *D. superans* in Norway, since egg clusters, larvae and imago may be present on branches and on the stems of the trees. *Dendrolimus superans* prefers forests older than 50 years of age (EPPO, 2005). However, the panel cannot exclude that the two *Dendrolimus* species may occur also on younger trees, such as plants for planting.

In the regulations of 1 December 2000 no. 1333 relating to plants and measures against pests (Ministry of Agriculture and Food, 2017) four specific special provisions concerning import to Norway are described.

§ 16 Import prohibitions, Annex 3, no. 1.1 and 1.2

It is forbidden to import into Norway Coniferales of plants, wood with bark and chips of wood with bark, isolated bark and wood waste of coniferales from Non-European countries and Portugal and all chips of Coniferales from Canada, China, Japan, Korea, Mexico, Portugal, Taiwan and the USA.

§ 17 Conditions of import, Annex 4A, no. 1.1, 1.3 and 5

Official statement that plants and wood of Coniferales originating from specific countries meet the requirement in the annex.

§ 18 Packaging, Annex 4A, no. 1.2

Wood packaging material is covered by specific requirements (in accordance with ISPM 15) for the import of certain plants and other regulated articles. cf. § 17 and Annex 4A.

§ 19 Consignments requiring phytosanitary certification, Annex 5A

Consignments containing plants and other regulated articles (wood) mentioned in Annex 5A shall on import be accompanied by a phytosanitary certificate for export in original or a phytosanitary certificate for re-export in original.

The EU Council Directive 2000/29 describe the following risk reduction measures:

Plants, plant products and other objects the introduction of which shall be prohibited in all member states:

- Isolated bark of conifers = Non-European countries

- Wood in the form of chips, particles, wood waste or scrap and obtained in whole or part from *Acer saccharum*, *Castanea*, *Platanus, Populus*, *Quercus* originating in non-European countries, and conifers (Coniferales) originating in non-European countries other than Canada, China, Japan, Korea, Taiwan and the USA.

- Plants of conifers (Coniferales) other than fruit and seeds, over 3 m in height, originating in non-European countries.

4.2 Management options to prevent further spread

4.3 Regulation of *Dendrolimus sibiricus* and *D. superans*

The import into Norway from Russia of commodities, that are potential hosts for *D. sibiricus* and *D. superans,* has declined during the last 20 years. There has been no import of these commodities during the last five years.

There was significant import of the commodities «Coniferous wood in the rough», «Wood for pulping of spruce and other Coniferous species», «Coniferous saw wood», «Wood for pulping of pine» and «Wood for pulping of other» from Russia. The import of these commodities peaked around the turn of the century and has since ceased. There is an ongoing, but very limited import of "Living plant of unknown species" from China. There was also a very limited import of «Coniferous sawn wood» from Japan in 1992.

Future import will depend on demand for these commodities by Norwegian industries, construction companies and for other purposes.

Both *D. sibiricus* and *D. superans* were added to the «EPPO A2 Action List» in 2002, and they are on the current «EPPO A2 List of pests recommended for regulation as quarantine pests» (EPPO, 2017).

Dendroliums sibiricus and *D. superans* are not regulated in Norway.

4.3.1 Establishment of demarcated zones

Following an outbreak, demarcated zones (infected zone and buffer area) should be established as soon as possible. The Forestry Commission of the United Kingdom recommends the establishment of regulated zones of at least 10 km radius around infested trees (Poulsom, 2016).

4.3.2 Pesticide application

It will be extremely difficult to limit an outbreak of *D. sibiricus* by pesticide application in Norwegian forests. The control of *D. sibiricus* in Russia includes the use of both chemical and bacterial products, which are applied by aircrafts and helicopters or by ground based spraying. In addition to chemical insecticides, bacterial insecticides containing *Bacillus thurigenienesis* var. *kurstaki* have been used to control *D. sibiricus* in Russia.

4.3.3 Imported host plants for planting and cut branches from the infested area should be free from soil

EPPO (2005) recommended that, to prevent the introduction of both *D. sibiricus* and *D. superans*, plants for planting and cut branches imported from infested areas should be free from soil.

4.3.4 Burn infested material

Burning of infested material is suggested as a Pest management procedure by the Forestry Commission, UK (Poulsom, 2016).

4.3.5 Adhesive tape

Adhesive tape has been used to trap *Dendrolimus* larvae and prevent their upward movement on the trunks of trees (Poulsom, 2016).

4.4 Evaluation of effectiveness and feasibility of risk reduction measures

4.5 Regulation of *Dendrolimus sibiricus* and *D. superans*

Regulation of *D. sibiricus* and *D. superans* to limit import to pest free areas will reduce the risk for entry of these pests. However, the distribution of the two *Dendrolimus* spp. is not well known.

A regulation stating that the import of plants for planting and cut branches of host plants should be free from soil, will reduce the risk for introduction of the pests.

4.5.1 Demarcated zones

A prohibition should be imposed on the movement of untreated host material with bark out of the demarcated zone. This applies to wood, branches and other coniferous plant materials and soil that have the potential to be a vector for *D. sibiricus* and *D. superans*.

Prohibition of movement out of the demarcated zones of infested commodities will reduce the risk for spread of *D. sibiricus* and *D. superans.*

4.5.2 **Pesticide application**

The Russian experience is that the application of chemical and bacterial products from the air and on the ground have only limited effects, because of the tremendous amounts of larvae attacking susceptible forest trees during an outbreak of *D. sibiricus* or *D. superans*.

There are currently no pesticides approved for insect control in forestry in Norway. With restrictions, similar to the current regulations on chemical weed control in Norwegian forestry, the effect of an application of pesticides on an outbreak of *D. sibiricus* or *D. superans* would be very limited.

The regulations for chemical control of vegetation in Norwegian forests states that herbicide application should only be used when it is clearly more effective than mechanical methods, and at the same time the herbicide does not conflict with landscape qualities and recreational values. Vegetation that is on average more than 2 meters high should not be sprayed (Levende skog, 2006).

Pesticide application will have only very limited effect on an outbreak of *D. sibiricus* or *D. superans.*

4.5.3 **Burning of infested material**

Burning of infested material will reduce the risk for spread of *D. sibiricus* and *D. superans* if all infested material is burnt. However, burning must comply with environmental protection regulations.

4.5.4 **Adhesive tape on trees**

A band of adhesive tape around tree trunks prevents the upward movement of insects. This is a relevant control method of *D. sibiricus* and *D. superans* on individual trees in parks and gardens. This method is not feasible on a large scale in forestry.

4.6 Conclusion on the risk reduction measures to prevent entry and establishment

The probability of risk reduction measures to prevent entry and establishment are for both situations considered as unlikely. However, with a high level of uncertainty.

Regulations to stop import of host plant materials, that may harbour *D. sibericus* and *D. superans*, will reduce the risk for entry of the pests. However, the distribution of the two *Dendrolimus* spp. is not well known.

A regulation stating that the import of plants for planting and cut branches of host plants should be free from soil, will reduce the risk for entry of the pests.

Measures such as demarcated zones, pesticide application, regulation of imports, burning of infested materials and adhesive tape on susceptible trees are unlikely to prevent introduction of the pests.

5 Uncertainties

In the following tables (Table 5 and 6) presented in this chapter, all the uncertainties that have been identified in the different steps of the current opinion are presented.

Table 5. List of Probability and uncertainties for pathways.

Pathway	Probability	Uncertainty
Natural spread of *D. sibiricus*	Unlikely	Medium
Natural spread of *D. superans*	Unlikely	Low
Living trees	Unlikely	Medium
Coniferous wood in the rough	Unlikely	Medium
Foliage, branches and other parts of plants	Unlikely	High
Probability of the pest being associated with the pathway	Very Likely	High
Probability of survival during transport or storage	Moderately likely	High
Probability of the pest surviving existing pest management procedures	Unlikely	Medium
Probability of transfer to a suitable host	Likely	Low
Conclusion of the probability of entry	Unlikely	Medium

Table 6. List of Probability and uncertainties for establishment and spread.

Establishment and Spread	Probability	Uncertainty
Conclusion of the probability of establishment	Unlikely	Medium
Probability of spread after establishment	Likely	High

6 Conclusions (with answers to the terms of reference)

Natural spread of *D. sibiricus* westwards is absent or very slow. There are three main reasons why *D. sibiricus* and *D. superans* are unlikely to spread to the PRA-area in the foreseeable future;

There is currently no trade of relevant commodities to facilitate entry into the PRA-area.

The PRA-area and neighbouring countries lack the main hosts of *D. sibiricus* and *S. superans*.

There are indications that *D. sibiricus* prefers a more continental climate than the climate in the PRA-area.

These three factors and the lack of documentation of the alleged westward spread of *D. sibiricus* suggest that this species will not spread to the PRA-area in the foreseeable future. However, the trade in plants for planting and wood commodities is highly dynamic in space and time, and the risks presented here are based on historical data. Therefore, they do not necessarily reflect the future. However, it is forbidden to import into Norway Coniferales of plants, wood with bark and chips of wood with bark, isolated bark and wood waste of Coniferales from Non-European countries and Portugal are prohibited according to "Regulations of 1 December 2000 no. 1333 relating to plants and measures against pests" (Ministry of Agriculture and Food, 2017).

1. **Summarize current knowledge about the taxonomy of *D. sibiricus* and *D. superans* and closely allied lappet moths as background for identifying their current distribution areas.**

Dendrolimus sibiricus and *D. superans* should be considered as two separate species (Kononov et al., 2016; Mikkola and Stahls, 2008). Historically, many researchers have considered *D. superans* to be a single species with two subspecies; *D. superans sibiricus* Tschetverikov and *D. superans albolineatus* Butler (Kononov et al., 2016). However, according to EPPO (2005) the common international opinion has been that they are two separate species. Genetic analysis by Kononov et al. (2016) has not identified *D. superans* in mainland Russia, so all references to *Dendrolimus superans albolineatus* in mainland Russia should be regarded as *D. sibiricus.*

The *Dendrolimus* species that occur in Europe and contiguous Russia are according to Mikkola and Stahls (2008) and Kononov et al. (2016):

Lepidoptera (Order)
Lasiocampidae (Family)

a. *Dendrolimus* Germar, 1812 (Genus)
    i. *D. pini* (Species)
    ii. *D. sibiricus* (Species)
    iii. *D. superans* (Species)

2. Summarize current knowledge of spread of the species and their host plants, including natural spread. Is there a risk that *D. sibiricus* can spread naturally from Russia to Norway?

Dendrolimus sibiricus is not expected to spread naturally from its current western distribution limit in Russia (Chuvash Republic, Mari El Republic and Kirov Oblast, Figure 1) to Norway within the foreseeable future. It is not possible to state, with absolute certainty, that the species is not moving westwards based on the current data. However, historical observations indicate that its westward spread is very slow or non-existent. *Dendrolimus sibiricus* has probably been present west of the 60th meridian since the late 19th century or early 20th century without expanding westwards (Mikkola and Stahls, 2008 and references therein). A few individuals were reportedly pheromone-trapped close to Moscow in 2001, but this observation is rejected by Baranchikov et al. (2006) on the basis of possible misidentification of *D. pini* as *D. sibiricus*. In addition, according to Baranchikov et al. (2010) , the distribution of *D. sibiricus* is limited by the distribution of its preferred host species, *Abies sibirica*, *Pinus sibirica* and *Larix sibirica* (Figure 1), and suboptimal climate conditions in European Russia.

3. **List countries where the status of the pests should be considered as present.**

Dendrolimus sibiricus should be considered as present in: Russia, Kazakhstan, Mongolia and China. The previously stated presence in the Democratic People's Republic of Korea and the Republic of Korea is not supported by Kononov et al. (2016).

Dendrolimus superans should be considered as present in Japan, China, and in Primorsky krai and on the Sakhalin Island, Russia (Kononov et al., 2016).

4. **Identify possible pathways for introduction of the two species into Norway.**

The two main pathways of concern for *D. sibiricus* are: (I) Living trees (plants for planting) and (II) wood commodities of conifer wood.

(I) Historically, the import of plants for planting is the pathway of most concern for the introduction of non-native forest insects, because transport of non-native living trees may also carry the non-native forest insects associated with that tree species at origin. All imports of living conifer host trees from the area where *D. sibiricus* is present could, therefore, lead to a potential introduction into the PRA-area, because the pest spends part of its life cycle on the host trees. There is currently no import of living conifer trees from Russia, and there has not been any import in the past 20 years (see chapter 3.1.3.1). Furthermore, it is forbidden to import into Norway Coniferales of plants, wood with bark and chips of wood with bark, isolated bark and wood waste of Coniferales from Non-European countries and Portugal are prohibited according to "Regulations of 1 December 2000 no. 1333 relating to plants and measures against pests" (Ministry of Agriculture and Food, 2017). However, as global trade increases and trade patterns change rapidly, attention to the origin of plants for planting should be closely monitored, and coupled with the distribution of *D. sibiricus* and *D. superans*.

(II) Conifer wood commodities, i.e. round wood and pulpwood, which are not sawn longitudinally, carrying its naturally rounded surface and containing bark, originating from areas where *D. sibiricus* or *D. superans* occurs.

Females of *D. sibiricus* will lay their eggs on the bark of tree trunks, and thus eggs can be transported between countries. To avoid this, bark needs to be removed from conifer wood commodities originating from areas where *D. sibiricus* is present.

5. **Assess the probability of the pests entering Norway from countries listed in (3) through the pathways listed in (4.).**

(I) There is currently no import to Norway of plants for planting from countries where *D. sibiricus* and *D superans* are present. In addition, the statistics currently available only provide limited information according to the harmonised custom system. Assessing the probability of *D. sibiricus* or *D. superans* entering Norway would require species-specific import statistics of the hosts. However, because the probability of the pests entering Norway is directly related to the propagule pressure (the number of individuals or host plants arriving over time), reduced import rate will reduce the probability of arrival, i.e. no imports equals zero probability.

(II) There is currently no import of conifer wood commodities. However, as global trade increases and trade patterns change rapidly, attention to the origin of plants for planting should be closely monitored, and coupled with the distribution of *D. sibiricus* and *D. superans*.

6. **Estimate the potential of establishment and further spread of the species in the Norwegian environment if they are introduced, also regarding climatic changes in the future.**

The potential for establishment of *D. sibiricus* are considered as unlikely, with medium uncertainty. The potential of establishment for *D. superans* are considered as very unlikely with low uncertainty.

The larvae of *D. sibiricus* probably require continuous, continental winters (Baranchikov et al., 2010), possibly a subarctic climate. Both establishment and further spread will be negatively affected by the Norwegian climate, with winter temperatures that are too high and periods with thawing, as well as too much precipitation during summer. In Norway, the average temperature has increased every decade during the past 115 years, and the temperature is expected to increase further, with the highest temperature increase during the winter months, according to both IPPC scenarios RCP8.5 and RCP4.5 (Norsk klimaservicesenter, 2015). In addition, the yearly precipitation has also increased in the period 1900-2014, and the precipitation is expected to increase further (Norsk klimaservicesenter, 2015), which would make future climates even less suitable for *D. sibiricus*.

The main host plants of *D. sibiricus* are not present in Norway. *Picea abies* and *Pinus sylvestris* are potential hosts in Norway, but they are considered intermediate and poor hosts, respectively.

7. **Assess the potential consequences (environmental, economic and social effects) if they are introduced and established in Norway.**

   We would like you to look at these effects in two scenarios:

   a) No regulations for these insects (no measures taken).

   b) The insects are regulated as quarantine pests with certain specific requirements.

The panel consider that the answers to terms of reference 7a & b can be identical, as the assessment has not found evidence to suggest that *D. sibiricus* qualifies as a quarantine pest.

With no measures taken it is assessed that no significant impact is expected on Norwegian forest production and ecosystems. The reason for this assessment is that the *Dendroliums* species are not expected to cause mass attacks under Norwegian climatic conditions and host availability.

Without any regulations it is possible that the *Dendrolimus* species would enter the PRA area from time to time. In such a situation the NFSA should be prepared for the case that the pest would cause attention, and the Authority could react by presenting the information given in this opinion.

Today, it is forbidden to import into Norway Coniferales of plants, wood with bark and chips of wood with bark, isolated bark and wood waste of Coniferales from Non-European countries and Portugal are prohibited according to "Regulations of 1 December 2000 no. 1333 relating to plants and measures against pests" (Ministry of Agriculture and Food, 2017). Furthermore, *D. sibiricus* is also included in the EU Plant Health Legislation by EU Directive 2000/29 Annex I/AI, requiring a phytosanitary certificate issued by Russia, ensuring that plants and plant products are inspected and free from *D. sibiricus* (Council Directive 2000/29/EC, 2000).

The larvae of *D. sibiricus* and *D. superans* feed on the needles of their conifer hosts. Because the insects have overlapping generations, and a life cycle that can last for four years, successive defoliation can kill the host trees. In bioassay experiments with *D. sibiricus* and *D. superans,* the two Norwegian hosts *Picea abies* and *Pinus sylvestris* were described as intermediate and poor hosts, respectively (Kirichenko et al., 2011). However, it is unknown how severe the impact would be under Norwegian climatic conditions, which are regarded as suboptimal. Severe damage caused by outbreaks of *D. sibiricus* and *D. superans* in Norway would probably require several years of drought stressed host trees, similar to the circumstances observed during the latest outbreaks of *D. pini* in Elverum and Løten, Hedmark County, Norway during 1812-1816 and in 1902-1904. However, interactions between *D. sibiricus* and *D. pini* could possibly result in more severe outbreaks than those caused by *D. pini* alone.

8. Identify relevant risk reduction measures and evaluate their effectiveness and feasibility. For wood packing material, also consider if ISPM 15 is effective enough to prevent the introduction of the pests.

The following risk reduction measures have been identified by the Panel: Import from pest free area, requirement of debarked, heat-treated, treated with ionizing radiation or fumigated wooden materials (EPPO Standard PM 10/6, PM10/8 and PM 10/7 respectively). Plants should be free from soil (EPPO Standard PM 3/54), harvested and imported only in the period between 1st October and 31st March. This measures also applies to plants grown under protected conditions.

Among the risk reduction measures identified, debarking of wood is assessed as the most relevant measure because it is both efficient and technically feasible. The problem with pest free area as a measure is that the true distribution of *Dendrolimus* spp. is not known. With exception from the combination of pest free area and harvesting in the period between 1st October and 31st March, the remaining risk reduction measures identified are generally assessed to be effective, but more demanding with respect to technical implementation.

Effectiveness of the risk reducing measures, described in the EPPO Standards 8/2 (2) Coniferae, under genus-specific requirements for *Abies, Picea, Pinus, Larix* and *Tsuga* for the commodities: Plants for planting (except seeds), cut branches, non-squared wood and wood originating in countries where *D. sibiricus* or *D. superans* occur, are regarded as applicable for Norway.

EPPO Standards 8/2 for conifer wood applies for imports of all conifer wood originating outside Europe, but does not apply for European Russia i.e. west of the 60^{th} meridian.

ISPM 15 deals with debarked wood packaging material and is not regarded as relevant for *Dendrolimus*, and, therefore, considered to be effective enough to prevent the introduction of the pests.

7 Data gaps

In this chapter (Table 7), insufficient knowledge and/or data related to the topic covered in the risk assessment are described. All data gaps described were uncovered during the risk assessment process.

Table 7. Knowledge and/or data uncovered in the current risk assessment and consequences if the knowledge and data would be provided.

Data gaps	Consequences if data gaps are filled (for VKM, the assigner, and/or the society)
Wide statistical categories: It is impossible to separate relevant commodity categories to species level through the data from statistics Norway.	Phytosanitary certificates contain information on plant products or other regulated articles and specified phytosanitary import requirements. Access to Plant Health Certificates with species level information and the origin of the plants would allow assessing the probability and uncertainty more accurately.

Data gaps	Consequences if data gaps are filled (for VKM, the assigner, and/or the society)
Insufficient knowledge of biological information of environmental stress factors, such as cold period, heath period, dependency of snow cover for survival.	Research is needed, or needs to be made available in English, on the species capacity to survive long-term or short-term exposure to low temperature at specific developmental stages and how this is affected by snow cover, i.e overwintering. Outbreaks of *D. sibiricus* has been analysed and quantified by remote sensing (Kharuk et al., 2004). However, the role of snow cover in the life cycle of *D. sibiricus* are not presented. By Remote sensing it should be relatively easy to analyse the correspondence of permanent snow cover during winter and the outbreak areas. Also, statements on the negative effect of precipitation need to be backed up by experiments.

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Appendices

Appendix I

List of publications and communications used to compile Figure 1.

Name of federal subjects in Russia	Reported as present	Reported as not present or disputed
Moscow	Gninenko and Orlinskii (2002) (Gninenko Y.U and Kryukov V.Y.U, 2007)	Mikkola and Stahls (2008) Baranchikov et al. (2006)
Sverdlovsk	Kulinich personal communication (2017)	
Tuva	Gninenko and Orlinskii (2002)	
Buryat	Gninenko and Orlinskii (2002) Mikkola and Stahls (2008)	
Tyumen	Orlinski (2006)	
Tomsk	Gninenko and Orlinskii (2002)	
Amur	Gninenko and Orlinskii (2002)	
Sakha (Yakutia)	Gninenko and Orlinskii (2002)	
Khabarovsk	Gninenko and Orlinskii (2002)	
Krasnoyarsk	Gninenko and Orlinskii (2002) N. and Beskorovainaia (2008) Valendik et al. (2006) Galkin (1993)	
Chita	Gninenko and Orlinskii (2002)	
Perm	Kulinich personal communication (2017) Mikkola and Stahls (2008)	
Udmurtiya	Kulinich personal communication (2017) Mikkola and Stahls (2008)	
Irkutsk	Gninenko and Orlinskii (2002)	

Name of federal subjects in Russia	Reported as present	Reported as not present or disputed
Primorye	Mikkola and Stahls (2008)	
Kirov	Kulinich personal communication (2017) Gninenko and Orlinskii (2002) Kononov et al. (2016)	
Marii-El	Kulinich personal communication (2017) (Gninenko Y.U and Kryukov V.Y.U, 2007)	Baranchikov et al. (2006) Mikkola and Stahls (2008)
Chuvash	Kulinich personal communication (2017)	
Chelyabinsk	Kulinich personal communication (2017) Mikkola and Stahls (2008)	
Khakass	Kononov et al. (2016)	
Sakhalin	Kononov et al. (2016)	
Novosibirsk	Gninenko and Orlinskii (2002) Kharuk et al., (2004)	
Altay	Gninenko and Orlinskii (2002)	
Bashkortostan	Gninenko and Orlinskii (2002)	

Appendix II

Ratings and descriptors are based on Appendix 2 in VKMs Risk Assessment of cockspur grass (Echinochloa crus-galli).

Table A1-1; Rating of probability of entry.

Rating	Descriptors
Very unlikely	The likelihood of entry would be very low because the pest: • is not, or is only very rarely, associated with the pathway at the origin • no import volume, • may not survive during transport or storage • cannot survive the current pest management procedures existing in the risk assessment area • may not transfer to a suitable habitat in the risk assessment area
Unlikely	The likelihood of entry would be low because the pest: • is rarely associated with the pathway at the origin, • very low import volume, • survives at a very low rate during transport or storage, • is strongly limited by the current pest management procedures existing in the risk assessment area, • has considerable limitations for transfer to a suitable habitat/crop in the risk assessment area.
Moderately likely	The likelihood of entry would be moderate because the pest: • is frequently associated with the pathway at the origin, • moderate import volume, • survives at a low rate during transport or storage, • is affected by the current pest management procedures existing in the risk assessment area, • has some limitations for transfer to a suitable habitat/crop in the risk assessment area.
Likely	The likelihood of entry would be high because the pest:

	• is regularly associated with the pathway at the origin, • high import volume, • mostly survives during transport or storage; • is partially affected by the current pest management procedures existing in the risk assessment area, • has very few limitations for transfer to a suitable habitat/crop in the risk assessment area.
Very likely	The likelihood of entry would be very high because the pest: • is usually associated with the pathway at the origin, • very high import volume, • survives during transport or storage; • is not affected by the current pest management procedures existing in the risk assessment area, • has no limitations for transfer to a suitable habitat/crop in the risk assessment area.

Table A1-2: Rating of the probability of establishment

Rating	Descriptors
Very unlikely	The likelihood of establishment would be very low because: • of the absence or very limited availability of suitable habitat/crop; • the unsuitable environmental conditions; • and the occurrence of other considerable obstacles preventing establishment.
Unlikely	The likelihood of establishment would be low because: • of the limited availability of suitable habitat/crop; • the unsuitable environmental conditions over the majority of the risk assessment area; • the occurrence of other obstacles preventing establishment
Moderately likely	The likelihood of establishment would be moderate because: • suitable habitats/crops are abundant in a few areas of the risk assessment area;

	• environmental conditions are suitable in a few areas of the risk assessment area; • no obstacles to establishment occur
Likely	The likelihood of establishment would be high because: • suitable habitats/crops are widely distributed in some areas of the risk assessment area; • environmental conditions are suitable in some areas of the risk assessment area; • no obstacles to establishment occur. • Alternatively, the pest has already established in some areas of the risk assessment area
Very likely	The likelihood of establishment would be very high because: • hosts plants are widely distributed; • environmental conditions are suitable over the majority of the risk assessment area; • no obstacles to establishment occur. • Alternatively, the pest has already established in the risk assessment area

Table A1-3: Ratings used for describing the level of uncertainty

Rating	Descriptors
Low	No or little information is missing or no or few data are missing, incomplete, inconsistent or conflicting. No subjective judgement is introduced. No unpublished data are used.
Medium	Some information is missing or some data are missing, incomplete, inconsistent or conflicting. Subjective judgement is introduced with supporting evidence. Unpublished data are sometimes used.
High	Most information is missing or most data are missing, incomplete, inconsistent or conflicting. Subjective judgement may be introduced without supporting evidence. Unpublished data are frequently used.