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Pathway Analysis and Horizon Scanning for Countries in Northern Europe








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Content

1. Preface

Invasive alien species are one of the main drivers of biodiversity loss, due to their ability to disperse and cause negative effects on native species and the environment. To reduce the introduction of invasive alien species in the future, preventive measures need to be implemented, and knowledge about pathways of introduction of new and potentially invasive alien species can facilitate tailor-made measures.

This report is the product of a collaboration between the Nordic Council of Ministers and ten participating countries and territories (Denmark, Estonia, Finland, the Faroe Islands, Iceland, Latvia, Lithuania, Norway, Svalbard & Sweden), all part of the NOBANIS network. The project extended from April 1st 2014 to February 28th 2015 and was funded through the Terrestrial Ecosystem Group (TEG) of the Nordic Council of Ministers.

The aim of the project is to contribute to the fulfilment of obligations in Aichi target 9 under the Convention on Biological Diversity, CBD and the EU Biodiversity Strategy 2020 target 5. This is done by identifying and prioritising the most significant pathways of introduction for invasive alien species to the regions. This identification and prioritisation is done to assist the participating countries and territories in minimising and preventing further introductions and establishment of invasive alien species through pathways of concern.

This report contains a pathway analysis and a horizon scanning. The pathway analysis examines the pathways of introduction for alien species into the Nordic region: Denmark (DK), Finland (FI), Norway (NO), Svalbard (SJ) & Sweden (SE), Baltic region: Estonia (EE), Lithuania (LT) & Latvia (LV) and the Islands of the North Atlantic Ocean represented by Iceland (IS) and the Faroe Islands (FO). The horizon scanning identifies species that may potentially become invasive in the participating countries or territories. Later in the report, guidelines and general recommendations on measures to control pathways of interest and advice on development of an early warning system for invasive alien species are presented.

Copenhagen, January 2015

2. Summary

One of the main drivers of biodiversity loss is invasive alien species (IAS), and in order to plan cost-effective measures to prevent the introduction of harmful invasive alien species, we need to know in what manner they are introduced. Until now, the measures to prevent harm to native environments and biodiversity by invasive alien species in the Nordic and Baltic countries, incl. Iceland and the Faroe Islands, have mainly been reactive methods based on knowledge of the invasive alien species already present. This approach has proven to be a costly and ineffective way to manage invasive alien species.

The prevention of introduction of new invasive alien species to the countries can be improved by gathering new knowledge on invasive and potentially invasive species and their pathways of introduction, as well as planning and implementing appropriate measures of control. Appropriate measures of control are: surveillance, early warning, detection and immediate control of the species.

The purpose of this project was to conduct a pathway analysis and a horizon scanning. The pathway analysis was done to identify and prioritise pathways of introductions by which alien species (particularly invasive alien species) were introduced in the Nordic and Baltic region, along with Iceland and the Faroe Islands. The horizon scanning was conducted to identify potential door knocker species that may be introduced in the future through the most significant pathways identified.

The NOBANIS network was initiated with funding by the Nordic Council of Ministers. The NOBANIS database contains information on alien species in 20 countries and territories in Northern and Central Europe, which have cooperated by sharing information on alien species in the countries. 10 of these countries and territories have participated in this project: Denmark, Estonia, the Faroe Islands, Finland, Iceland, Latvia, Lithuania, Norway (including Svalbard) and Sweden. The data in the NOBANIS database has formed the basis for the pathway analysis, and each country updated their national data with relevant information available using relevant literature and articles and by consulting national experts.

In this project we conducted the pathway analysis and the horizon scanning on a regional level, where the participating countries and territories were divided into three regions:

- A Nordic region consisting of Denmark, Finland, Norway and Sweden (for the pathway analysis also Svalbard).
- A Baltic continental region consisting of Estonia, Latvia and Lithuania.
- A region consisting of the islands in the North Atlantic Ocean represented by Iceland and the Faroe Islands.

The pathway analysis contains the following subanalyses:

- Pathways of introduced species.
- Invasiveness of introduced species.
- Taxonomic groups of introduced species.
- Temporal development of pathways.
- Species origin and the pathway of introduction.

The pathway analysis showed that the main pathway of introduction was horticulture, followed by agriculture, transport, forestry and ballast water & sediments, but there were variations between the regions.

To examine which new species may be introduced and established in the three regions in the future, a number of potential *door knocker species* was assessed.

The list of 414 potential *door knocker species* was assessed by experts across the participating countries and territories. Of the 414 species, 43 were evaluated as high risk species and 78 as medium risk species for the regions combined.

In this report a prioritised list of pathways of concern is also presented, along with guidelines and general recommendations on measures to control pathways of interest in the regions and advice on an early warning system.

3. Methods

In this chapter the methods of the analyses are described. The first analysis is the *Pathway analysis*, which identifies which human activities have caused the introduction of alien species already present in the participating countries.

The second analysis is the *Horizon scanning,* which examines the risk of new alien species arriving, establishing and causing damage. In this horizon scanning the knowledge collected in the pathway analysis will be applied to highlight the most immediate threats.

Guidelines and general recommendations on measures to control pathways of interest are presented, along with advice on the development of an early warning system for invasive alien species in the region.

3.1 General approach

3.1.1 The NOBANIS database

The NOBANIS database has formed the basis for identifying pathways of introduction for non-native species in Denmark (DK), Estonia (EE), Finland (FI), the Faroe Island (FO), Iceland (IS), Latvia (LV), Lithuania (LT), Norway (NO), Svalbard (SJ) and Sweden (SE). The database was also used to make the list for the horizon scanning, by searching the database on invasive alien species in the NOBANIS network.

The database includes all alien species, i.e. all species that have been introduced as a result of human activities intentionally or unintentionally. This means that the database covers both invasive alien species (causing harm to native biodiversity) and non-invasive alien species (not causing harm to native biodiversity).

The database includes organisms from the agricultural landscape, forestry and animal husbandry, when the species are found in natural or semi-natural ecosystems, or on native animal or plants. Species native to some part of a country, but alien in other parts are also included in the database.

The species included in the database are organisms that are:

- naturalized (established) in natural or semi-natural ecosystems
- only present from time to time (incidental)
- non-naturalized (not established) in natural or semi-natural ecosystems, but introduced regularly.

3.1.2 Regional level

In this study we will conduct the pathway analysis and the horizon scanning on a regional level. The participating countries and territories were divided into three different regions:

- A Nordic region consisting of DK, FI, NO & SE (for the Pathway analysis also SJ).
- A Baltic continental region consisting of EE, LT & LV.
- A region consisting of the islands in the North Atlantic Ocean represented by IS and FO.

The division of the countries and territories into the different regions was based on several differences. Differences in the geographical position of the countries and territories can cause variations in climate, topography etc. There are also differences in how species are introduced, especially to islands as opposed to the continents. Furthermore, the countries' or territories' political history can affect how the import and trade of goods have developed and are being handled.

By dividing the countries and territories into regions in the analysis, we might be able to see if the pathways of introduction can vary in the different regions.

There are also large geographical differences within some of the countries' and territories' terrestrial and aquatic environments. The database only has information about the presence of a species within a country or territories and therefore we are not able to take this into account in this analysis.

In the Pathway analysis Svalbard is analysed as a separate territory, even through it is a part of Norway. This is due to the data in the NOBANIS database being separated for Svalbard. In the Horizon scanning Svalbard is not analysed separately, but considered as part of Norway.

3.2 Pathway analysis

The pathway analysis identifies which human activities have caused the introduction of alien species already present in the participating countries and territories. It also examines the taxonomy, invasiveness and origin of the introduced species, along with the changes of the introductions over time.

3.2.1 Approach

Prior to the pathway analysis, each participating country and territory was asked to update and fill in the blanks for the data available in the NOBANIS database. This should be done by consulting experts and search for literature to acquire the data.

All the participating countries and territories except for Lithuania and the Faroe Islands managed to update the data in the NOBANIS database for this project, with the relevant information available for the species listed.

The data used for the pathway analysis from Lithuania was last updated in 2006, and the data used from the Faroe Islands was last updated in 2012.

In the analysis the results are presented in processed form. Raw data with species lists for the regions is available by request to the NOBANIS secretariat.

For the Norwegian data some information regarding pathway of introduction is missing due to differences in classification of pathways between NOBANIS and the Norwegian ArtsDatabanken (see the Norwegian classification in appendix 1).

In connection to this project, ArtsDatabanken in Norway has matched some of their pathway classifications with the NOBANIS classification, but for some species matching was inadequate. In such cases the pathway of introduction is classified as *not known* in the pathway analysis.

In the NOBANIS database some species are registered with a pathway that is not suited for that group of organism. Some species of angiosperms are registered with *ornamental* as their pathway, even though that pathway is designed for animals. Therefore, where ornamental is registered as a pathway for an angiosperm, the pathway has been changed to *horticulture* in the data for this analysis. The pathway horticulture is suited for ornamental plants among others.

3.2.2 Subanalyses

The pathway analysis contains the following subanalyses:

- Pathways of introduced species.
- Invasiveness of introduced species.
- Taxonomic groups of introduced species.
- Temporal development of pathways.
- Species origin and the pathway of introduction.

In the first three subanalyses (pathway, invasiveness and taxonomic groups), species appearing in more than one country or territory are only represented once for each pathway. As an example, Giant hogweed (*Heracleum mantegazzianum*) was introduced to Denmark, Finland, Norway and Sweden by horticulture only, and will therefore only count as one species introduced to the Nordic region. But if a species is introduced by more than one pathway, it will count as one species with the actual number of pathways, e.g. the Warty comb jelly (*Mnemiopsis leidyi) introduced by ballast water & sediment and secondary introduction*.

In the same three subanalyses, species without data on both pathway and invasiveness were taken out of the dataset. This is due to the lack of information contributed.

Pathway for introduced species

Here we examine the number of species introduced through the different pathways, to find the most active pathways used by alien species in the three regions. The used pathways are presented for each region in both absolute numbers and as a percentage distribution.

Invasiveness of introduced species

A pathway of introduction can be used frequently by many non-native species. Whether or not the species using the pathway has a negative impact, controlling the pathway can be time consuming and expensive. To prioritize management of the pathways that pose the greatest risk in the regions, we conducted an analysis for the different type of invasiveness for each pathway. The types of invasiveness used by the NOBANIS database are:

- Invasive.
- Potentially invasive.
- Not invasive.

Also, invasive alien species from all taxonomic groups are a major threat to native biodiversity, and it is possible that some taxonomic groups could include more invasive species than others (both relative and absolute). Therefore, this analysis also examines the type of invasiveness for each taxonomic group.

The results are presented in two ways. Firstly, the invasiveness of the taxonomic groups of species is shown in both absolute numbers and percentage distribution. The percentage distribution is the number of species in each invasiveness category relative to the total number of species in the taxonomic group (N). Secondly, the invasiveness of species using the different pathways is presented.

Taxonomic groups of introduced species

When dealing with non-native species it is relevant to see if the main pathway of introductions is the same across the different taxonomic groups, or if different taxonomic groups use different pathway of introduction when entering a region. For that reason we conducted this subanalysis where both pathway and type of introduction (intentional or unintentional) is presented for each taxonomic group for each region.

Temporal development of pathways

When looking at the development of pathways over time, some pathways may have been active earlier, but not in recent times, and new pathways may have developed due to globalisation etc. Therefore, in order to make contemporary management plans for invasive alien species and their pathway of introduction, we need to know which pathways are relevant. This subanalysis examines the active pathways over an extensive period of time.

In this analysis the development of the use of pathways over time is presented for all three regions. The time length of registration of arrival of alien species differs amongst the countries. For some countries and territories some species is registered as being introduced early (pre 1200), while other countries and territories only have registrations from a couple of hundred years ago. In order to have comparable data for all countries and territories, we conducted the analysis using data from the *age of enlightenment* around the 1700s and until today. Note that the data from the year 2000 and forward only contains data from the last 14 years.

The year of introduction and year of first report are registered for many alien species in Iceland. The same information is not available for the Faroe Islands, so the analysis is only based on the Icelandic data.

Species origin and the pathway of introduction

In order to get an overview of where in the world most of the non-native species are introduced from, an analysis regarding the origin of the non-native species was conducted. This was done for the non-native species identified in the NOBANIS database for all of the participating countries and territories. This knowledge can be useful in relation to control and management of non-native species when dealing with trading goods entering the regions from all around the world.

Before conducting the analysis *Species origin and the pathway of introduction* the data concerning the species' natural distribution area was unified for all the participation countries and territories. The species without information on both origin and pathway of introduction were taken out of this subanalysis.

The NOBANIS database works with 14 different natural distribution areas (see table 1), which are the basis for this subanalysis.

Table 1: Natural distribution areas of alien species. From the technical manual for the NOBANIS database

Areas	Explanation
Continents	
Africa	The African continent
Antarctica	The Antarctic continent
Asia	Divides Asia from Europe along Ural/Kazakhstan, Black Sea
Europe	Divides Europe from Asia along Ural/Kazakhstan
N. America	Canada, USA and Mexico
Oceania	Australia, New Zealand, Tasmania and a number of small islands
S. America	All countries on the S. American continent south of Mexico
Oceans	
Arctic Ocean	The ocean surrounding the North Pole
Indian Ocean	The Ocean south of India to the southern tip of Africa and to the northern tip of Australia
N. Atlantic Ocean	Upper part of the Atlantic Ocean divided by the equator
S. Atlantic Ocean	The lower part of the Atlantic Ocean divided by the equator
N. Pacific Ocean	The upper part of the Pacific Ocean divided by the equator
S. Pacific Ocean	The lower part of the Pacific ocean divided by the equator
Southern Oceans	The ocean surrounding the South Pole

For a number of species establishing the origin was challenging. This is due to the registrations of different areas of origin from the participating countries and territories. In this analysis we used the origin that was registered the most for each species. When different areas of origin for a species was registered an equal number of times, all areas were used in the analysis.

3.2.3 Pathway categories

Pathways are the dispersal mechanisms for which alien species can enter a country or territory. The importance of knowledge concerning pathways of introduction for invasive alien species has been addressed by several authors (NISC 2007, ISCC 2013, Kelly *et al*. 2013,) and a need for a common terminology has been pointed out. Currently the EU COST Action TD1209 "Alien Challenge" is working on a common terminology for identifying pathways of introduction for alien species. In the following sections the NOBANIS terminology is described.

3.2.4 Type of introduction

The term *Type of introduction* refers to whether the introduction is intentional or unintentional.

- *Intentional introduction* refers to the deliberate movement and/or release by humans of an alien species outside its natural range.
- *Unintentional introduction* refers to all other introductions which are not intentional.

3.2.5 Pathway of introduction

The pathways are based on the categories used by NOBANIS (see table 2). The categories used are based on the framework that NOBANIS uses for the database, and the definition of pathways that NOBANIS uses is based on the European Strategy on invasive alien species.

The European Strategy on invasive alien species works with three definition of a pathway:

1. The geographic route by which a species moves outside its natural range (past or present).
2. The corridor of introduction (e.g. road, canal, tunnel).
3. The human activity that gives rise to an intentional or unintentional introduction.

NOBANIS has focused on the definition for pathways of introduction regarding human activity (option 3).

Table 2: Descriptions of the pathways of introduction for alien species. From the technical manual for the NOBANIS database

Pathway	Explanation
Agriculture	Plants for production of food for human and animal consumption, incl. crops and contaminants of hay, grain, fodder
Angling/sport	Live bait or dispersal via fishing gear and/or boats or as a consequence of aqua sports
Animal husbandry	Animals for production of food for humans, including the pest species introduced via the animal hosts
Aquaculture	Fish/crayfish/algae/shellfish/seafood farming, or consequences of stocking of species (pest species) – including marine cultures, animals escaping from aquaculture
Aquaria	Garden ponds and aquariums
Ballast water and sediments	Ballast water and sediments in tanks, as well as solid ballast, incl. also the dispersal via shipping in general (e.g. Brown rat)
Biological control	Introduced as a putative bio control agent/pest of another species
Escapes	Fur farming, pet-animals escapes from captivity, laboratory animals, animal escapes, pet trade
Fisheries	Commercial fishing
Forestry	Timber and tree production, including the pest species introduced via tree hosts or products thereof
Horticulture	Plants used for ornamental purpose, gardening
Hull fouling	Fouling of ships hulls
Hunting	Released as hunting quarry or prey
Landscaping	The use of plants in the landscape (such as hedge plantings, binding of silt, erosion control)
Medicinal	Plants or animals used for this purpose
Reintroduction	Re-introduction of species that have previously died out in the country
Ornamental	Animals used for ornamental purposes such as colourful slugs and birds in parks, etc.
Secondary introduction	Introduced species where populations have been introduced from a nearby country/sea area – which are not the natural distribution area
Transport	Infrastructure, translocation of machinery, transportation along roads and rails, planes, package material etc.

3.3 Horizon scanning

In the horizon scanning the risk of new alien species arriving, establishing and causing damage is examined. The potentially invasive species are called potential *door knocker species,* which refers to their potential introduction and impact in the participating countries and territories in the near future.

In the analysis the results are presented in processed form. Raw data used for the analysis (regional level) and expert evaluations is available by request. Please contact the NOBANIS secretariat for further information.

Door knocker species

Door knocker species are defined as an alien species which has not yet arrived and established in any of the participating countries and territories (DK, EE, FI, FO, IS, LT, LV, NO & SE), but can be expected to be introduced in the near future.

This might be an alien species which is already established in a neighbouring country, and which unaided can manage to cross national boundaries into any of the participating countries and territories. This is called secondary introduction (Gederaas *et al*. 2012). It could also be a species with a natural range in other geographical areas that can potentially spread to the participating countries and territories by using a pathway of introduction e.g. by horticulture, transport, forestry etc.

In this report a door knocker species can also include alien species already present but not established in the wild with a sustainable population, in any of the participating countries and territories. This can apply to species which initially only survive indoors, in greenhouses or in compost heaps (Gederaas *et al*. 2012).

3.3.1 Approach

A list of potential *door knocker species* was compiled using:

- The NOBANIS database to search and list invasive or potentially invasive species established in non-participating countries (Austria, Belarus, Belgium, Czech Republic, Germany, Greenland, Ireland, the Netherlands, Poland, Slovakia and the European part of Russia) that are part of the NOBANIS network.
- Data from alert lists made by Denmark (Pathway for non-native species in Denmark, 2014), Norway (Alien Species in Norway, 2012), Germany (Warnliste, 2013) and Ireland (Risk analysis and prioritisation, 2013).

All species already present in the 10 countries and territories participating in the project were excluded from the analysis. These species were identified by using the NOBANIS database. Species that are present, but not yet established in the wild, were kept on the list.

When categorising the species on the list, the taxonomic groups used in NOBANIS were applied. Some of the taxonomic groups were divided into subgroups to give more information about the kind of organism, e.g. Arthropods were divided into Coleoptera etc.

An assessment criteria table was then made – based on other horizon scanning projects (Sutherland *et al*. 2008, Kelly *et al*. 2013 and Roy *et al*. 2014). The assessment criteria table and the *door knocker species* list were sent to experts in different taxonomic groups across Scandinavia and the Baltic. See appendix 2 for the list of experts.

The assessment criteria table (see appendix 3) consists of three different factors and associated questions. The factors and questions are based on horizon scanning projects by Sutherland *et al*. (2008), Kelly *et al*. (2013) and Roy *et al*. (2014):

- Arrival.
  - What is the possibility that the species will arrive?
- Establishment.
  - What is the possibility that the species will become established?
- Impact assessment.
  - Does the species pose a threat to biodiversity?
  - Does the species pose a risk to human health?
  - Does the species pose a risk regarding socio-economic concerns?

The answers to these questions were one of four assessment scores for the experts to choose (see table 3). Each question was answered for each species in each region.

Table 3: Assessment scores used to evaluate the risk of the different factors

Score	Description
0	Not possible to evaluate
1	Low risk
2	Medium risk
3	High risk

3.3.2 Final risk assessment

In the final risk assessment, the results from the expert assessments mentioned above were calculated into three risk categories: high, medium or low risk species. This was done for all three regions separately and the high and medium risk species are highlighted in the results. The method of the final risk assessment is described in the following sections.

Calculations

For each species the score for establishment was added to the mean score of the impact (establishment + mean impact) (see appendix 3). The mean impact was calculated with the scores of the three categories: biodiversity, human health and socio-economic concerns. The result of the "establishment + mean impact" is the ranking value seen in table 4. This ranking was then held against the assessments score (ranking) for the species ability to arrive, by plotting the results against each other using table 4.

By using this method, the species assessed by experts were categorised into three groups: High risk species (A), medium risk species (B) and low risk species (C). A description of the categories is found in the next section.

Table 4: Final risk categorisation of potential door knocker species

Final risk categorisation		**Arrival**		
	Score	**3**	**2**	**1**
Establishment + mean impact (impact on biodiversity, human health and socio economic concerns)	5-6	High risk species A	High risk species A	Medium risk species B
	4-4.9	High risk species A	Medium risk species B	Low risk species C
	2-3.9	Medium risk species B	Low risk species C	Low risk species C

Risk categorisation

High risk species (A): species that were assessed as having one of these two scenarios:

- A high risk of arrival in the region of concern, and a medium risk of establishing and having a negative impact.
- A medium or high risk of arrival in the region of concern, and a high risk of establishing and having a negative impact.

Medium risk species (B): species that were assessed as having one of three scenarios:

- A high risk of arrival in the region of concern, but a low risk of establishing and having an impact.
- A medium risk of arrival in the region of concern, and a medium risk of establishing and having an impact.
- A low risk of arrival in the region of concern, but a high risk of establishing and having an impact.

Low risk species (C): species that were assessed as having one of these two scenarios:

- A low risk of establishing and having an impact, and a low or medium risk of arrival in the region of concern.
- A medium risk of establishing and having an impact, but a low risk of arrival in the region of concern.

Species categorised to be high or medium risk species are discussed further, while low risk species will not be thoroughly discussed in this report.

There may be some uncertainty for a number of species in this analysis, due to either limitation in knowledge about the species or the unpredictability of climate change, species survival and behaviour in new environments etc.

Risk categorisation

The risk categorisation has three cells for each of the categories (see table 4). This causes some of the species that score in the medium range in one of the parameters (i.e. arrival), to be assessed as high risk species due to high risk of the other parameter (i.e. establishment+mean impact). This is also the case with a species scoring in the low range of one parameter, which can be assessed to a medium risk species due to a high risk in the other risk parameter.

As an example of the "low+high=medium"-scenario mentioned above, we might have a species that has a high risk of arrival, but a low risk of establishment and impact. This species is therefore likely to have several opportunities to establish, and might have a wider habitat range than currently known and higher survival rate in the absence of natural predators and parasites and therefore scores as a medium risk species.

In another scenario we can have a species with a high risk of establishment and impact, but with a low risk of arrival. If only a few of these individuals manage to arrive they can have considerable impact and therefore score as medium risk species.

3.3.3 Species not included

Some species are not included in the horizon scanning:

- Species native to any of the participating countries and territories.
- Alien species already established with sustainable populations in the wild in any of the participating countries and territories.
- Subspecies or lower taxa (except vascular plants and macroalgae).

3.3.4 Expert evaluations

In order to make a validated assessment of the potential *door knocker species* on the horizon scanning list, NOBANIS contacted experts in different taxonomic groups from universities, scientific research centres, associations inside the scientific community etc. across Scandinavia and the Baltic region.

We attempted to consult more than one expert for each taxonomic group (and for arthropods also for individual order) on the list, but for many of the taxonomic groups and orders this was not possible, due to the lack of experts in that particular field.

All experts used for the horizon scanning originated from one of the participating countries and territories. We chose only to use expert from the three regions, due to their expert knowledge of the geographical region that forms the framework for this project.

The experts assessed the species for the region as a whole, except for the Baltic region. In the Baltic region it was not possible for the experts to assess the taxonomic group of non-parasitic fungi for the entire region, so each country was assessed separately for that specific group. In order to achieve results for the region as a whole, the results from the three countries were combined. This was done by taking the mean of the scores for each species of fungus. For paracitic species of fungi, we were not able to find experts to conduct the assessment for the Baltic region and the Islands of the North Atlantic Ocean. Therefore, *door knocker species* of paracitic fungi are only assessed for the Nordic region in this report.

For some taxonomic groups more than one expert assessed the species ability to arrive, establish and have an impact. For those species where the experts did not agree on the assessments, the assessments with the highest risk were used in the final results.

3.3.5 Challenging taxa

Finding experts on some taxonomic groups for the horizon scanning proved to be a difficult task. Many experts were reluctant to do the assessments for other countries and territories than their own, but also the short time frame, limited information on the *door knocker species* and the lack of experts in some taxonomic groups, made it difficult to find experts for all the species on the *door knocker* list.

The groups of organisms especially challenging to obtain assessments for were some insects (Coleoptera, Diptera and Hemiptera), crustacean (Isopods and Copepods), microorganisms, flatworms, phytoplankton, annelids and angiosperms.

For some taxonomic groups (angiosperms and orders of arthropods (Coleoptera and Diptera)) we provided additional information regarding the individual species in those groups, by searching relevant literature. Each species was searched for in one or more sources, until the adequate data was obtained. The data obtained is related to the species' native range, distribution, reproduction, ecology, negative effects etc. The purpose of finding that information was to help experts make the assessments.

Some of the accessible data collected was not from recent years, which means that the data obtained on the species distribution may have changed. The data collected for the species are available by contacting the NOBANIS secretariat.

For some groups and orders of species it was not possible to find experts that could do the assessments for the horizon scanning (see table 5).

Table 5: Groups of species not assessed by experts

Groups not assessed in the Horizon scanning	
Arthropods	Hemiptera Opiliones Copepods (Cladocera, Calanoida & Poecilostomatoida) Isopods
Flatworms	All
Microorganisms	Bacteria Vira
Annelids	All
Phytoplankton	All
Protists	All

3.4 Prioritisation of pathways

In the process of prioritising pathways of concern, we looked at the results from the pathway analysis. Here, the prioritisation was done based on:

- Number of introduced invasive species by the pathway.
- Number of introductions through the pathway.

Subsequently, other parametres from the pathway analysis and the horizon scanning were taken into account to make ajustments to the prioritisation of the pathways:

- Percentage of invasive introductions.[1]
- Number of high risk (A) *door knocker species* that is assigned to the pathway.
- Number of medium risk (B) *door knocker species* that is assigned to the pathway.
- Number of potentially invasive introductions.
- Temporal development of pathways.

Pathways with less than 25 registrations of introduction were not considered to be pathways of concern in this report, and were therefore not included in the prioritised list, unless other of the parametres above showed that the pathway was a of concern.

[1] Percentage of invasive introductions = (invasive introductions by that pathway/all introductions by that pathway) x 100).

4. Pathway analysis

The pathway analysis contains the following subanalyses:

- Pathways of introduced species.
- Invasiveness of introduced species.
- Taxonomic groups of introduced species.
- Temporal development of pathways.
- Species origin and the pathway of introduction.

Each subanalysis is divided into the three regions: the Nordic region, the Baltic region and Islands in the North Atlantic Ocean. The total number of introduced species for each of the regions is presented in table 6.

Table 6: Total number of introduced species per country, and total number of introduced species per region analysed for the pathway analysis

Region	Country	Number of species (N)
Nordic region	Denmark	2,422
	Finland	407
	Norway	2,240
	Svalbard	89
	Sweden	2,192
	*Total**	*4,796*
Baltic region	Estonia	970
	Latvia	416
	Lithuania	580
	*Total**	*1,354*
Islands of the North Atlantic Ocean	Iceland	154
	The Faroe Islands	147
	*Total**	*279*

*The totals differ from the sum of the numbers above, due to the removal of redundant species. The redundant species are present in more than one country or territory in the same region, and will therefore appear more than once in the data for the regional analyses if not removed.

4.1 Pathways of introduced species

In the following sections the pathway analysis for the regions is presented. The analysis comprises the number of alien species introduced by each pathway. It is important to remember, that species might use more than one pathway of introduction or have different pathways of introduction in the different countries in the region. Species may also be registred in one country or territory as introduced by an unknown pathway, but registred with a known pathway in another country or territory. In this situation the species is assigned with the known pathway for the region in these analyses.

4.1.1 Nordic region

A total of 4,796 alien species were analysed for the Nordic region.

A total of 22 taxonomic groups were represented in the data: angiosperms, annelids, arthropods, birds, bryophytes, cnidarians, comb jellies, coniferous plants, ferns, fish, flatworms, fungi, macroalgae, mammals, microorganisms, molluscs, nematodes, other chordates, other invertebrates, phytoplankton, protozoans, and reptiles & amphibians.

A total of 19 pathways were registered for this region: agriculture, angling/sport, animal husbandry, aquaculture, aquaria, ballast water & sediments, biological control, escapes, fisheries, forestry, horticulture, hull fouling, landscaping, medicinal, ornamental, reintroduction, secondary introduction and transport.

Some of the species use more than one pathway of introduction, and may be represented more then once in the analysis.

In figure 1 the number of alien species introduced by the different pathways is shown for the Nordic region. In figure 2 the introductions are shown for the Nordic countries separately.

Figure 1: Pathway of introduction for non-native species in the Nordic region. The graph shows the number of species introduced by each pathway

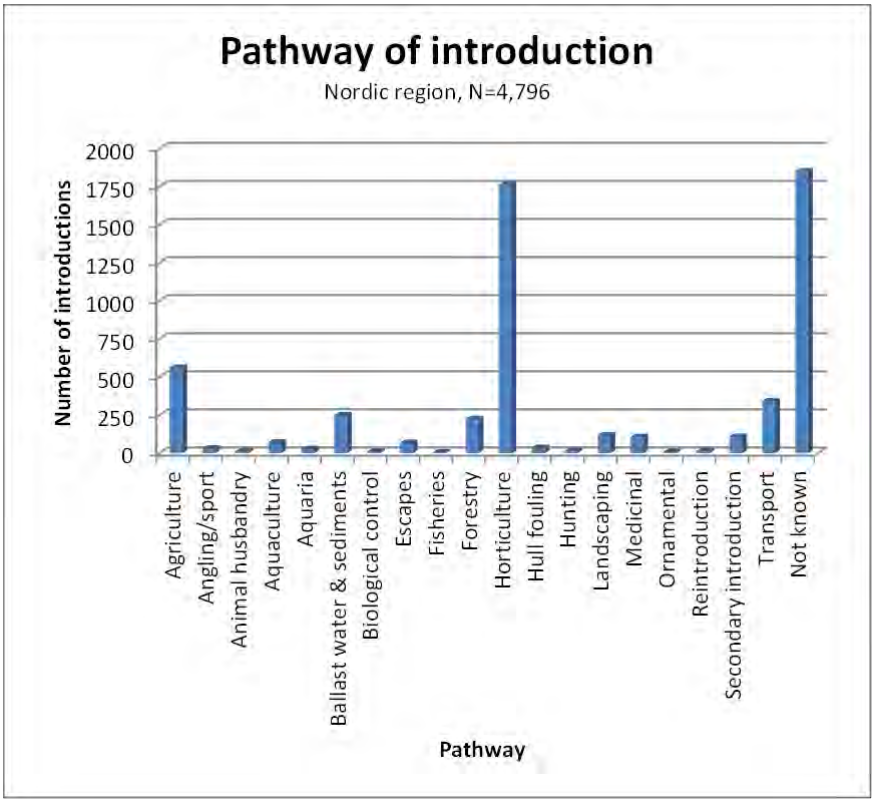
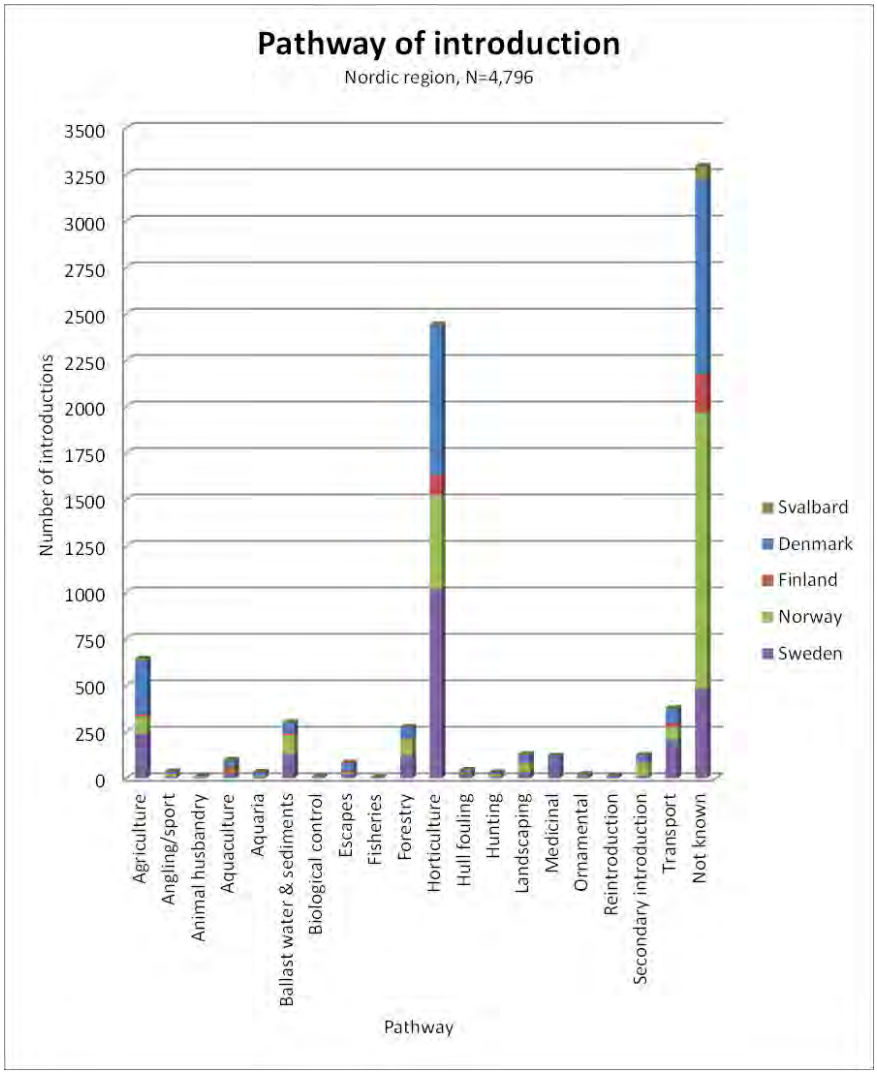


Figure 2: Pathway of introduction for non-native species in the Nordic region. The graph shows the number of species introduced by each pathway



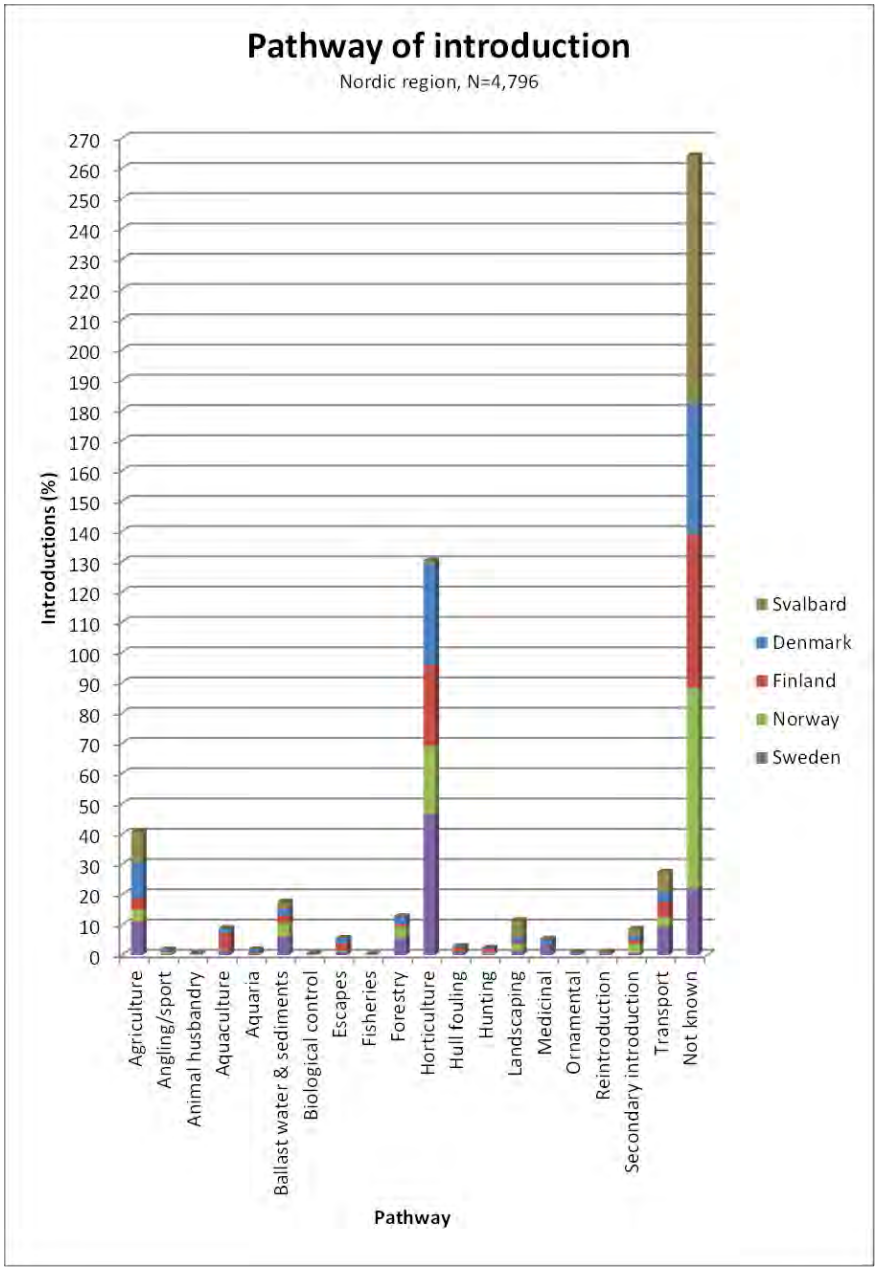
The most common pathway of introduction is horticulture, which is used by 1,763 of the alien species recorded in the region. Also agriculture (N=561), transport (N=342), ballast water & sediments (N=250) and forestry (N=225) are registered for several species, while the remaining pathways are registered less in the region.

For a large number of species registered as alien in the region, no pathway of introduction is currently recorded. Most of the species with unknown pathway were recorded in the Norwegian database (N=1,486),[2] and in Denmark (N=1,049), while Sweden (N=483), Finland (N=206) and Svalbard (N=73) had fewer species with unidentified pathways. For the whole region a total of 1850 alien species were registered without a pathway of introduction, due to the removal of redundant species (see chapter 4 *Pathway analysis)*.

The percentage of species using each pathway is shown in figure 3. The distribution of alien species for each pathway shows a similar pattern to the absolute number in figure 2. Although, the percentage distribution highlights that Sweden has a relatively low percentage of alien species with unknown pathways, while Svalbard (82%), Norway (66.3%) and Finland (50.6%) has a high percentage of alien species with unknown pathways.

[2] This may be due to the differences in pathway categorisation between the Norwegian ArtsDatabanken and the NOBANIS database (see *Methods* for further explanation).

Figure 3: Percentage distribution of pathway of introduction for non-native species in the Nordic region. The graph shows the percentage of species introduced by each pathway. Each columb shows the cumulated percentages for each pathway, and therefore the percentage may exceed 100%



4.1.2 Baltic region

A total of 1,354 alien species were analysed for the Baltic region.

A total of 16 taxonomic groups were represented: angiosperms, annelids, arthropods, birds, bryophytes, cnidarians, coniferous plants, fish, flatworms, fungi, mammals, microorganisms, molluscs, nematodes, phytoplankton and reptilia & amphibia.

A total of 17 pathways were registered for this region: agriculture, animal hunbandry, aquaculture, aquaria, ballast water & sediments, Biological control, escapes, fisheries, forestry, horticulture, hull fouling, landscaping, medicinal, ornamental, secondary introduction and transport. Some of the species use more than one pathway of introduction and may be represented more than once in the analysis.

In figure 4 the number of alien species introduced by the different pathways is shown for the Baltic region. In figure 5 the introductions are shown for the Baltic countries separately.

Figure 4: Pathway of introduction for non-native species in the Baltic region. The graph shows the number of species introduced by each pathway

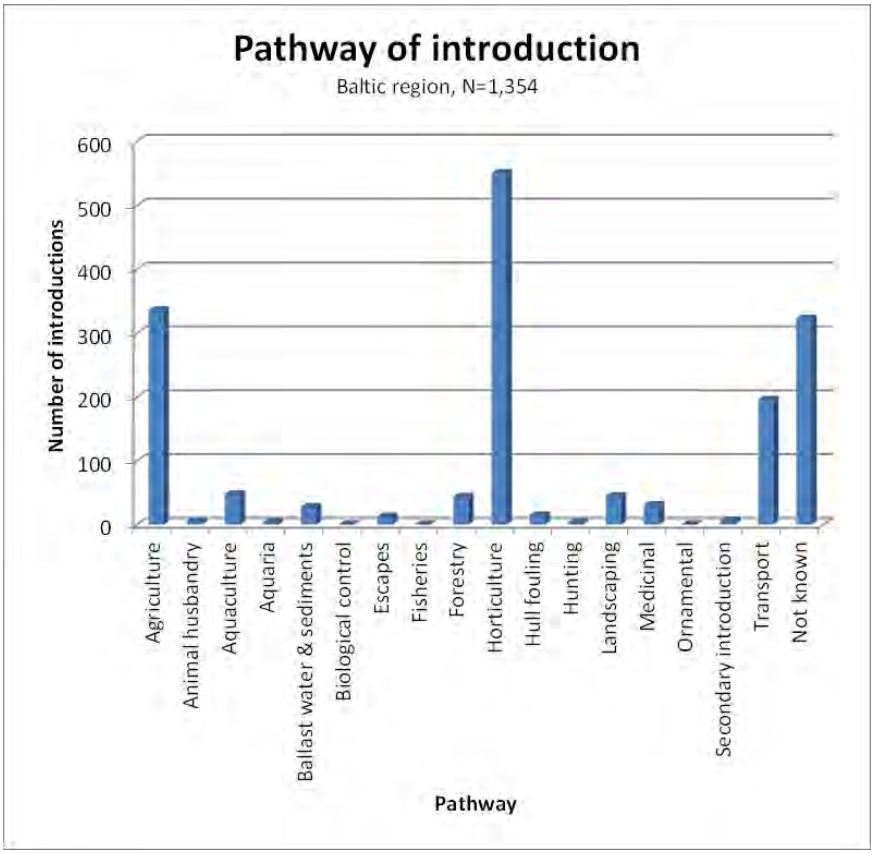
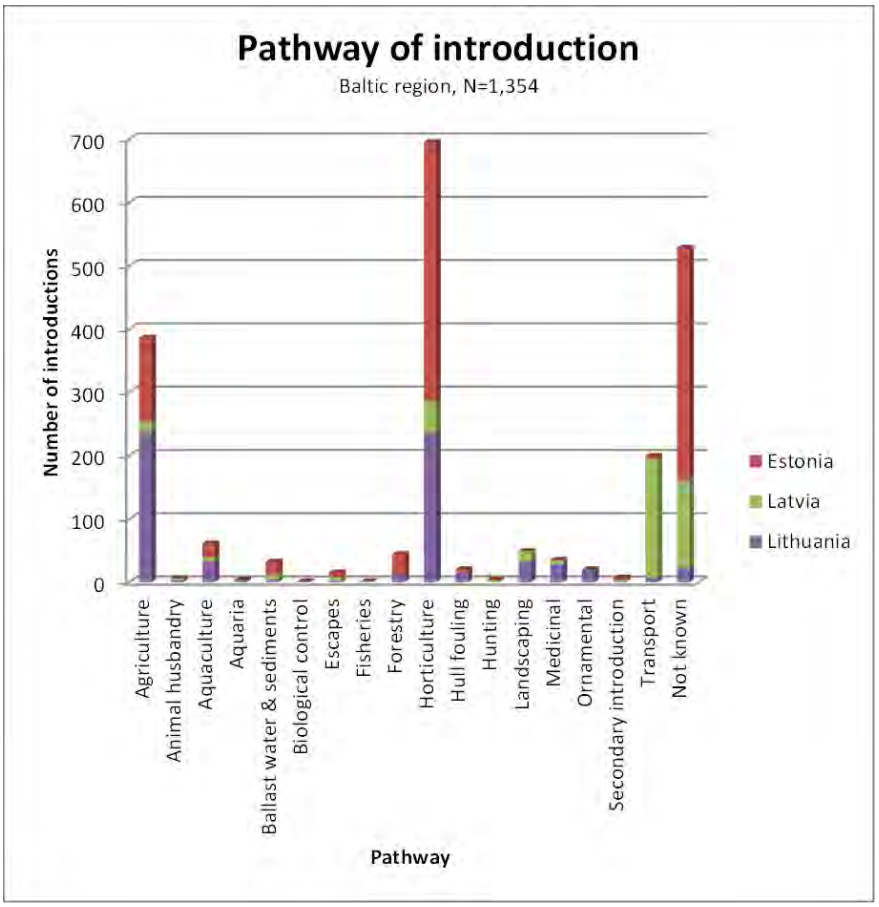


Figure 5: Pathways of introduction for non-native species in the Baltic region. The graph shows the number of species introduced by each pathway



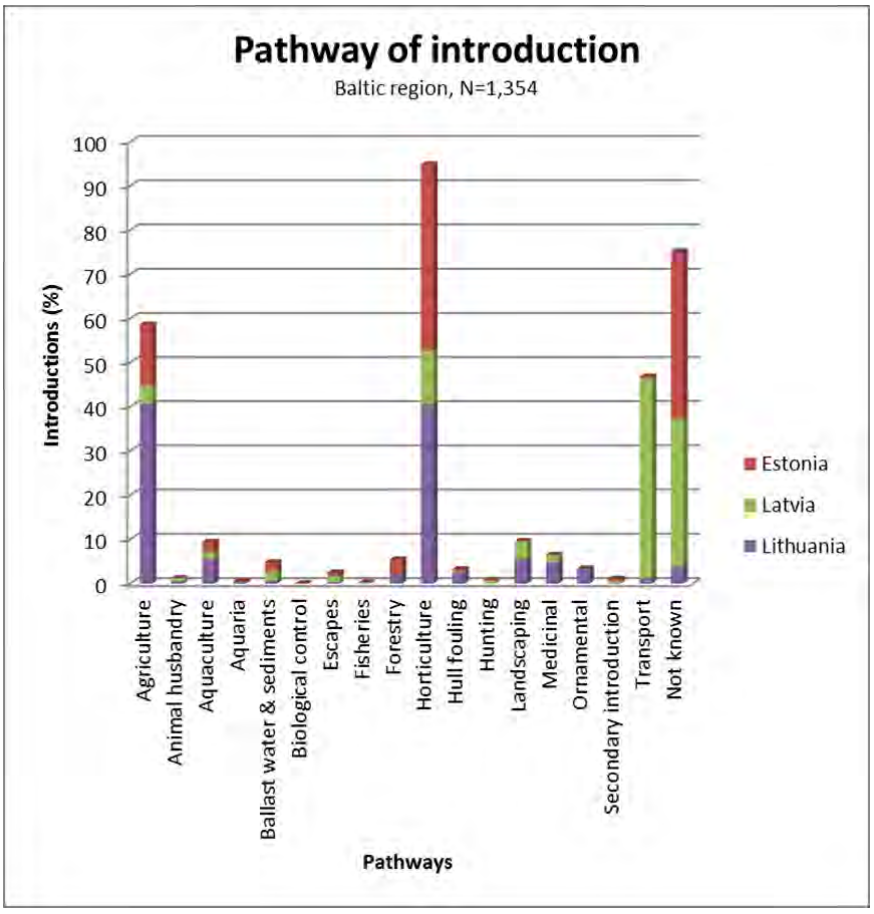
The most common pathway of introduction is horticulture, which by 551 of the alien species recorded in the region. Also agriculture (N=336) and transport (N=196) are registered for several species, while the remaining pathways are registered less in the region.

The pathway of introduction and the number of alien species registered in Estonia follows the tendency in the region as a whole, while Latvia stands out with transport as the most used pathway. In Lithuania most alien species are introduced by horticulture and agriculture.

For some species registered as alien in the region, no pathway of introduction is currently recorded. Most of the species with no known pathway is located in Estonia (N=366), while Latvia (N=140) and Lithuania (N=22) have fewer species with unknown pathways. For the whole region a total of 323 alien species are registered without a pathway of introduction, due to the removal of redundant species in the regional analysis (see chapter 4 *Pathway analysis)*.

The percentage of species using each pathway is shown figure 6. The distribution of alien species for each pathway shows a similar pattern to the absolute number in figure 5. Although, the percentage distribution highlights that the highest percentage of alien species using the transport pathway is for Latvia. It also highlights that Latvia (33.7%) like Estonia has (37.7%) a high percentage of species with unknown pathways.

Figure 6: Pathways of introduction for non-native species in the Baltic region. The graph shows the cumulated percentage of species using each pathway. Each columb shows the cumulated percentages for each pathway, and therefore the percentage may exceed 100%



The graph also shows that the number of alien species using horticulture as a pathway of introdution registered for Estonia and Lithuania is very similar, while alien species using horticulture as a pathway of introduction in Latvia is minor.

4.1.3 Islands of the North Atlantic Ocean

A total of 279 alien species is analysed for the Islands of the North Atlantic Ocean.

A total of 13 taxonomic groups are represented: angiosperms, annelids, arthropods, birds, bryophytes, coniferous plants, fish, flatworms, fungi, macroalgae, mammals, microorganisms and molluscs.

A total of 14 pathways are registered for this region: agriculture, animal husbandry, aquaculture, aquaria, ballast water & sediments, escapes, forestry, horticulture, hunting, landscaping, medicinal, ornamental, secondary introduction and transport. Some of the species use more than one pathway of introduction.

In figure 7 the number of alien species introduced by the different pathways is shown for the region. In figure 8 the introductions are shown for Iceland and the Faroe Islands separately.

Figure 7: Pathways of introduction for non-native species in Islands of the North Atlantic Ocean. The graph shows the number of species introduced by each pathway

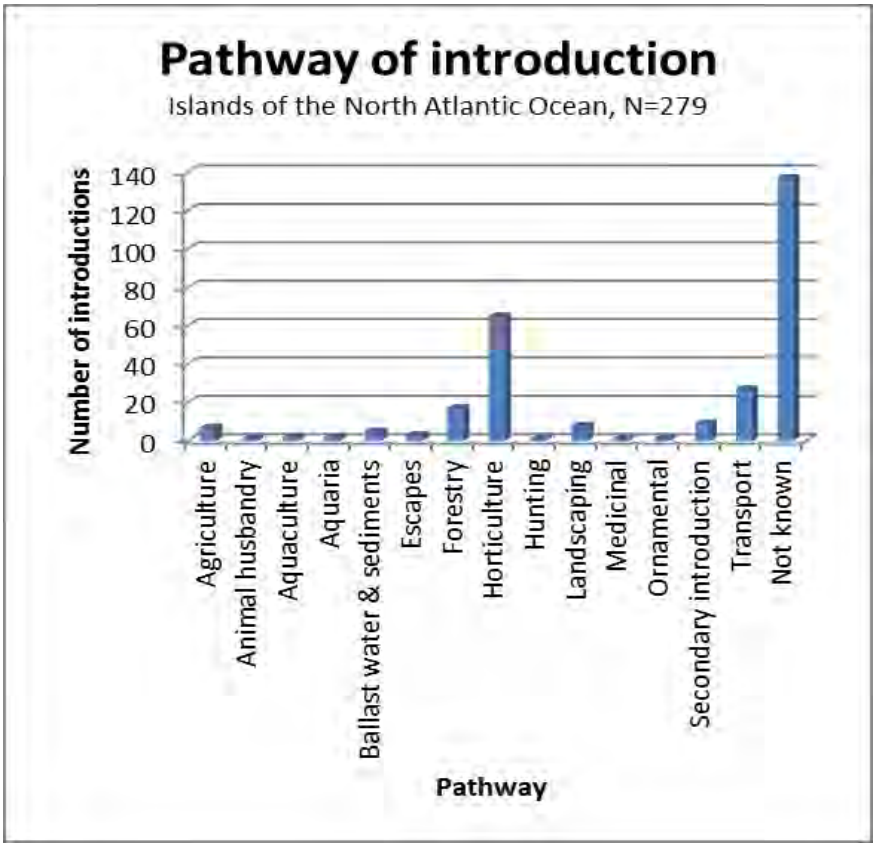
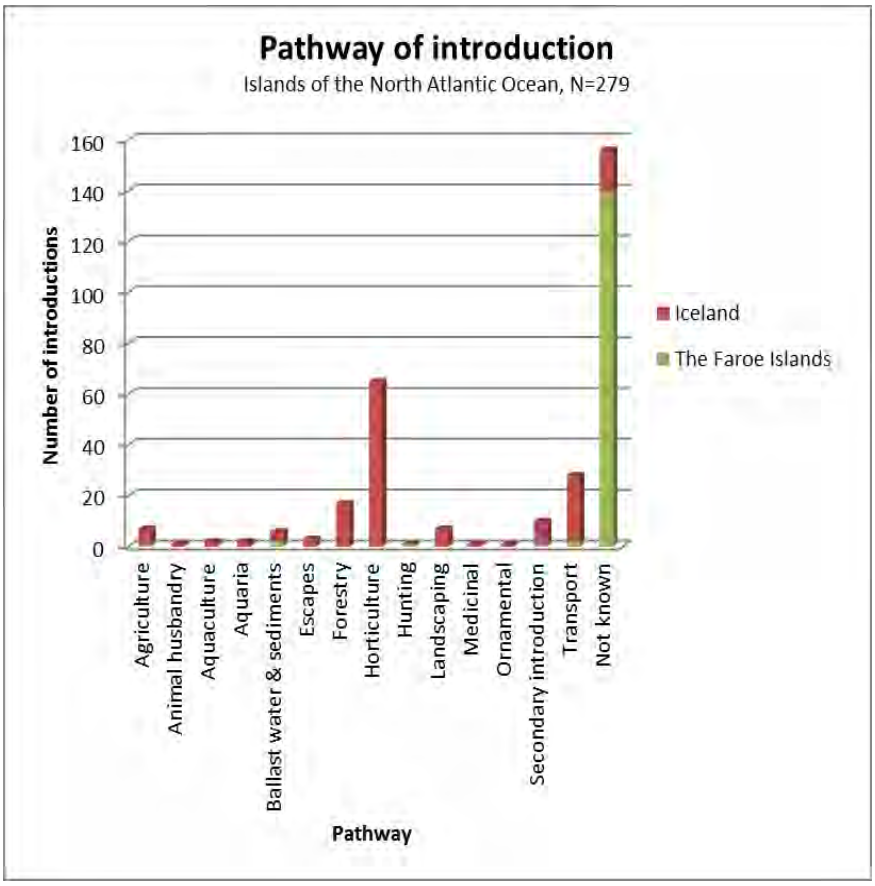


Figure 8: Pathways of introduction for non-native species in Islands of the North Atlantic Ocean. The graph shows the number of species introduced by each pathway



The most common pathway of introduction is horticulture, which is used by 65 of the alien species recorded in the region. Also transport (N=27) and forestry (N=17) are registered for several species, while the remaining pathways are registered less in the region. The data for this region is predominantly based on the data from Iceland.

For some species registered as alien in the region, no pathway of introduction is currently recorded. Most of the species with no known pathway are in the Faroe Islands (N=140). For Iceland there are fewer species (N=16) with unknown pathways. For the whole region a total of 137 alien species have an unknown pathway, due to the removal of redundant species for this analysis (see chapter 4 *Pathway analysis)*.

In the pathway analysis for the Nordic region and Baltic region the percentage distribution of each pathway is shown for the regions. Although, this is not the case for this region, due to the similarity of the

number of alien species for Iceland (N=154) and the Faroe Islands (N=147). When the numbers are similar the presentation of a percentage distribution will not contribute new information.

4.1.4 Summary

The most common pathway of introduction in all three regions is horticulture, while also agriculture, transport, forestry and ballast water & sediments are registered as being used by several species.

Nordic region
The most used pathway of introduction is horticulture. Also agriculture, transport, ballast water & sediments and forestry are registered for several species.

For the whole region a total of 1,850 alien species are registered without a pathway of introduction. The highest numbers are from Norway and Denmark. But if we look at the percentage distribution, Svalbard, Norway and Finland has the highest percentage of alien species with an unknown pathway of introduction.

Baltic region
The most used pathway of introduction is horticulture. Also agriculture and transport are registered for several species.

The pathway of introduction and the number of alien species registered in Estonia follows the tendency in the region as a whole, while Latvia stands out with transport as the most common pathway. In Lithuania most alien species are introduced by horticulture and agriculture, while in Latvia the percentage of species using horticulture is minor.

For the whole region a total of 323 alien species were registered without a pathway of introduction, where the highest number are from Estonia. Looking at the percentage distribution, Estonia and Latvia has the highest percentage of alien species with an unknown pathway.

Islands of the North Atlantic Ocean
The most used pathway of introduction is horticulture, but also transport and forestry are registered for several species. The data for this region is predominantly based on data from Iceland.

For the whole region a total of 137 alien species has an unknown pathway. Faroe Islands have the highest number of species reported with unknown pathways of introduction.

4.2 Invasiveness of introduced species

The invasiveness of the species is presented in two ways. Firstly, the invasiveness of the taxonomic groups is shown in both absolute numbers and percentage distribution (%). The percentage distribution for the taxonomic groups is the number of species in each invasiveness category relative to the total number of species in the taxonomic group (N). The percentage distribution for the pathways is the number of species in each invasiveness category relative to the total number of species using the pathway. Secondly, the invasiveness of species using the different pathways is presented.

The species may have different status of invasiveness in the different countries in the region. Therefore a species can have more than one status of invasiveness, whereby the number of statuses exceeds the number of species (N) and also exceeds 100%.

Nordic region

The invasiveness status is known for 4,796 alien species registered in the NOBANIS database for the Nordic region. As shown in table 7,646 species are considered invasive, 427 as potentially invasive and 3,216 are not invasive.

Table 7: The invasiveness status of the species in the taxonomic groups in the Nordic region

		Status of invasiveness			
	Species (N)	**Invasive**	**Potentially invasive**	**Not invasive**	**Not known**
Angiosperms	3,272	255	242	2,700	334
Annelids	26	3	3	7	15
Arthropods	928	182	114	254	468
Birds	81	7	8	68	7
Bryophytes	6	2	0	1	3
Cnidarians	8	3	2	3	2
Comb jellies	4	1	1	0	3
Coniferous plants	82	15	15	60	9
Ferns	11	0	1	11	0
Fish	40	12	10	17	8
Flatworms	8	5	0	2	1
Fungi	120	68	6	48	3
Macroalgae	17	8	2	5	3
Mammals	43	19	4	15	13
Microorganisms	35	29	4	3	0
Molluscs	69	21	4	19	30
Nematodes	13	5	1	1	7
Other chordates	1	1	1	0	0
Other invertebrates	2	0	2	0	0
Phytoplankton	17	6	5	0	7
Protozoans	2	2	0	0	0
Reptiles & amphibians	11	2	2	2	5
Total	*4,796*	*646*	*427*	*3,216*	*918*

A total of 22 different taxonomic groups are registered for the region. The group with the highest number of invasive species is angiosperms (N=255), followed by arthropods (N=182). This tendency is also seen in the categories potentially invasive and not invasive, which reflects that these two groups have the highest number of alien species in the Nordic region.

No species of ferns or *other invertebrates* are considered invasive in the Nordic region, but a few species in the groups are considered potentially invasive.

In table 8 the percentage distribution of invasive status is shown for each taxonomic group. The groups with the highest percentage of invasive species are microorganisms (83%), flatworms (63%), fungus (57%), macroalgae (47%) and mammals (44%). Protozoans (100%) and *other chordates* (100%) also have a high percentage of species registered as invasive, but the results are based on only two and one registrations in the region. This is also the case when looking at potentially invasive species, where *other chordates* and *other invertebrates* have a high percentage of species registered (100%) but the results are based on only one and two registrations respectively.

Table 8: The percentage distribution of the invasive status for the species in the taxonomic groups in the Nordic region

		Status of invasiveness (% distribution)			
	Species (N)	Invasive (%)	Potentially invasive (%)	Not invasive (%)	Not known (%)
Angiosperms	3,272	8	7	83	10
Annelids	26	12	12	27	58
Arthropods	928	20	12	27	50
Birds	81	9	10	84	9
Bryophytes	6	33	0	17	50
Cnidarians	8	38	25	38	25
Comb jellies	4	25	25	0	75
Coniferous plants	82	18	18	73	11
Ferns	11	0	9	100	0
Fish	40	30	25	43	20
Flatworms	8	63	0	25	13
Fungi	120	57	5	40	3
Macroalgae	17	47	12	29	18
Mammals	43	44	9	35	30
Microorganisms	35	83	11	9	0
Molluscs	69	30	6	28	43
Nematodes	13	38	8	8	54
Other chordates	1	100	100	0	0
Other invertebrates	2	0	100	0	0
Phytoplankton	17	35	29	0	41
Protozoans	2	100	0	0	0
Reptiles & amphibians	11	18	18	18	45

In table 9 the invasiveness for species using each pathway is shown. Horticulture (N=282) is the main pathway of introduction of alien species considered to be invasive. Many species considered to be invasive are also introduced by transport (N=109), agriculture (N=86) and ballast water & sediments (N=72).

Table 9: The invasive status of the species entering through different pathways of introduction to the Nordic region

	Status of invasiveness			
	Invasive	**Potentially invasive**	**Not invasive**	**Not known**
Agriculture	86	63	461	57
Angling/sport	16	8	16	2
Animal husbandry	4	3	3	2
Aquaculture	30	11	21	17
Aquaria	8	3	11	9
Ballast water & sediments	72	57	146	36
Biological control	3	1	4	3
Escapes	22	11	34	17
Fisheries	5	3	2	0
Forestry	48	39	114	79
Horticulture	282	251	1,379	192
Hull fouling	19	11	10	4
Hunting	11	3	9	1
Landscaping	41	27	82	10
Medicinal	19	12	83	18
Ornamental	5	0	4	1
Reintroduction	4	0	5	6
Secondary introduction	43	23	63	9
Transport	109	61	191	73
Not known	121	54	1,344	445

The main pathway for the majority of species considered to be potentially invasive is also horticulture (N=251), while agriculture (N=63), transport (N=61) and ballast water & sediments (N=57) are used by numerous potentially invasive species.

The pathways with the lowest number of invasive and potentially invasive species are animal husbandry, biological control, fisheries, ornamental and reintroduction.

The majority of the species with unknown pathway of introduction is considered not invasive (N=1,344), but a number of the species with unknown pathway also has an unknown invasiveness status (N=445).

In table 10 the percentages of the registered introductions of each invasiveness category are shown. Angling/sport, hull fouling, aquaculture and secondary introduction are the pathways with the highest percentage of invasive species (fisheries, hunting and ornamental have a higher percentage, but this is based on relatively few introductions).

Table 10: Percentages of the registered introductions of each invasiveness category is shown for each pathway in the Nordic region

		Status of invasiveness (% distribution)			
	Registration	Invasive (%)	Potentially invasive (%)	Not invasive (%)	Not known (%)
Agriculture	561	15	11	82	10
Angling/sport	31	52	26	52	6
Animal husbandry	12	33	25	25	17
Aquaculture	71	42	15	30	24
Aquaria	27	30	11	41	33
Ballast water & sediments	250	29	23	58	14
Biological control	9	33	11	44	33
Escapes	68	32	16	50	25
Fisheries	6	83	50	33	0
Forestry	225	21	17	51	35
Horticulture	1,763	16	14	78	11
Hull fouling	35	54	31	29	11
Hunting	16	69	19	56	6
Landscaping	117	35	23	70	9
Medicinal	106	18	11	78	17
Ornamental	8	63	0	50	13
Reintroduction	15	27	0	33	40
Secondary introduction	108	40	21	58	8
Transport	342	32	18	56	21
Not known	1,850	7	3	73	24

Baltic region

The invasiveness status for many of the 1,354 alien species registered in the NOBANIS database for the Baltic region is unknown (N=819). For the alien species where the invasive status is known, the majority are considered to be not invasive (N=327), while only 130 species are considered to be invasive and 160 species are considered being potentially invasive (see table 11).

Table 11: The invasiveness status of the species in the taxonomic groups in the Baltic region

		Status of invasiveness			
	Species (N)	**Invasive**	**Potentially invasive**	**Not invasive**	**Not known**
Angiosperms	1,069	91	113	274	652
Annelids	10	2	7	0	1
Arthropods	164	24	8	14	124
Birds	19	2	2	12	5
Bryophytes	1	0	1	0	0
Cnidarians	4	1	4	0	0
Coniferous plants	13	0	3	2	8
Ferns	1	0	0	0	1
Fish	34	4	14	17	7
Flatworms	1	0	1	0	0
Fungi	10	0	0	1	9
Macroalgae	1	0	0	1	0
Mammals	6	2	2	2	1
Microorganisms	1	0	0	0	1
Molluscs	9	2	2	4	3
Nematodes	8	1	1	0	7
Phytoplankton	1	1	1	0	0
Reptiles & amphibians	2	0	2	0	0
Total	*1,354*	*130*	*161*	*327*	*819*

A total of 18 different taxonomic groups are registered for the region. The group with the highest number of invasive species is angiosperms (N=91), and thereafter arthropods (N=24). The highest numbers of potentially invasive, not invasive and species of unknown invasiveness is also largely represented by angiosperms, which reflects that the group have the highest number of alien species in the Baltic region.

No species of bryophytes, coniferous plants, ferns, flatworms, fungi, macroalgae, microorganisms or reptiles & amphibians is considered invasive in the Baltic region, although some species in the groups are considered potentially invasive.

In table 12 the percentage distribution of invasive status is shown for each taxonomic group. The groups with the highest percentage of invasive species are cnidarians (25%) and mammals (33%). Phytoplankton also has a high percentage of species registered as invasive (100%), but the result is only based on a single registration in the region.

Table 12: The percentage distribution of the invasive status for the species in the taxonomic groups in the Baltic region

		Status of invasiveness (% distribution)			
	Species (N)	Invasive (%)	Potentially invasive (%)	Not invasive (%)	Not known (%)
Angiosperms	1,069	9	11	26	61
Annelids	10	20	70	0	10
Arthropods	164	15	5	9	76
Birds	19	11	11	63	26
Bryophytes	1	0	100	0	0
Cnidarians	4	25	100	0	0
Coniferous plants	13	0	23	15	62
Ferns	1	0	0	0	100
Fish	34	12	41	50	21
Flatworms	1	0	100	0	0
Fungi	10	0	0	10	90
Macroalgae	1	0	0	100	0
Mammals	6	33	33	33	17
Microorganisms	1	0	0	0	100
Molluscs	9	22	22	44	33
Nematodes	8	11	11	0	78
Phytoplankton	1	100	100	0	0
Reptiles & amphibians	2	0	100	0	0

The groups with the highest percentage of species registered as potentially invasive are annelids, bryophytes, cnidarians, flatworms, fish, mammals, phytoplankton and reptiles & amphibians. However, it should be noted that for some of the groups the results are based on a single registration, namely the bryophytes, flatworms and phytoplankton. Also for the group reptiles & amphibians there are only two registrations.

In table 13 the status of invasiveness for species using each pathway is shown for the Baltic region. Horticulture (N=67) is the main pathway of introduction for the majority of alien species considered to be invasive. Many species considered being invasive are also introduced by agriculture (N=34), forestry (N=23), landscaping (N=21) and transport (N=21).

Table 13: The invasive status of the species entering through different pathways of introduction for the Baltic region

	Status of invasiveness			
	Invasive	Potentially invasive	Not invasive	Not known
Agriculture	34	30	98	202
Angling/sport	0	0	0	0
Animal husbandry	1	2	5	1
Aquaculture	16	22	27	3
Aquaria	1	3	0	0
Ballast water & sediments	7	17	8	4
Biological control	0	0	0	1
Escapes	4	3	6	2
Fisheries	0	1	0	0
Forestry	23	20	11	7
Horticulture	67	81	108	333
Hull fouling	6	6	9	0
Hunting	3	1	1	0
Landscaping	21	9	7	15
Medicinal	5	3	13	15
Ornamental	1	1	1	0
Reintroduction	0	0	0	0
Secondary introduction	3	5	3	0
Transport	21	14	99	80
Not known	7	4	44	268

For the majority of species considered to be potentially invasive the main pathway of introduction is by horticulture (N=81), but also agriculture (N=30), aquaculture (N=22) and forestry (N=20) are important for numerous potentially invasive species.

The pathways with the lowest number of invasive and potentially invasive species are animal husbandry, aquaria, biological control, fisheries, hunting and ornamental. The categories angling/sport and reintroduction have no registrations of invasiveness in the Baltic region.

In table 14 the percentages of the registered introductions of each invasiveness category are shown. Forestry, landscaping, secondary introduction and hull fouling are the pathways with the highest percentage of invasive species (hunting and ornamental have a higher percentage, but this is based on only a few introductions).

Table 14: Percentages of the registered introductions of each invasiveness category is shown for each pathway in the Baltic region

		Status of invasiveness (% distribution)			
	Registrations	Invasive (%)	Potentially invasive (%)	Not invasive (%)	Not known (%)
Agriculture	336	10	9	29	60
Angling/sport	0	0	0	0	0
Animal husbandry	6	17	33	83	17
Aquaculture	48	33	46	56	6
Aquaria	4	25	75	0	0
Ballast water & sediments	28	25	61	29	14
Biological control	1	0	0	0	100
Escapes	13	31	23	46	15
Fisheries	1	0	100	0	0
Forestry	44	52	45	25	16
Horticulture	551	12	15	20	60
Hull fouling	15	40	40	60	0
Hunting	3	100	33	33	0
Landscaping	45	47	20	16	33
Medicinal	31	16	10	42	48
Ornamental	1	100	100	100	0
Reintroduction	0	0	0	0	0
Secondary introduction	7	43	71	43	0
Transport	196	11	7	51	41
Not known	323	2	1	14	83

4.2.1 Islands of the North Atlantic Ocean

The invasiveness status for many of the 279 alien species registered in the NOBANIS database for the Islands of the North Atlantic Ocean is unknown (N=131). For the alien species where the invasive status is known, the majority are considered to be not invasive (N=116), while only 8 species are considered to be invasive and 24 species are considered being potentially invasive (see table 15).

Table 15: The invasive status of the different taxonomic groups on the Islands of the North Atlantic Ocean

		Status of invasiveness			
	Species (N)	Invasive	Potentially invasive	Not invasive	Not known
Angiosperms	120	2	10	56	52
Annelids	6	0	1	0	5
Arthropods	101	1	2	39	59
Birds	8	0	5	3	0
Bryophytes	3	1	0	1	1
Coniferous plants	3	0	1	2	0
Fish	2	0	0	2	0
Flatworms	1	1	0	0	0
Fungi	10	0	0	10	0
Macroalgae	2	0	1	1	0
Mammals	7	1	3	1	2
Microorganisms	1	0	1	0	0
Molluscs	15	2	0	1	12
Total	*279*	*8*	*24*	*116*	*131*

A total of 13 different taxonomic groups are registered for the region. None of the groups has markedly more invasive species than others, however when looking at species considered to be potentially invasive, angiosperms (N=10) and birds (N=5) stands out together with mammals (N=3).

The categories not invasive and unknown are largely represented by angiosperms and arthropods, which reflects that these taxonomic groups have the highest number of alien species in the region.

In table 16 the percentage distribution of invasive status is shown for each taxonomic group. The group with the highest percentage of invasive species is bryophytes (33%) and mammals (14%). The group flatworms also have a high percentage of species registered as invasive (100%), but the result is based on a single registration in the region.

Table 16: The percentage distribution and the invasive status for the species in the taxonomic groups on the Islands of the North Atlantic Ocean

		Status of invasiveness (% distribution)			
	Species (N)	Invasive (%)	Potentially invasive (%)	Not invasive (%)	Not known (%)
Angiosperms	120	2	8	47	43
Annelids	6	0	17	0	83
Arthropods	101	1	2	39	58
Birds	8	0	63	38	0
Bryophytes	3	33	0	33	33
Coniferous plants	3	0	33	67	0
Fish	2	0	0	100	0
Flatworms	1	100	0	0	0
Fungi	10	0	0	100	0
Macroalgae	2	0	50	50	0
Mammals	7	14	43	14	29
Microorganisms	1	0	100	0	0
Molluscs	15	13	0	7	80

The taxonomic groups with the highest percentage of species registered as potentially invasive are birds, macroalgae, mammals and microorganisms. Although for microorganisms the result is based on a single registration.

In table 17 the invasiveness of species using each pathway is shown. Horticulture (N=3) is the main pathway of introduction where the largest number of alien species that are considered to be invasive are introduced. For the majority of potentially invasive species the main pathway of introduction is horticulture (N=8), ballast water & sediments (N=3) or secondary introduction (N=4).

Table 17: The invasive status of the species entering through different pathways of introduction to the Islands of the North Atlantic Ocean

		Status of invasiveness			
	Registrations	**Invasive**	**Potentially invasive**	**Not invasive**	**Not known**
Agriculture	7	1	0	6	0
Animal husbandry	1	0	0	1	0
Aquaculture	2	0	1	1	0
Aquaria	2	1	1	0	0
Ballast water & sediments	5	0	3	0	2
Escapes	3	1	1	1	0
Forestry	17	0	2	15	0
Horticulture	65	3	8	52	2
Hunting	1	0	0	0	1
Landscaping	8	1	2	5	0
Medicinal	1	0	0	1	0
Ornamental	1	0	1	0	0
Secondary introduction	9	1	4	4	0
Transport	27	1	0	25	1
Not known	137	0	2	10	125

In the Nordic and Baltic regions the percentages of the registered introductions of each invasiveness category are shown for each pathway, but due to the small amount of data available for this region the calculations will not be shown.

4.2.2 Summary

Nordic region

The analysis shows that of the 4,796 species registered for the Nordic region, 646 species are considered invasive, 427 as potentially invasive, 3,216 not invasive, while 918 have an unknown status of invasiveness.

The highest number of invasive species is registered for the angiosperms and arthropods. This tendency is also seen in the categories potentially invasive and not invasive. But when examining the invasiveness within each

taxonomic group, the groups with the highest percentage of invasive species are microorganisms, flatworms, fungi, macroalgae and mammals.

The main pathway of introduction for the majority of species considered to be invasive is horticulture, followed by transport, agriculture and ballast water & sediments. However, looking at the percentage distribution angling/sport, hull fouling, aquaculture and secondary introduction are the pathways with the highest percentage of invasive alien species introduced.

Baltic region

The analysis shows that of the 1,354 alien species registered for the Baltic region, 819 species have an unknown status of invasiveness. 130 are considered to be invasive, 161 to be potentially invasive and 327 to be not invasive.

The highest number of invasive and potentially invasive species is represented by angiosperms.

When examining the invasiveness within each taxonomic group, the groups with the highest percentage of invasive species are the annelids, bryophytes, cnidarians, flatworms, phytoplankton and reptiles & amphibians.

For the analysis concerning the invasive status of the taxonomic groups, many results have here been based on single species registration causing some uncertainties in the results. But also the lack of information concerning the invasive status for many of the species registered in the region makes the results for the Baltic region unclear.

The main pathway of introduction for the majority of species considered to be invasive or potentially invasive is horticulture, but also agriculture, forestry and aquaculture are registered several times. However, looking at the percentage distribution forestry, landscaping, secondary introduction and hull fouling are the pathways with the highest percentage of invasive alien species introduced.

Islands of the North Atlantic Ocean

The analysis shows that of the 279 alien species registered for the region, 131 have an unknown status of invasiveness. 8 are considered to be invasive, 10 to be potentially invasive and 116 to be not invasive.

None of the taxonomic groups has markedly more invasive species than others, however when looking at species considered being potentially invasive, angiosperms and birds stand out. The number of registrations as invasive and potentially invasive is relatively low, and some groups are represented by only one or two species.

The group with the highest percentage of invasive species are bryophytes, mammals and flatworms, while the groups with the highest per-

centage of species registered as potentially invasive are birds, macroalgae, mammals and microorganisms. However, for flatworms and microorganisms the results are based on a single registration in each group.

The main pathway of introduction for the majority of species considered to be invasive or potentially invasive is horticulture, but also ballast water & sediments and secondary introduction are registered a number of times. 47% of the species in the region have an unknown invasiveness status.

4.3 Taxonomic groups of introduced species

4.3.1 Nordic region

The pathways of introduction are shown for each group of species registered in the Nordic region. The types of introduction – intentional and/or unintentional, as well as unknown – are also presented for each taxonomic group. Introductions of both types – intentional & unintentional – may be registered with both types in one country, or as unintentional in one country and as intentional in another.

A total of 22 taxonomic groups were represented: angiosperms, annelids, arthropods, birds, bryophytes, cnidarians, comb jellies, coniferous plants, ferns, fish, flatworms, fungi, macroalgae, mammals, microorganisms, molluscs, nematodes, other chordates, other invertebrates, phytoplankton, protozoans and reptiles & amphibians.

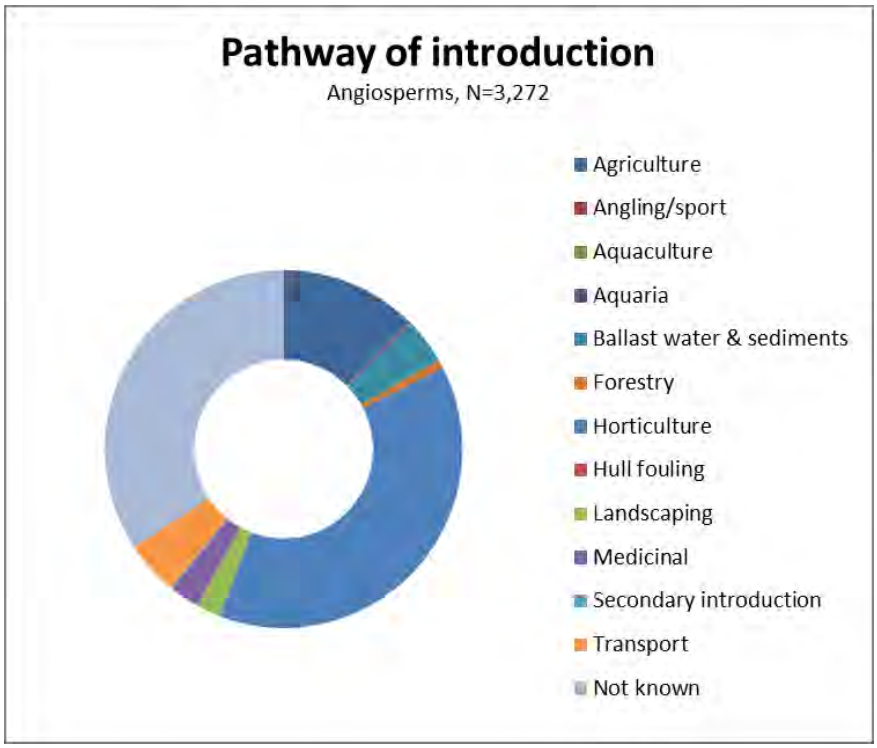
A total of 19 pathways of introduction were represented: agriculture, angling/sport, animal husbandry, aquaculture, aquaria, ballast water & sediments, biological control, escapes, fisheries, forestry, horticulture, hull fouling, hunting, landscaping, medicinal, ornamental, reintroduction, secondary introduction and transport. Each species may have multiple pathways of introduction.

Angiosperms

There are 3,272 non-native species of angiosperms currently identified in the NOBANIS database for the Nordic region.

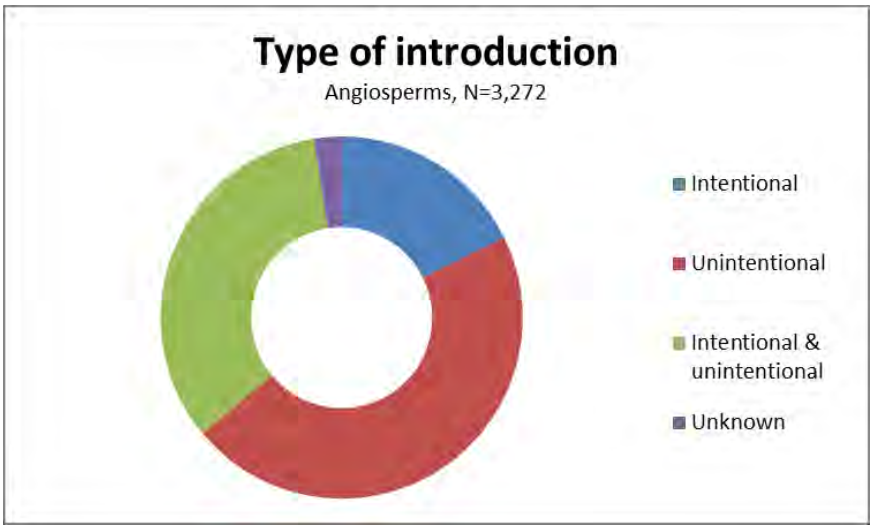
A total of 12 pathways of introduction are currently recorded for the group (see figure 9). The most frequently registered pathway of introduction is horticulture (N=1,460), followed by agriculture (N=477) and transport (N=186). For 1,305 of the non-native angiosperms the pathway of introduction is unknown.

Figure 9: Pathways of introduction for non-native angiosperms introduced to the Nordic region



Most introductions of angiosperms are unintentional (N=1,763, see figure 10). The majority of these are introduced by unknown pathways (N=953), followed by agriculture (N=270) and horticulture (N=265). Of the intentional introductions (N=675), the vast majority are introduced by horticulture (N=480).

Figure 10: Types of introduction (intentional, unintentional, both or unknown) for non-native angiosperms in the Nordic region



Some of the introductions are registered as both unintentional and intentional (N=1,280), where these primarily are introduced by horticulture (N=710) as well.

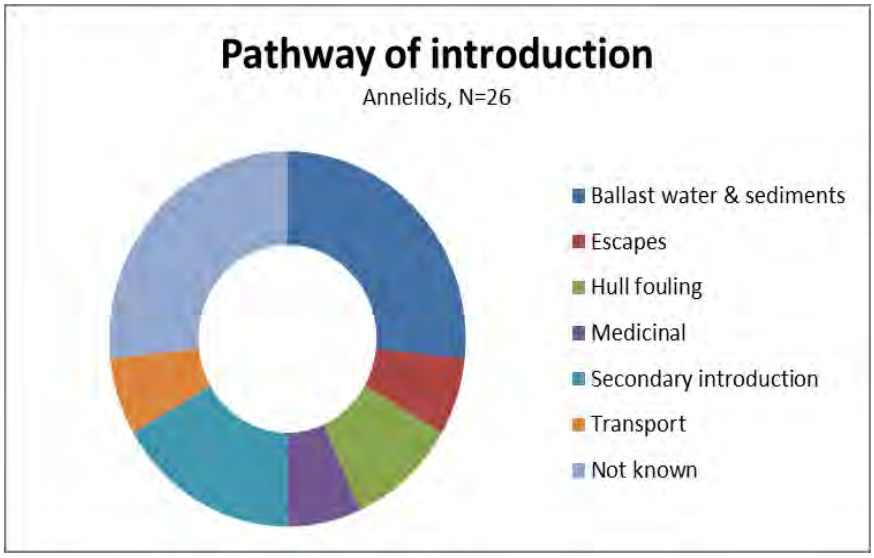
A number of introductions are registered with unknown type (N=93), where the vast majority of these also lacks information on the pathway of introduction.

Annelids

There are presently identified 26 non-native species of annelids in the NOBANIS database for the Nordic region.

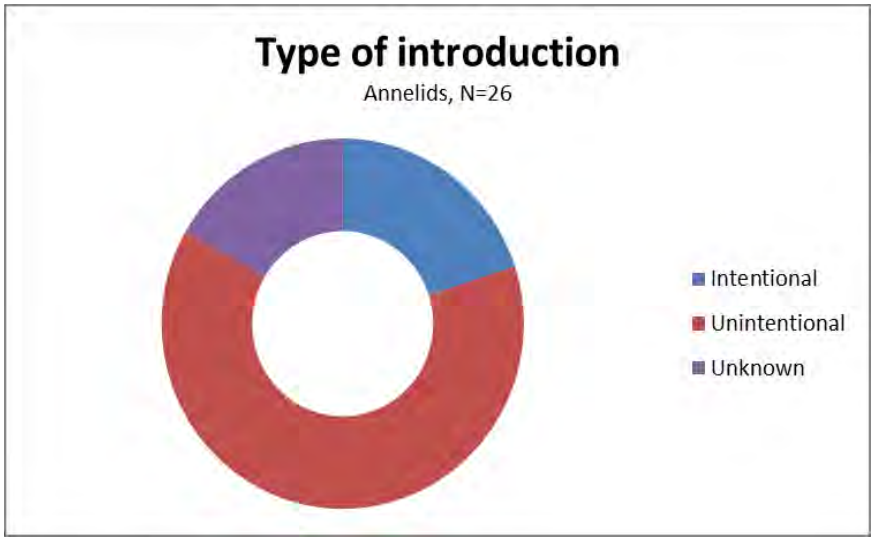
A total of 6 pathways of introduction are currently recorded for the group (see figure 11). The most registered pathway of introduction is ballast water & sediments (N=8), while for 8 species the pathway of introduction is unknown.

Figure 11: Pathways of introduction for non-native annelids introduced to the Nordic region



Most types of introductions are unintentional (N=19, see figure 12), and the majority of the unintentional introductions are by ballast water & sediments (N=7)

Figure 12: Types of introduction (unintentional, intentional or unknown) for non-native annelids in the Nordic region



The introductions that are intentional (N=6), are introduced by escapes (N=2), medicinal (N=2) and by unknown pathways (N=2).

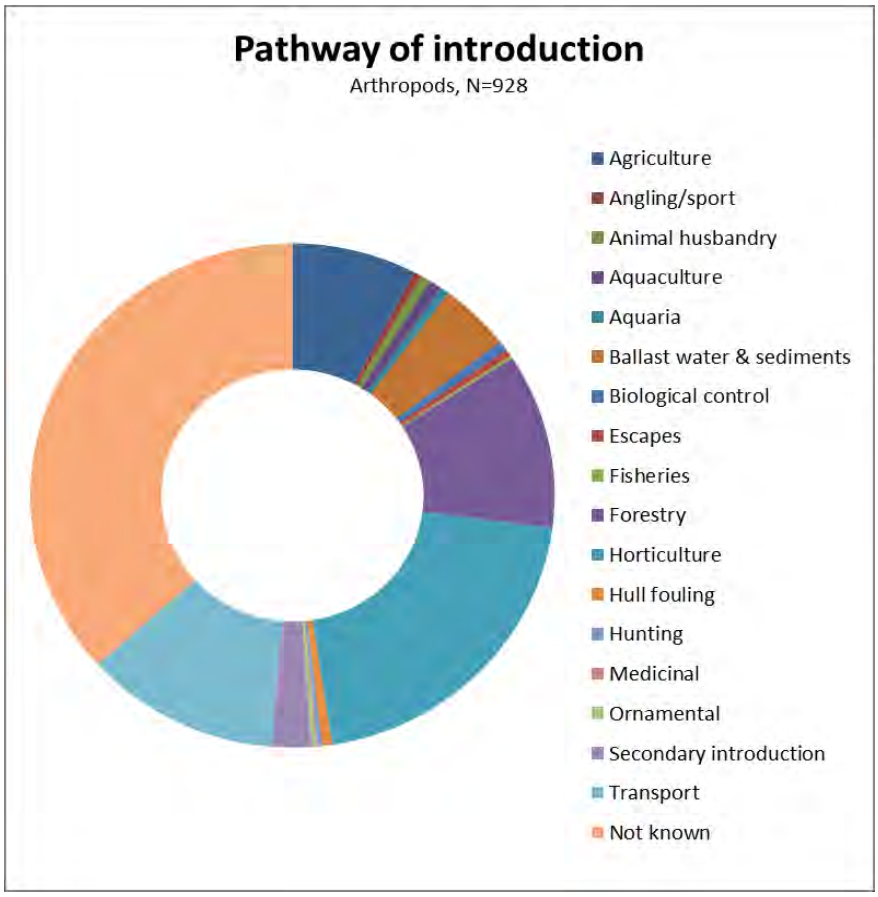
A number of species are registered with unknown types of introduction (N=5), where the majority is introduced by from secondary introduction (N=3).

Arthropods

There are currently identified 928 non-native species of arthropods in the NOBANIS database for the Nordic region.

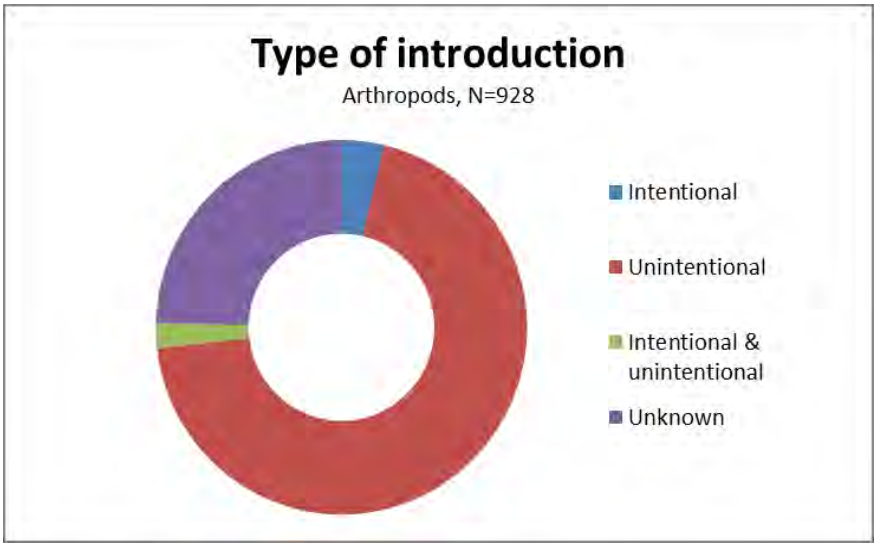
A total of 17 pathways of introduction are currently recorded for the group (see figure 13). The most frequently registered pathways of introduction are horticulture (N=228), forestry (N=225) and transport (N=134). For 408 species the pathway of introduction is still not identified.

Figure 13: Pathways of introduction for non-native arthropods introduced to the Nordic region



Most introductions of arthropods are unintentional (N=773, see figure 14). The majority of these are introduced by unknown pathways (N=290), but a large number of unintentional introductions are by horticulture (N=142) and transport (N=122). The arthropods that are intentionally introduced (N=41) is primarily by unknown pathways (N=15).

Figure 14: Types of introduction (intentional, unintentional, both or unknown) for non-native arthropods in the Nordic region



Some of the introductions are registered as both unintentional and intentional (N=24), and these are dispersed by several pathways, but primarily by horticulture (N=5) and biological control (N=4).

A number of introductions are registered with unknown types of introduction (N=274), and the most commonly registered pathway of introduction for these species is "unknown" (N=102).

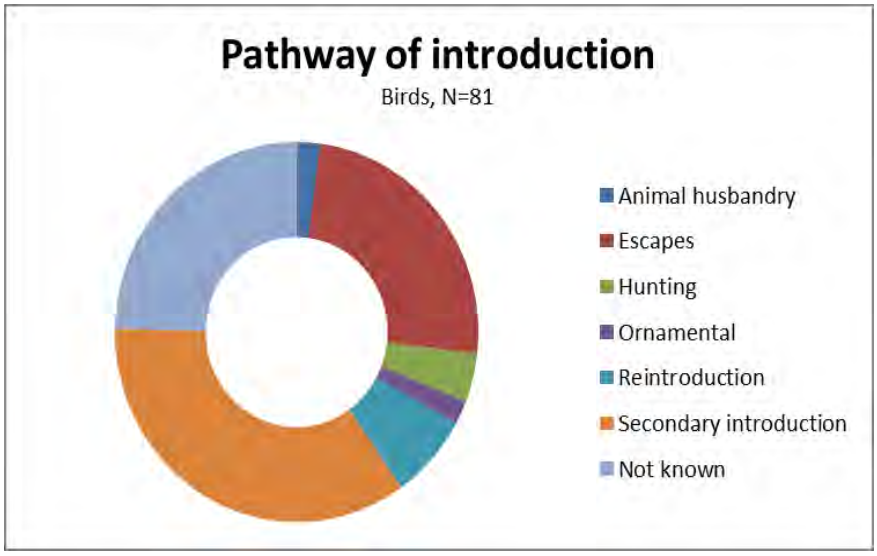
The analysis also shows that alien species of arthropods are registered with 17 different pathways of introduction, but many of the pathways are used by only a few species.

Birds

There are currently identified 81 non-native species of birds in the NOBANIS database for the Nordic region.

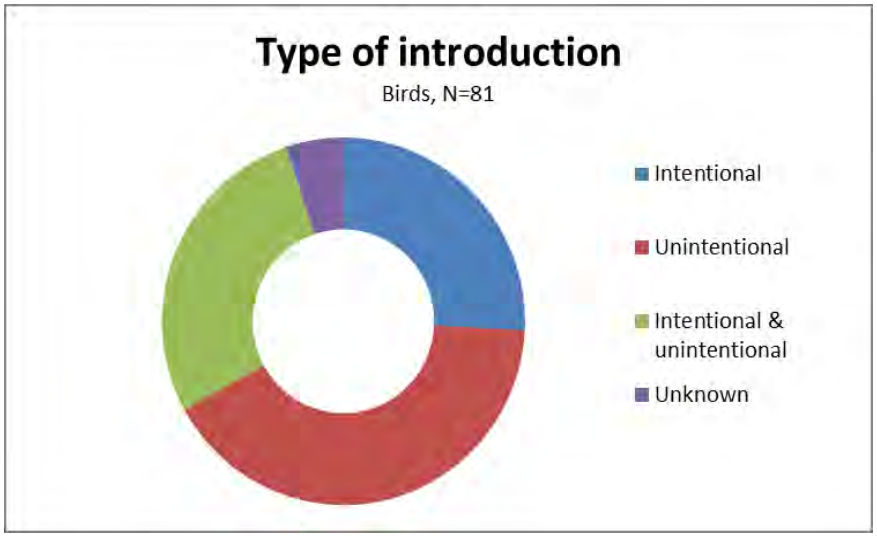
A total of 6 pathways of introduction are currently recorded for the group (see figure 15). The most frequently registered pathway of introduction are secondary introduction (N=34), followed by escapes (N=24). For 24 species of birds the pathway of introduction is unknown.

Figure 15: Pathways of introduction for non-native birds introduced to the Nordic region



Most types of introductions are unintentional (N=40, see figure 16), and most of these are secondary introductions (N=17). The intentional introductions (N=25) are primarily escapes (N=8) or reintroductions (N=6).

Figure 16: Types of introduction (intentional, unintentional, both or unknown) for non-native birds in the Nordic region



Some of the introductions are registered as both unintentional and intentional (N=27), and these are primarily escapes (N=12) and secondary introductions (N=11).

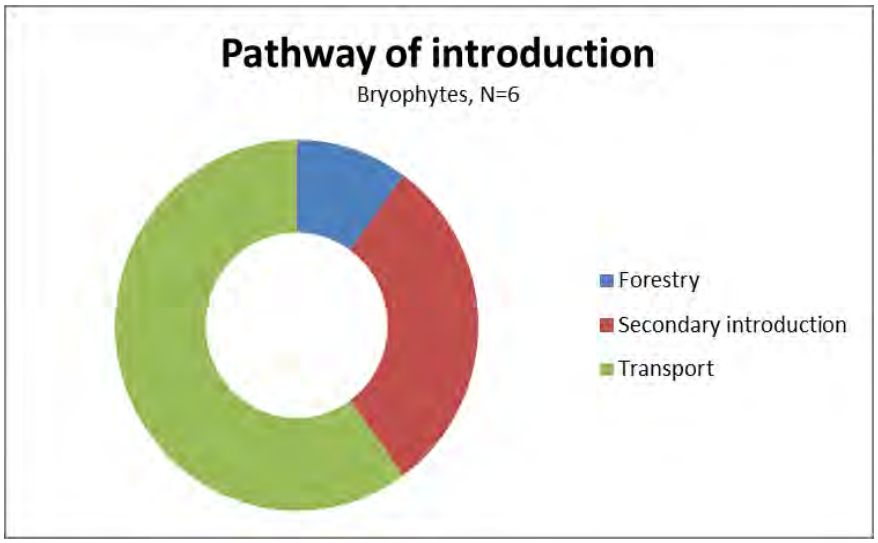
A number of introductions are registered with unknown types of introduction (N=5).

Bryophytes

There are currently identified 6 non-native species of bryophytes in the NOBANIS database for the Nordic region.

Three pathways of introduction are currently recorded for the group (see figure 17). The most registered pathway of introduction are transport (N=6), followed by secondary introduction (N=3) and forestry (N=1).

Figure 17: Pathways of introduction for non-native bryophytes introduced to the Nordic region



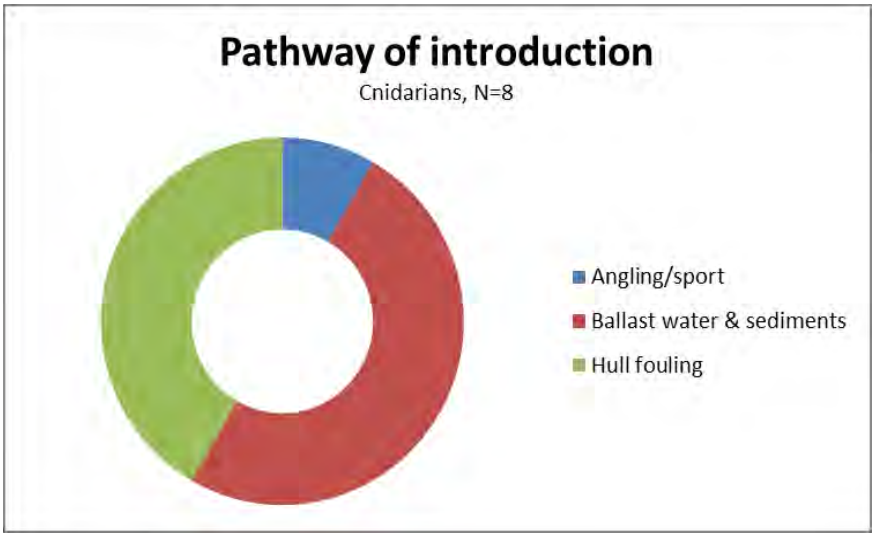
All alien introductions of bryophytes in the Nordic region are recorded as unintentional.

Cnidarians

There are currently identified 8 non-native species of cnidarians in the NOBANIS database for the Nordic region.

A total of three pathways of introduction are currently recorded for the group (see figure 18). The most frequently registered pathways of introduction are ballast water & sediments (N=6), followed by hull fouling (N=5) and angling/sport (N=1).

Figure 18: Pathways of introduction for non-native cnidarians introduced to the Nordic region



Most introductions are unintentional (N=10), and by ballast water & sediments (N=5) or hull fouling (N=4).

Comb jellies

There are currently identified four non-native species of comb jellies in the NOBANIS database for the Nordic region.

Two pathways of introduction are currently recorded for the group. The most frequently registered pathway of introduction is ballast water & sediments (N=4), but also secondary introduction (N=1) is registered.

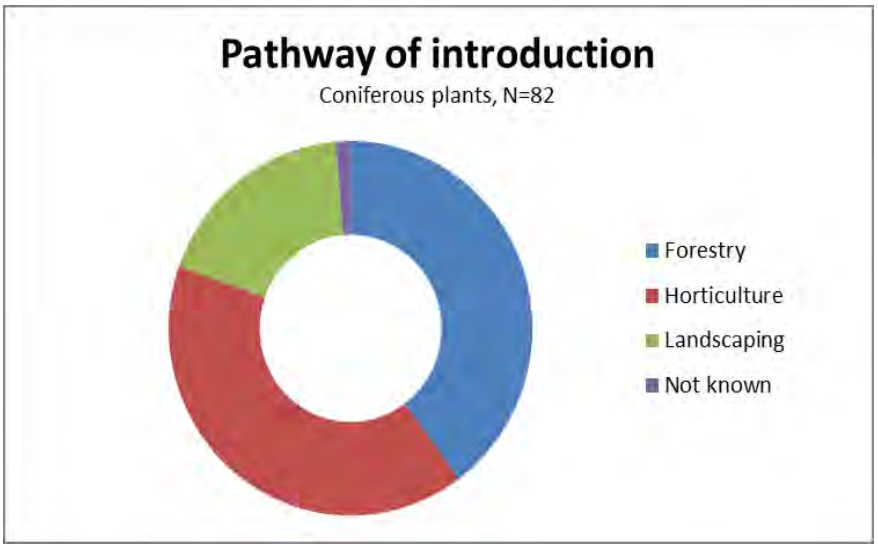
Three of the introductions by ballast water & sediments are unintentional. Of the two introductions registered in the category intentional & unintentional, one is by ballast water & sediments and one is by hull fouling.

Coniferous plants

There are currently identified 82 non-native species of coniferous plants in the NOBANIS database for the Nordic region.

Three pathways of introduction are currently recorded for the group (see figure 19). The most frequently registered pathways of introduction are horticulture (N=62) and forestry (N=61), but also landscaping (N=28) is registered. For two species the pathways of introduction are unknown.

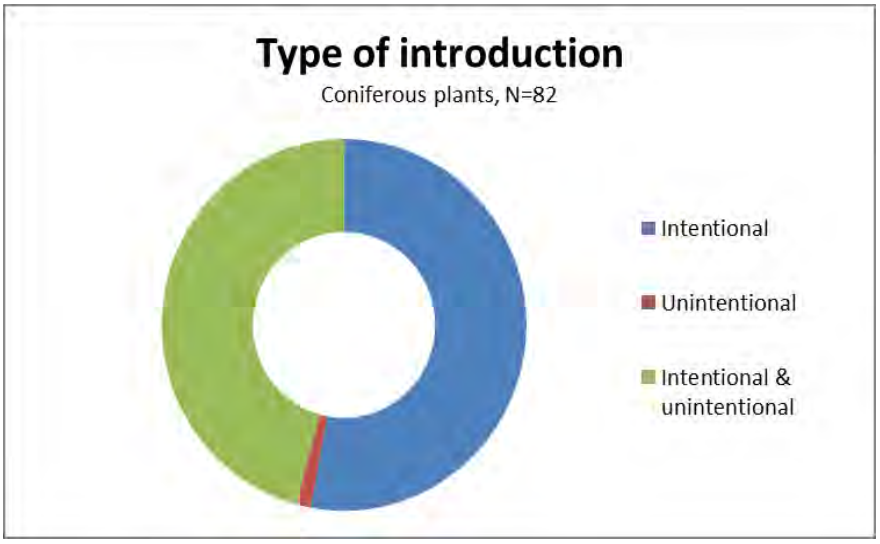
Figure 19: Pathways of introduction for non-native coniferous plants introduced to the Nordic region



Most introductions are intentional (N=81, see figure 20), and these are primarily by horticulture (N=34) or forestry (N=33).

A number of the introductions are registered as both unintentional and intentional (N=70), and these are primarily by horticulture (N=28) and forestry (N=28).

Figure 20: Types of introduction (intentional, unintentional or both) for non-native coniferous plants in the Nordic region

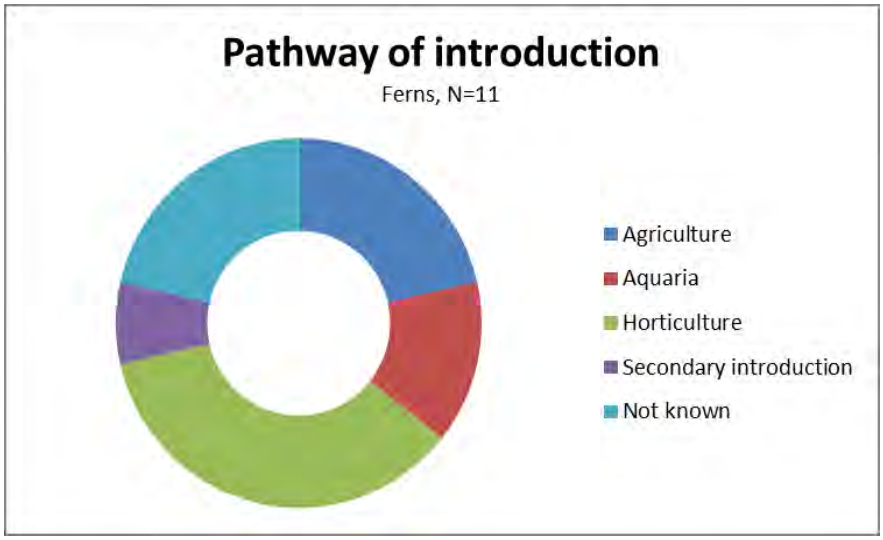


Ferns

There are currently identified 11 non-native species of ferns in the NOBANIS database for the Nordic region.

A total of four pathways of introduction are currently recorded for the group (see figure 21). The most frequently registered pathways of introduction are horticulture (N=5) and agriculture (N=3). For three species the pathway of introduction is unknown.

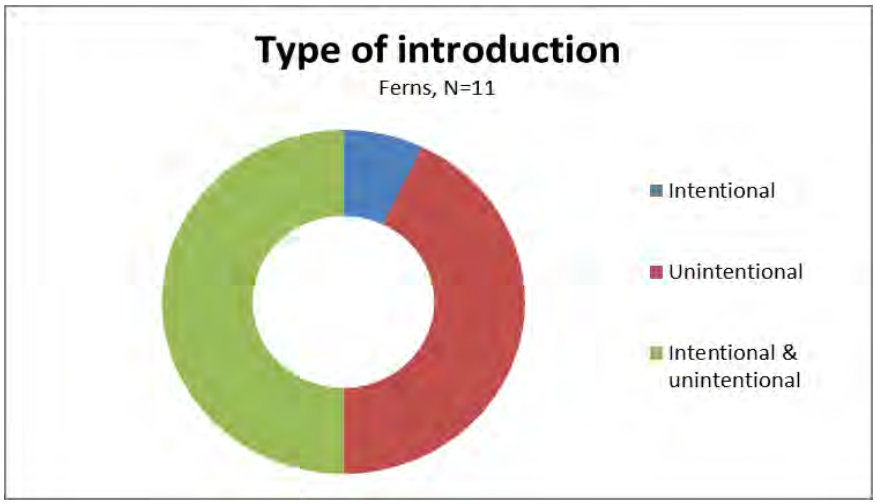
Figure 21: Pathways of introduction for non-native ferns introduced to the Nordic region



Of the introduced ferns, half of the introductions are categorised as intentional & unintentional (N=7, see figure 22), and most of these are by horticulture (N=4).

For the introductions that are categorised as unintentional (N=6) most of the pathways were unknown (N=3), and for the one intentionally introduced species the cause of introduction is horticulture.

Figure 22: Types of introduction (intentional, unintentional or both) for non-native ferns in the Nordic region

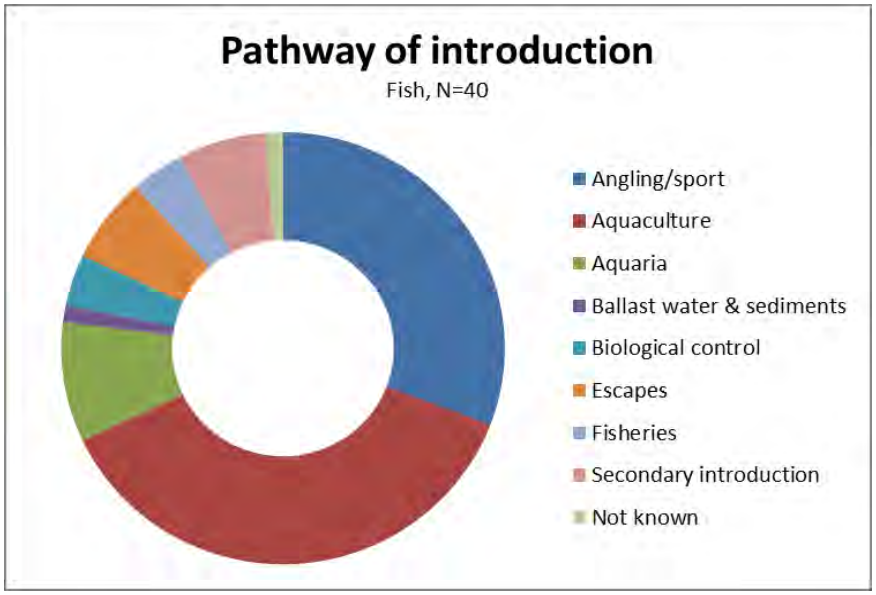


Fish

There are currently identified 40 non-native species of fish in the NOBANIS database for the Nordic region.

A total of 8 pathways of introduction are currently recorded for the group (see figure 23). The most frequently registered pathways of introduction are aquaculture (N=29) and angling/sport (N=24). Only one species is registered with an unknown pathway of introduction.

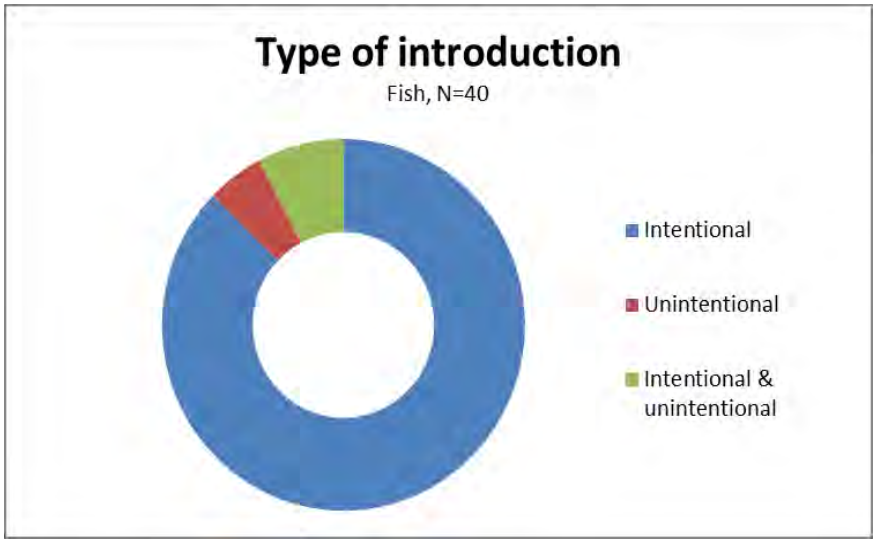
Figure 23: Pathways of introduction for non-native fish introduced to the Nordic region



Most introductions are intentional (N=68, see figure 24). The most registered pathways of these are aquaculture (N=26) and angling/sport (N=21). The introductions that are unintentional (N=4) are mostly by aquaculture (N=2).

A number of the introductions are registered with both unintentional and intentional introductions (N=3), and these are primarily by angling/sport (N=3).

Figure 24: Types of introduction (intentional, unintentional or both) for non-native fish in the Nordic region

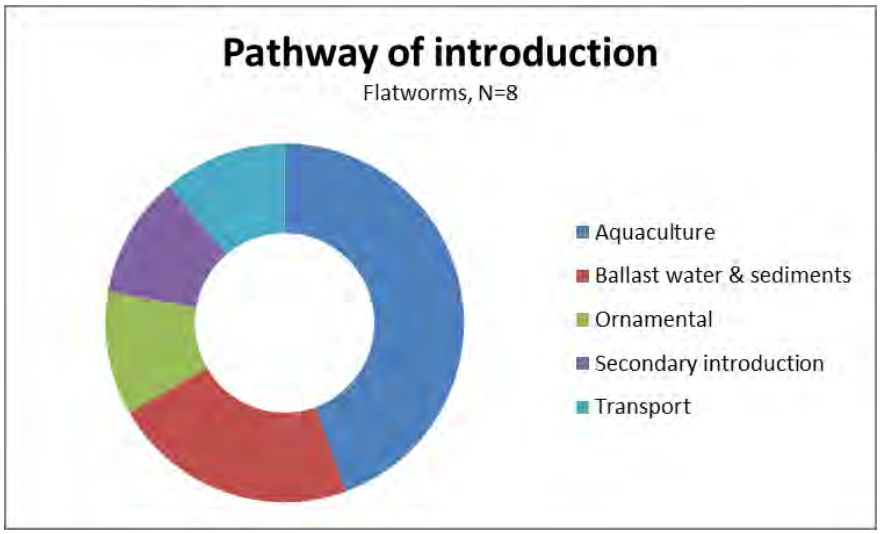


Flatworms

There are currently identified 8 non-native species of flatworms in the NOBANIS database for the Nordic region.

A total of 5 pathways of introduction are currently recorded for the group (see figure 25). The most frequently registered pathways of introduction are aquaculture (N=4) and ballast water & sediments (N=2). All of the introductions are unintentional.

Figure 25: Pathways of introduction for non-native flatworms introduced to the Nordic region

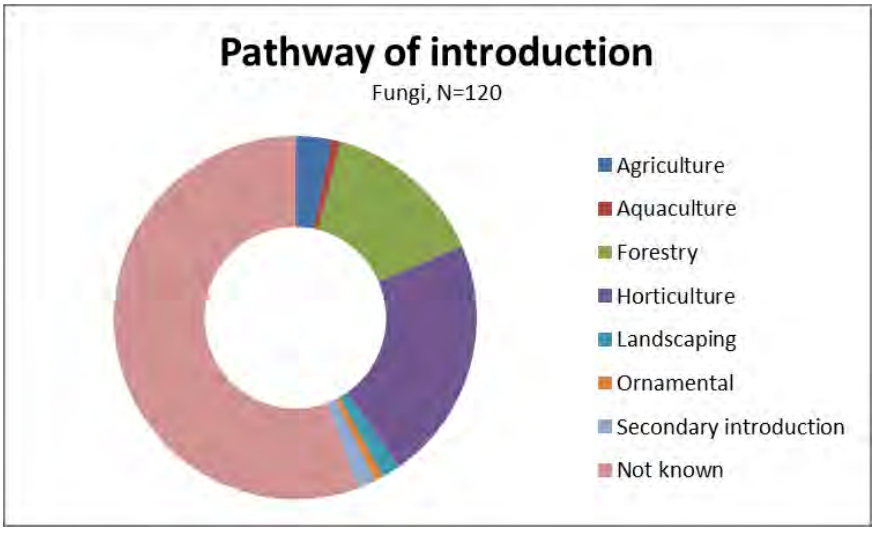


Fungi

There are currently identified 120 non-native species of fungi in the NOBANIS database for the Nordic region.

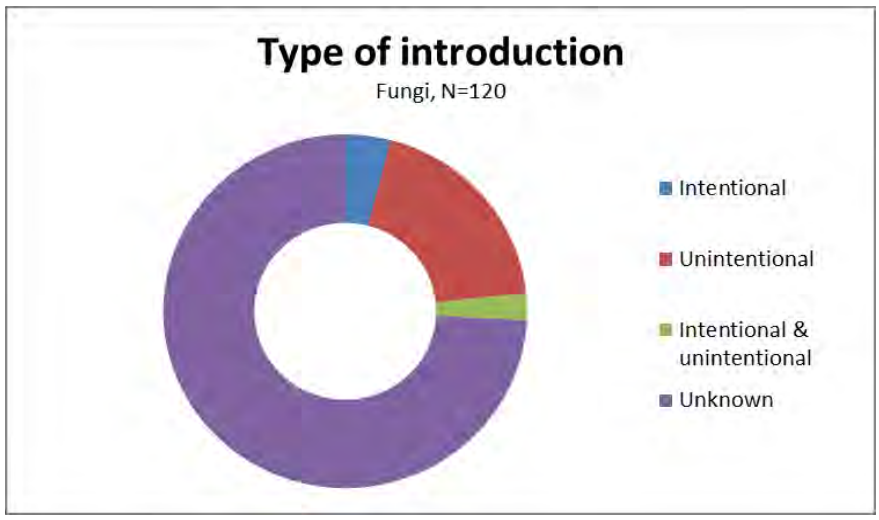
A total of 8 pathways of introduction are currently recorded for the group (see figure 26). The most frequently registered pathways of introduction are horticulture (N=27) and forestry (N=18), but for 69 species the pathway of introduction is unknown.

Figure 26: Pathways of introduction for non-native fungi introduced to the Nordic region



Most types of introductions are unknown (N=92, see figure 27). A number of introductions are unintentional (N=24), where most are by forestry (N=10) or horticulture (N=9). A few introductions are registered as intentional & unintentional (N=3).

Figure 27: Types of introduction (intentional, unintentional, both or unknown) for non-native fungi in the Nordic region

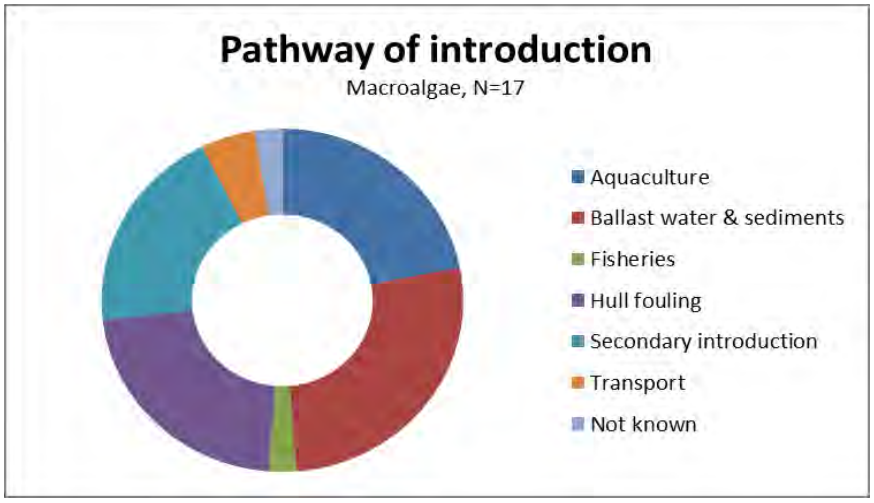


Macroalgae

There are currently identified 17 non-native species of macroalgae in the NOBANIS database for the Nordic region.

A total of 6 pathways of introduction are currently recorded for the group (see figure 28). The most frequently registered pathway of introduction is ballast water & sediments (N=11), followed by aquaculture (N=9) and hull fouling (N=9). For one species the pathway of introduction is unknown.

Figure 28: Pathways of introduction for non-native macroalgae introduced to the Nordic region



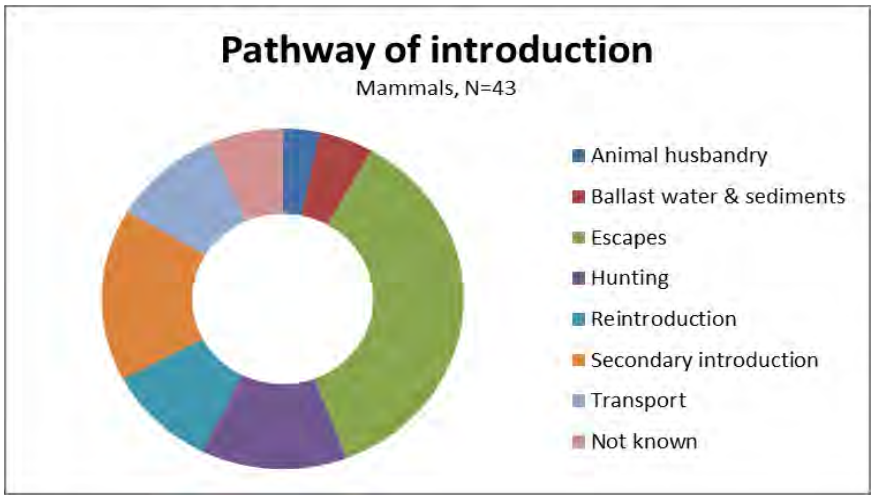
The vast majority of the introductions are unintentional (N=38), and for a few the type of introduction is unknown (N=3).

Mammals

There are currently identified 43 non-native species of mammals in the NOBANIS database for the Nordic region.

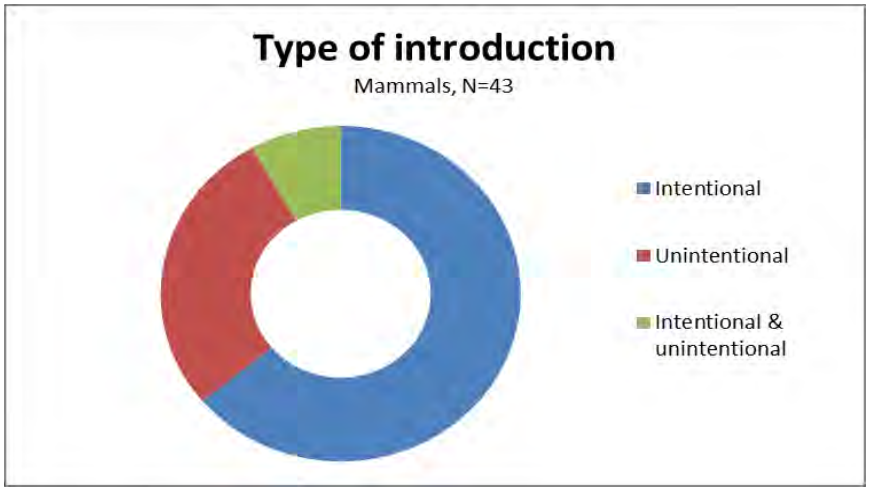
A total of 7 pathways of introduction are currently recorded for the group (see figure 29). The most frequently registered pathway of introduction is escapes (N=22), followed by secondary introduction (N=10). For four species the pathway of introduction is unknown.

Figure 29: Pathways of introduction for non-native mammals introduced to the Nordic region



Most introductions are intentional (N=39, see figure 30) and by escapes (N=14) or secondary introductions (N=7).

Figure 30: Types of introduction (intentional, unintentional or both) for non-native mammals in the Nordic region

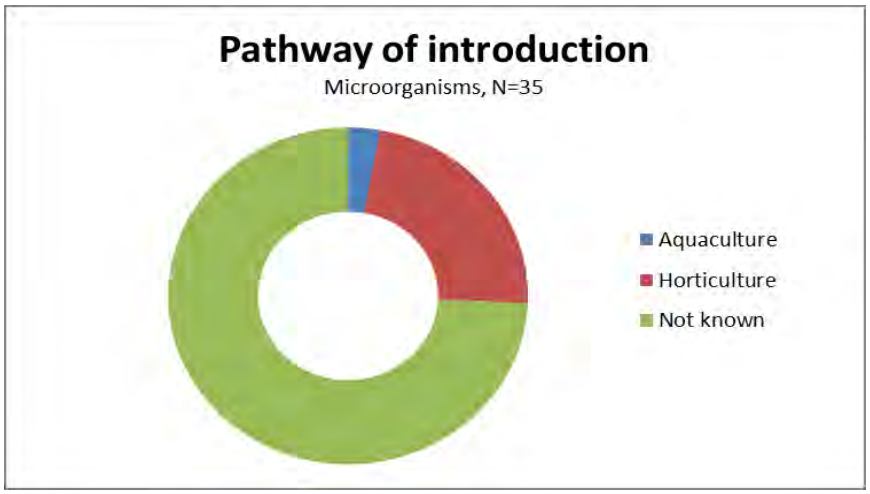


Microorganisms

There are currently identified 35 non-native species of microorganisms in the NOBANIS database for the Nordic region.

Two pathways of introduction are currently recorded for the group (see figure 31). The most common pathway of introduction is horticulture (N=8), but for the majority of the species the pathway of introduction is unknown (N=26).

Figure 31: Pathways of introduction for non-native microorganisms introduced to the Nordic region



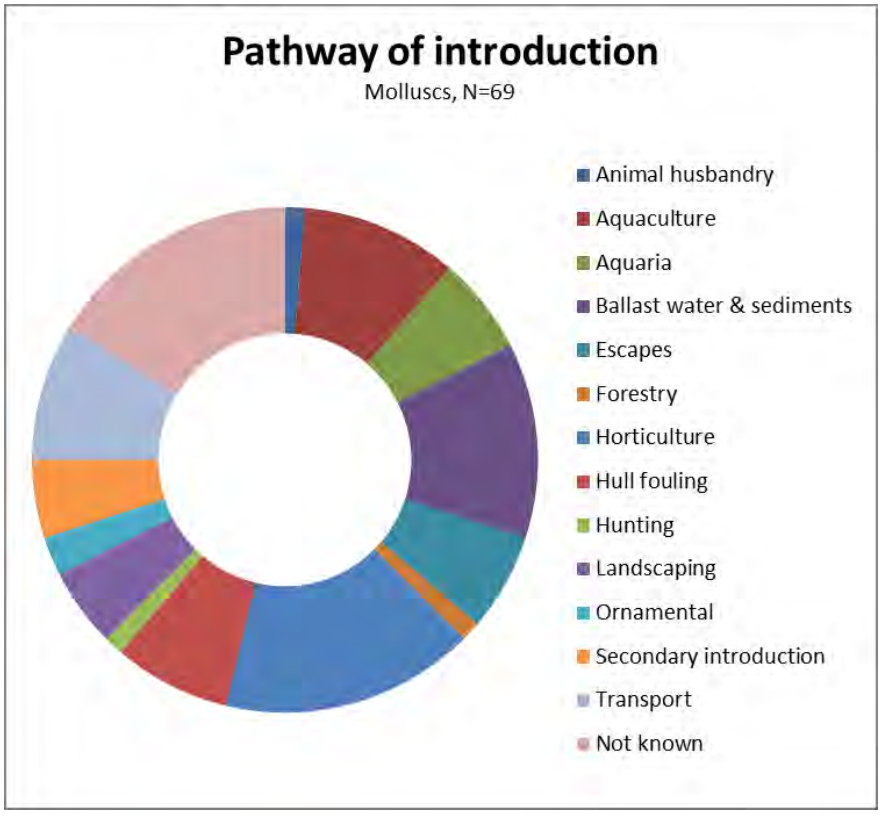
Two of the introductions are registered as unintentional, but for the majority of the non-native species the type of introduction is unknown (N=33).

Molluscs

There are currently identified 69 non-native species of molluscs in the NOBANIS database for the Nordic region.

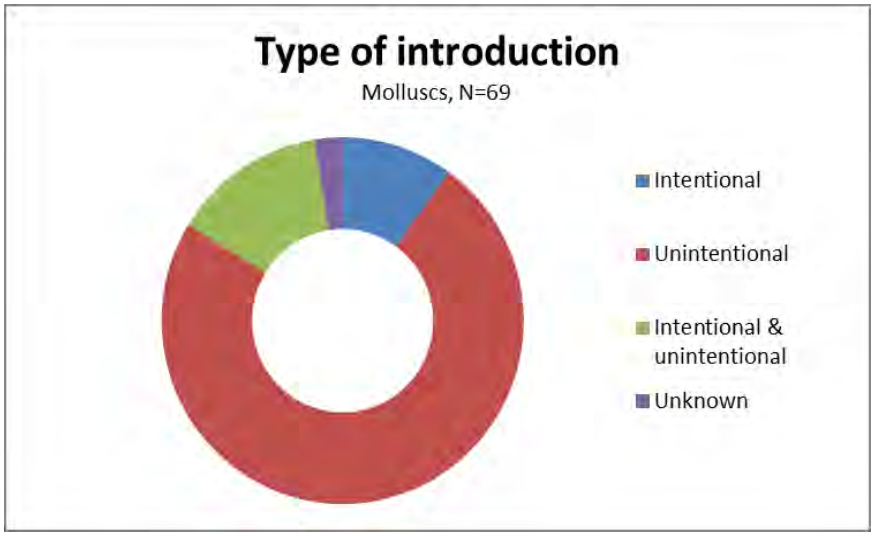
A total of 13 pathways of introduction are currently recorded for the group (see figure 32). The most frequently registered pathway of introduction is horticulture (N=13), followed by ballast water & sediments (N=10). For 13 species the pathway of introduction is unknown.

Figure 32: Pathways of introduction for non-native molluscs introduced to the Nordic region



Most introductions are unintentional (N=59, see figure 33), while 8 are intentional and 11 are registered as intentional & unintentional.

Figure 33: Types of introduction (intentional, unintentional, both or unknown) for non-native molluscs in the Nordic region

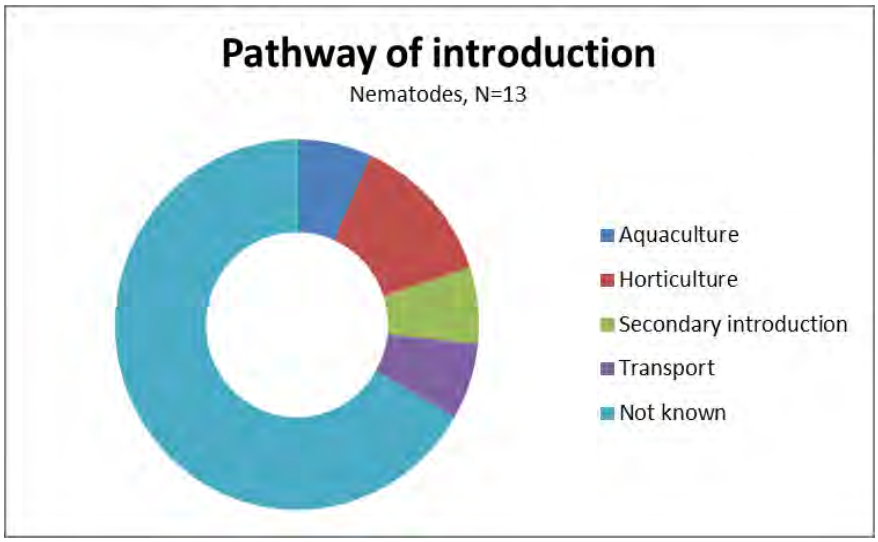


Nematodes

There are currently identified 13 non-native species of nematodes in the NOBANIS database for the Nordic region.

A total of four pathways of introduction are currently recorded for the group (see figure 34). The main pathway of introduction is horticulture (N=2), but for most introductions the pathway is unknown (N=10).

Figure 34: Pathways of introduction for non-native nematodes introduced to the Nordic region



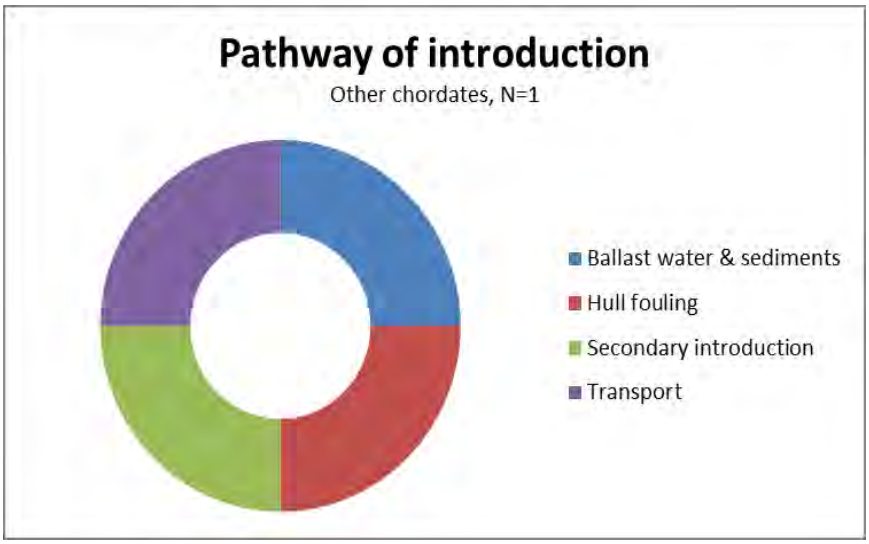
Most introductions are unintentional (N=13), while a few are unknown (N=2) and 11 are in the intentional & unintentional category.

Other chordates

There are currently identified only one non-native species of *other chordates* in the NOBANIS database for the Nordic region. The species is *Styela clava* (Subphylum: Tunicata).

A total of four pathways of introduction are currently recorded for the species (see figure 35). The four pathways are registered once each and all types of introductions are registered as being unintentional.

Figure 35: Pathways of introduction for non-native species of other chordates introduced to the Nordic region

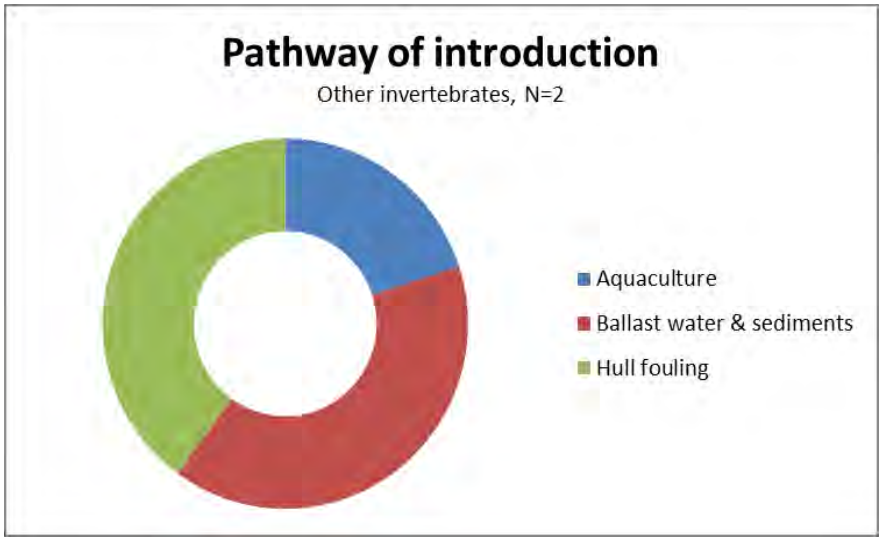


Other invertebrates

There are currently identified two non-native species of *other invertebrates* in the NOBANIS database for the Nordic region. The species are the bryozoans *Bugula neritina* and *Victorella pavida* (Phylum: Bryozoa).

Three pathways of introduction are currently recorded for the species in the Nordic region (see figure 36). The registered pathways are ballast water & sediments (N=2) and hull fouling (N=2), and all types of introductions are registered as unintentional.

Figure 36: Pathways of introduction for non-native species of other invertebrates introduced to the Nordic region

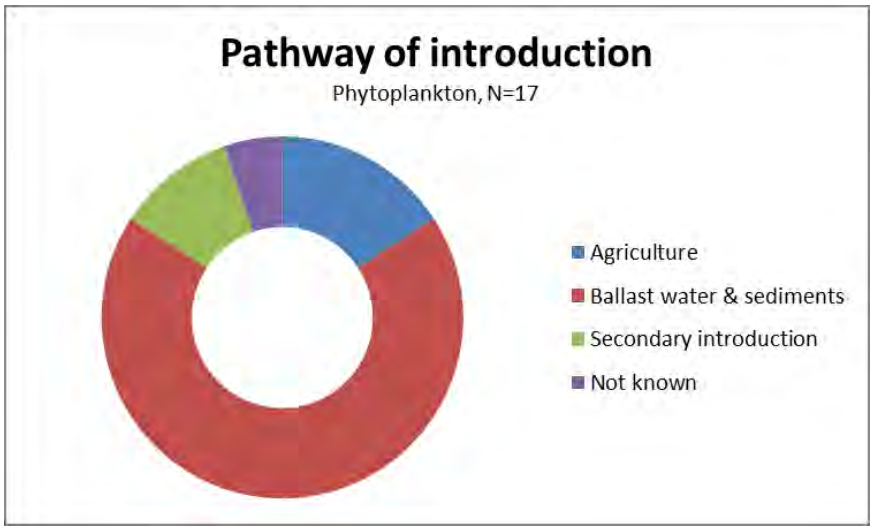


Phytoplankton

There are currently identified 17 non-native species of phytoplankton in the NOBANIS database for the Nordic region.

A total of three pathways of introduction are currently recorded for the group (see figure 37). The most frequently registered pathway of introduction is ballast water & sediments (N=13).

Figure 37: Pathways of introduction for non-native phytoplankton introduced to the Nordic region



The majority of the introductions are registered as being unintentional (N=19), while a few are registered as being of unknown type (N=3).

Protozoans

There are currently identified two non-native species of protozoans in the NOBANIS database for the Nordic region. The species are the rhizaria *Marteilia refringens* and *Plasmodiophora brassicae*.

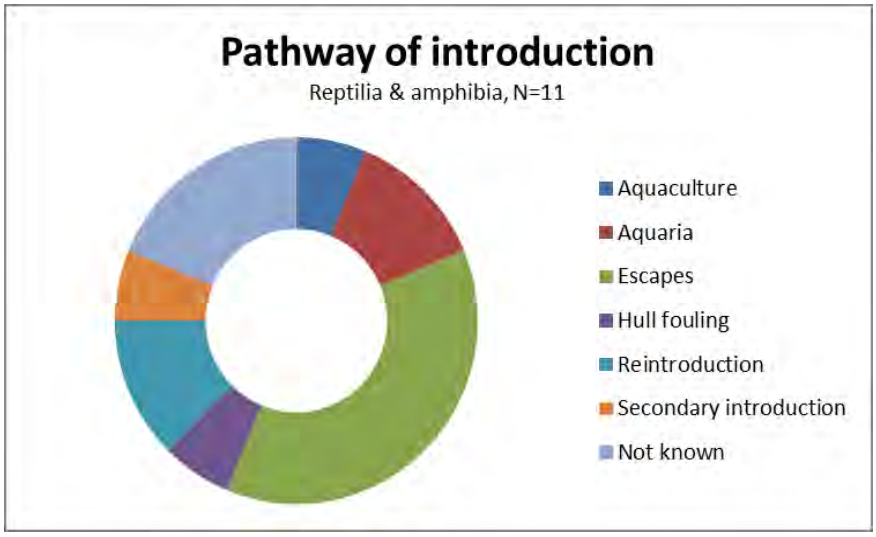
One pathway of introduction is currently recorded for these species in the Nordic region. For *Marteilia refringens* the pathway of introduction is aquaculture and is unintentional, while the pathway of introduction for *Plasmodiophora brassicae* is unidentified.

Reptiles & amphibians

There are currently identified 11 non-native species of reptiles & amphibians in the NOBANIS database for the Nordic region.

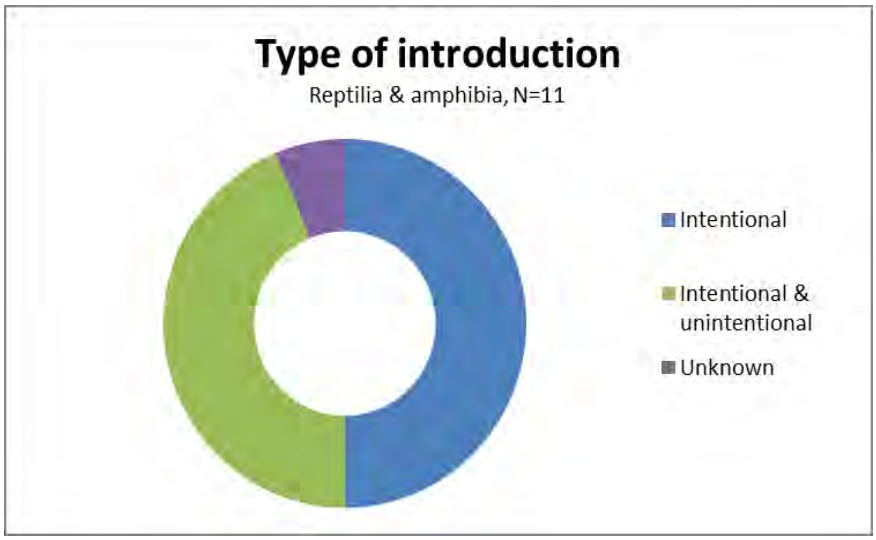
A total of 6 pathways of introduction are currently recorded for the group (see figure 38). The most frequently registered pathway of introduction is escape (N=6). For three species the pathway of introduction is unknown.

Figure 38: Pathways of introduction for non-native reptilian & amphibians introduced to the Nordic region



Most types of introductions are intentional (N=8, see figure 39) or intentional & unintentional (N=7). The intentional introductions are mostly escapes (N=4) or reintroductions (N=2).

Figure 39: Types of introduction (intentional, intentional & unintentional or unknown) for non-native reptiles & amphibians in the Nordic region



4.3.2 Baltic region

The pathways of introduction are shown for each group of species registered in the Baltic region. The type of introduction – intentional and/or unintentional, as well as unknown – is also presented for each taxonomic group. The introductions of both types – intentional & unintentional – may be registered with both types in one country, or as unintentional in one country and as intentional in another.

A total of 18 taxonomic groups are represented: angiosperms, annelids, arthropods, birds, bryophytes, cnidarians, coniferous plants, ferns, fish, flatworms, fungi, macroalgae, mammals, microorganisms, molluscs, nematodes, phytoplankton, and reptiles & amphibians.

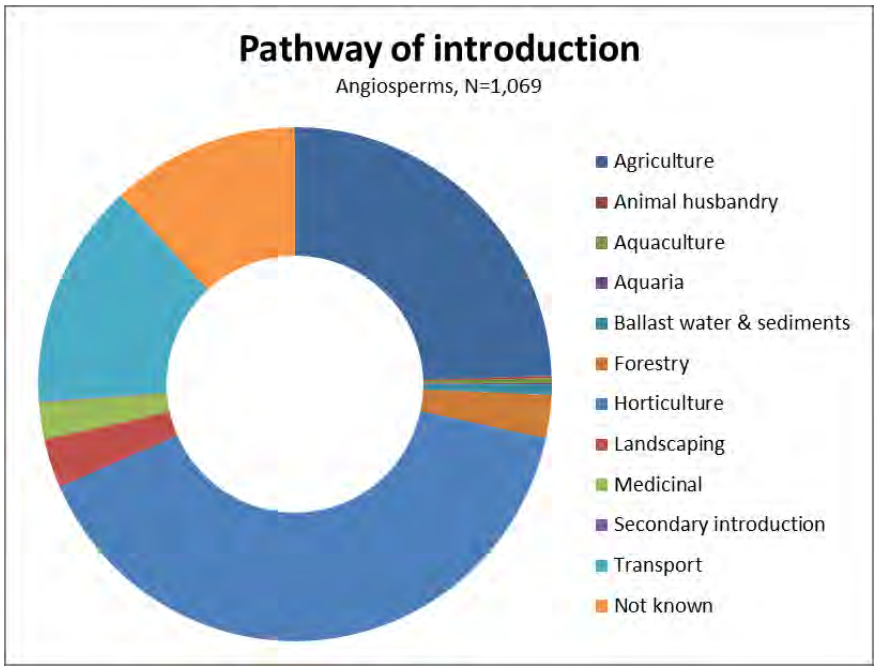
A total of 17 pathways of introduction are represented: agriculture, animal husbandry, aquaculture, aquaria, ballast water & sediments, biological control, escapes, fisheries, forestry, horticulture, hull fouling, hunting, landscaping, medicinal, ornamental, secondary introduction and transport. Each species may have more than one pathway of introduction.

Angiosperms

There are currently identified 1,069 non-native species of angiosperms in the NOBANIS database for the Baltic region.

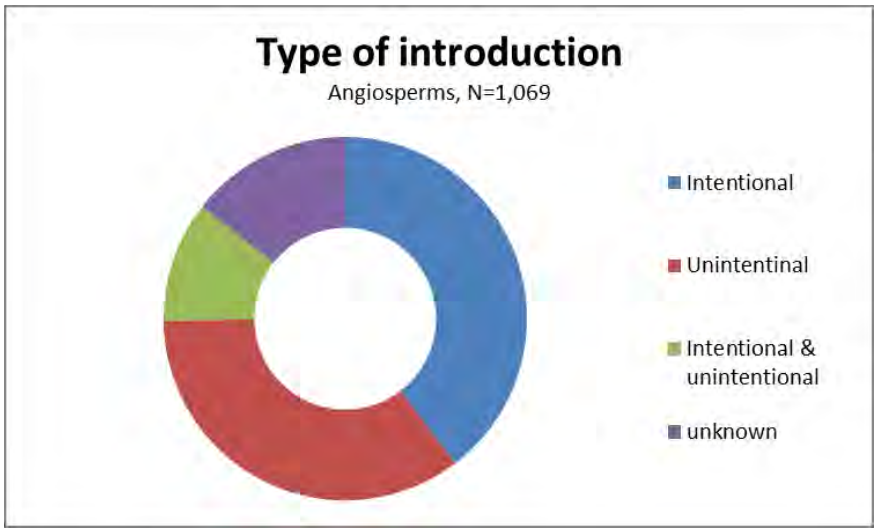
A total of 11 pathways of introduction are currently recorded for the group (see figure 40). The most frequently registered pathway is horticulture (N=535), followed by agriculture (N=326) and transport (N=189). For 158 species the pathway of introduction is unidentified.

Figure 40: Pathways of introduction for non-native angiosperms introduced to the Baltic region



For the majority of species introduced by horticulture, the introduction is intentional, while species introduced by agriculture and transport mostly are unintentionally introduced. An overview of the distribution of introductions is shown in figure 41.

Figure 41: Types of introduction (intentional, unintentional, both or unknown) for alien species of angiosperms in the Baltic region

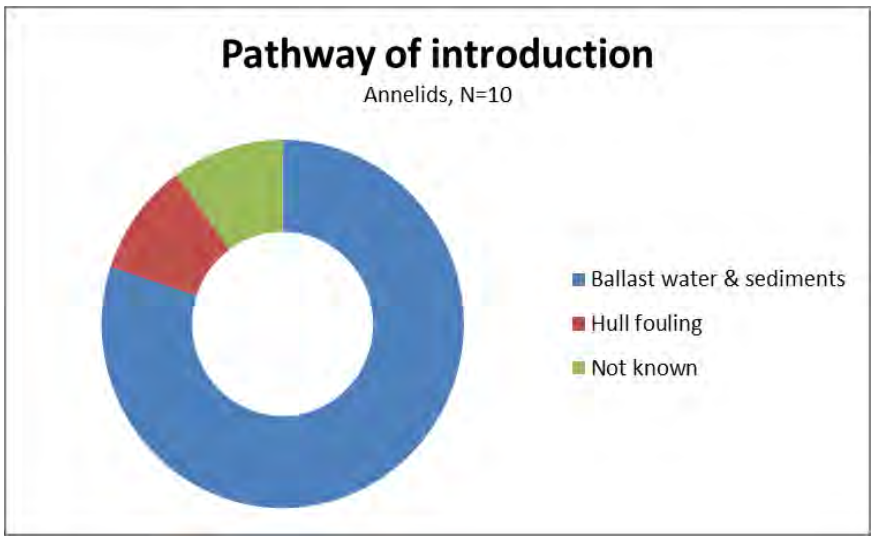


Annelids

There are currently identified 10 non-native species of annelids in the NOBANIS database for the Baltic region.

Two pathways of introduction are currently recorded for the group (see figure 42), and the most frequently registered pathway of introduction is ballast water & sediments (N=8). All types of introductions are registered as being unintentional. For only one species the pathway of introduction is unidentified.

Figur 42: Pathways of introduction for non-native annelids introduced to the Baltic region

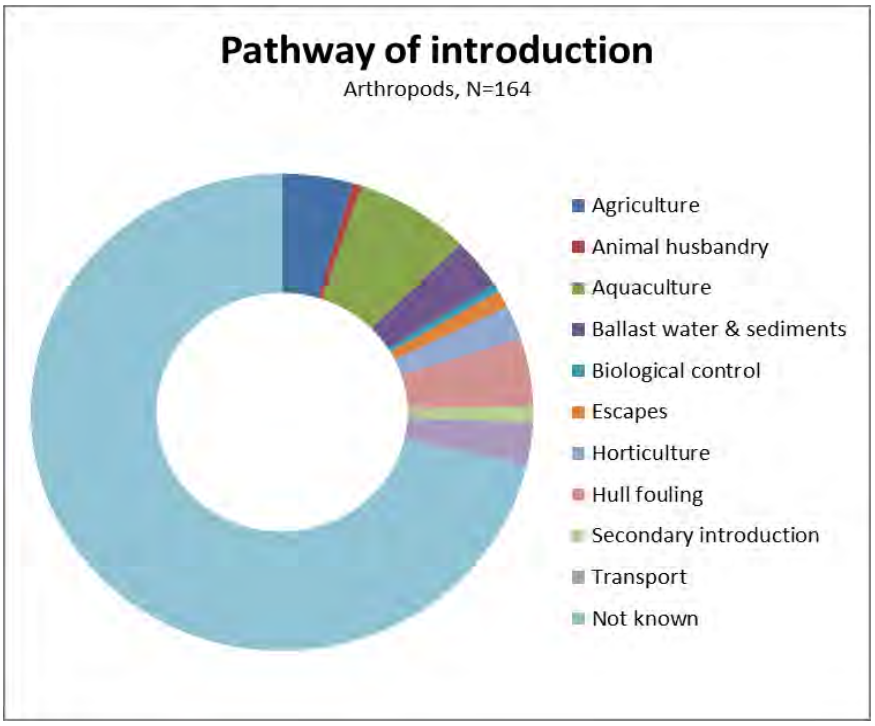


Arthropods

There are presently identified 164 non-native species of arthropods in the NOBANIS database for the Baltic region.

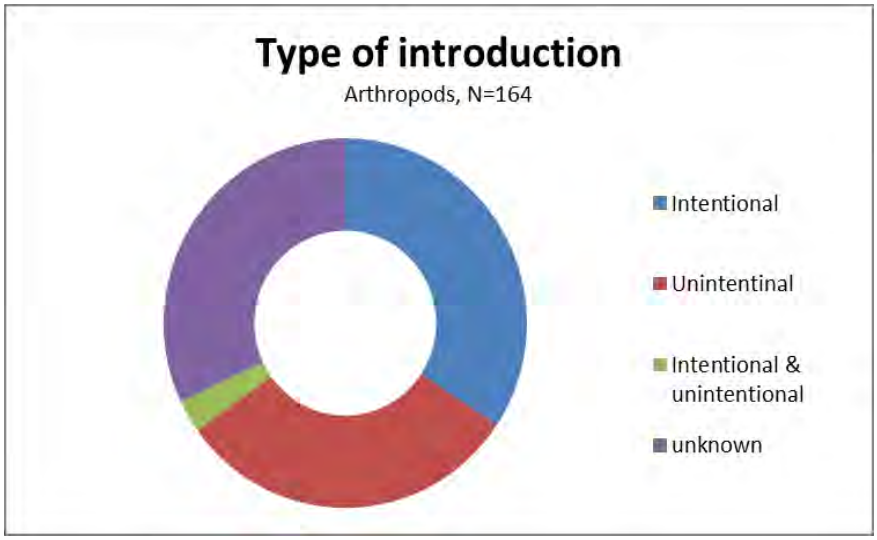
A total of 10 pathways of introduction are currently recorded for the group (See figure 43). The main pathway of introduction is aquaculture (N=13), but for the majority of the species (76%) the pathway of introduction is unidentified (N=125).

Figure 43: Pathways of introduction for non-native arthropods introduced to the Baltic region



60 of the introductions are intentional, 54 are unintentional and for 56 species the type of introduction is unknown (see figure 44).

Figure 44: Types of introduction (intentional, unintentional, both or unknown) for alien species of arthropods in the Baltic region

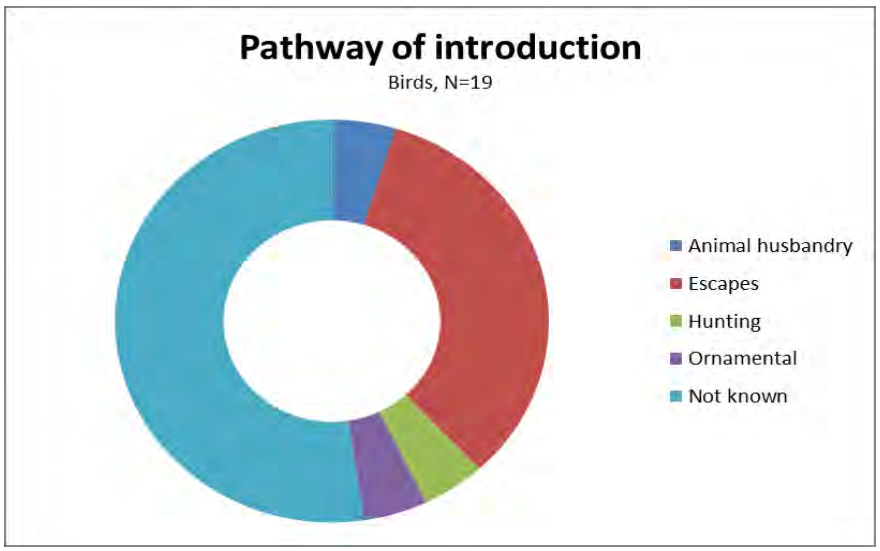


Birds

There are presently identified 19 non-native species of birds in the NOBANIS database for the Baltic region.

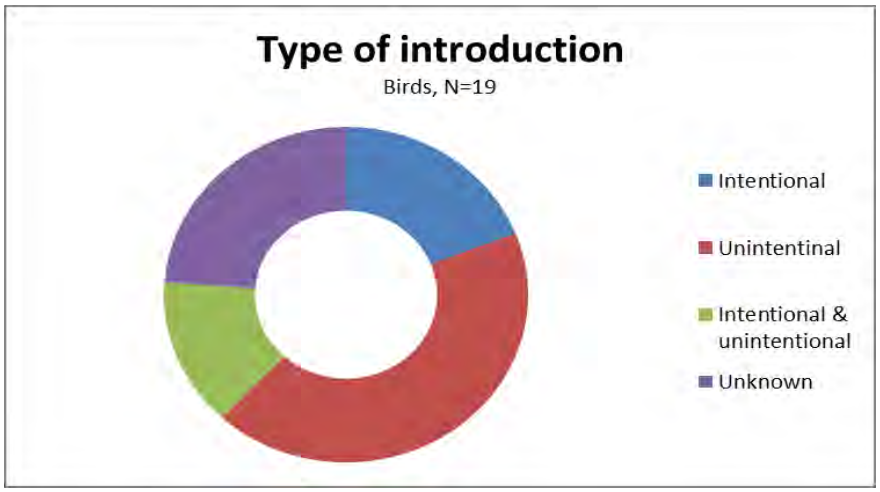
A total of four pathways of introduction are currently recorded for the group (see figure 45), and the main pathway of introduction is escapes (N=7). For 11 species the pathway of introduction is unidentified.

Figure 45: Pathways of introduction for non-native birds introduced to the Baltic region



The majority of the introduction occured unintentionally (N=9, see figure 46).

Figure 46: Types of introduction (intentional, unintentional, both or unknown) for alien species birds in the Baltic region



Bryophytes

There are presently identified only one non-native species of bryophytes in the NOBANIS database for the Baltic region. The species *Campylopus introflexus* is registered as alien in Estonia.

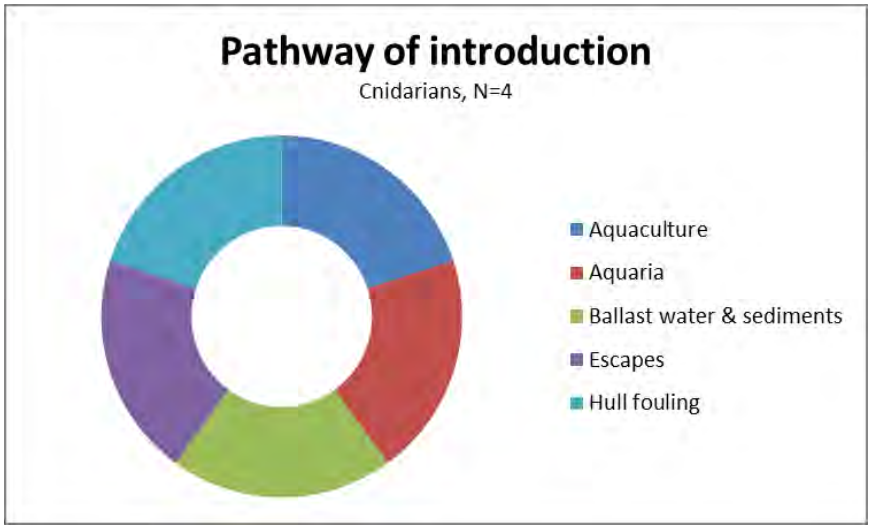
The introduction is categorised as unintentional but the pathway of introduction is unknown.

Cnidarians

There are presently identified four non-native species of cnidarians in the NOBANIS database for the Baltic region.

A total of four pathways of introduction are currently recorded for the group (see figure 47), and all introductions are registered as being unintentional.

Figure 47: Pathways of introduction for non-native cnidarians introduced to the Baltic region



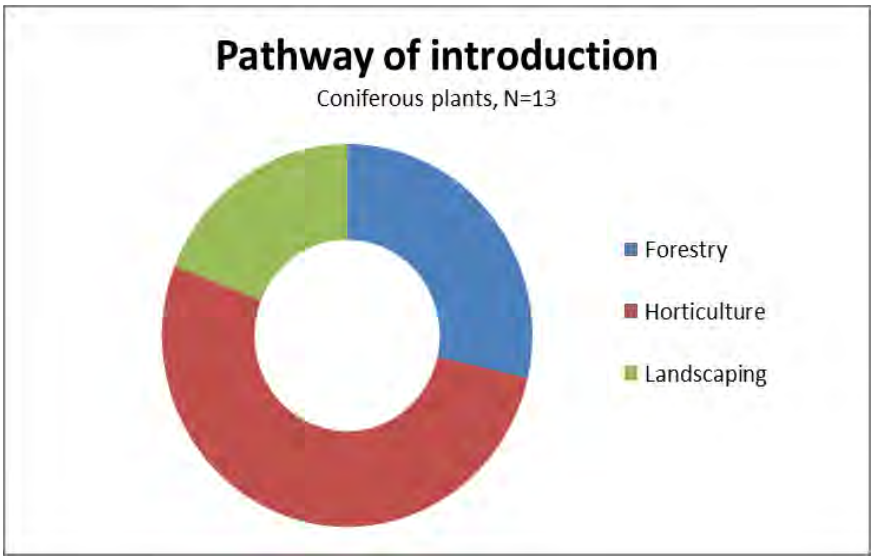
The analysis have not shown any main pathways of introduction, but that the introductions are unintentional and by many different pathways.

Coniferous plants

There are presently identified 13 non-native species of coniferous plants in the NOBANIS database for the Baltic region.

A total of three pathways of introduction are currently recorded for the group (see figure 48). The main pathway of introduction is horticulture (N=11) and all introduction are categorised as intentional.

Figure 48: Pathways of introduction for non-native species of coniferous plants introduced to the Baltic region



Ferns

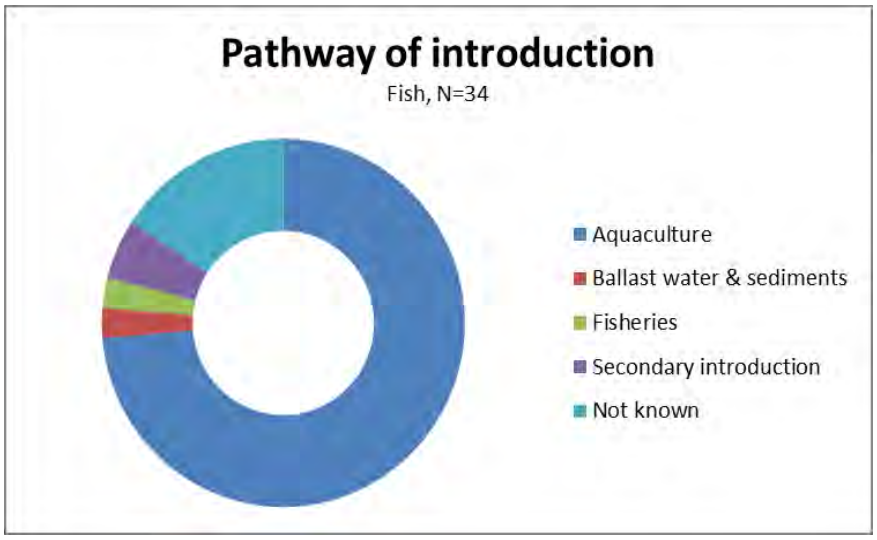
There are presently identified one non-native species of ferns in the NOBANIS database for the Baltic region. The species *Azolla filiculoides* is registered as alien in Lithuania, and has been introduced intentional by horticulture.

Fish

There are presently identified 34 non-native species of fish in the NOBANIS database for the Baltic region.

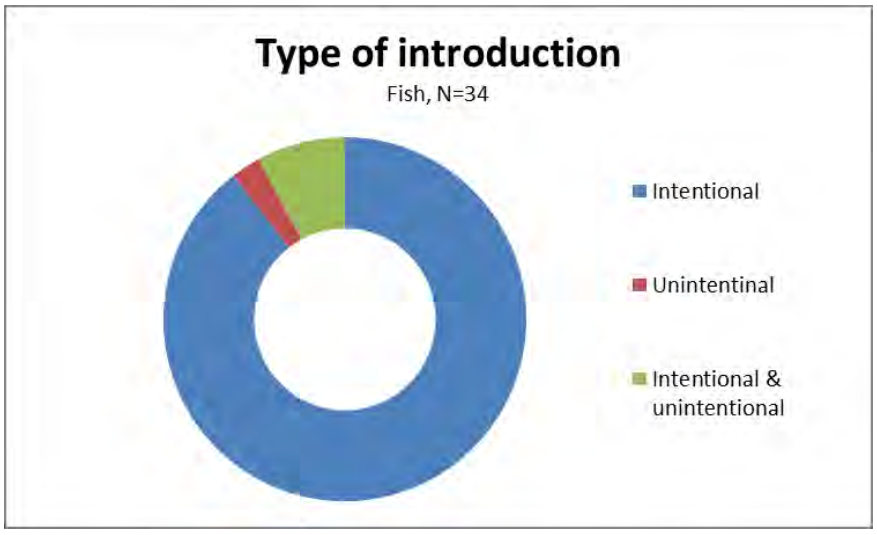
A total of four pathways of introduction are currently recorded for the group (see figure 49), and the main pathway of introduction is aquaculture (N=28). For 6 species the pathway of introduction is unidentified.

Figure 49: Pathways of introduction for non-native species of fish introduced to the Baltic region



The majority of the introductions of alien species of fish in the region are intentional (see figure 50).

Figure 50: Types of introduction (intentional, unintentional or both) for alien species of fish in the Baltic region



Flatworms

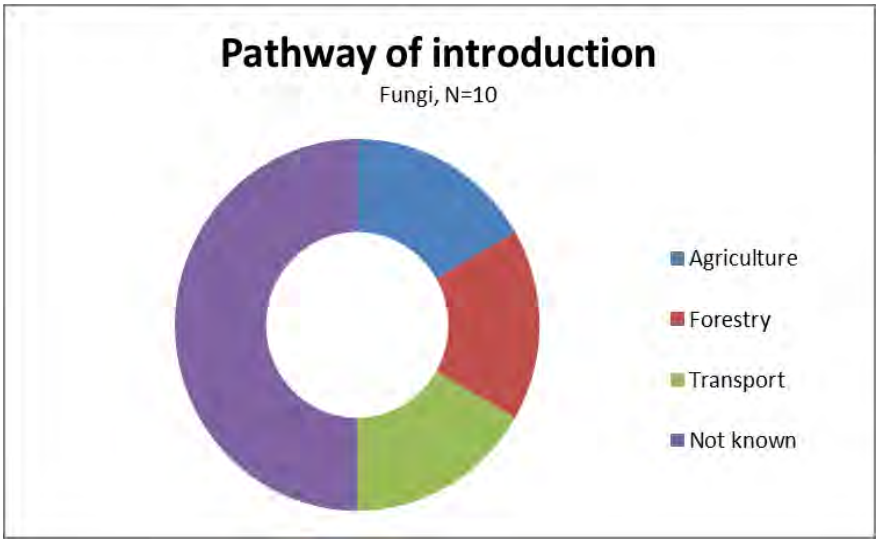
There are presently identified one non-native species of flatworm in the NOBANIS database for the Baltic region. The species is *Valipora campylancristrota,* which is registered as alien in Estonia and is introduced unintentionally by aquaculture.

Fungi

There are presently identified 10 non-native species of fungi in the NOBANIS database for the Baltic region.

A total of three pathways of introduction are currently recorded for the group (see figure 51) and all types of introductions are registered as unintentional. For 6 species the pathway of introduction is unidentified.

Figure 51: Pathways of introduction for non-native fungi introduced to the Baltic region



The analysis shows that the pathways of introduction for half of the introductions are unknown (N=6).

The introductions with known pathways are unintentional (N=6), while the introductions with unknown pathway have an unknown type of introduction (N=6).

Macroalgae

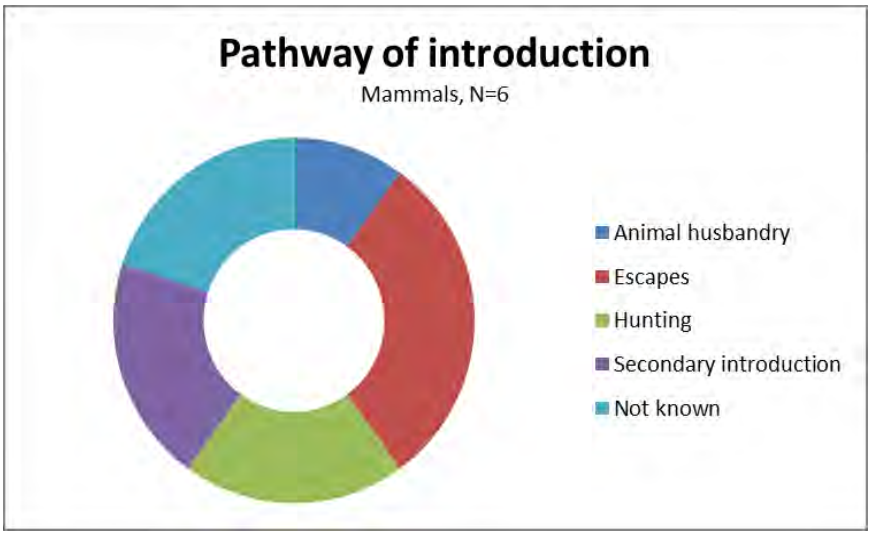
There are presently identified one non-native species of macroalgae in the NOBANIS database for the Baltic region. *Chara connivens* is registered as an alien species in Lithuania, and is introduced unintentionally by hull fouling.

Mammals

There are presently identified 6 non-native species of mammals in the NOBANIS database for the Baltic region

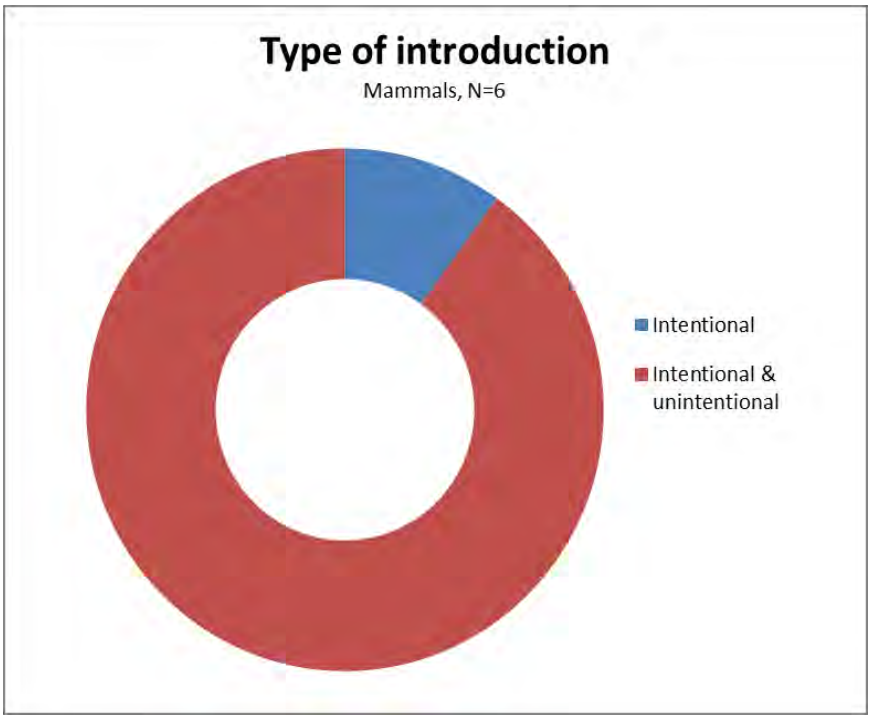
A total of four pathways of introduction are currently recorded for the group (see figure 52) and the most frequently registered pathway of introduction is escapes (N=3). For two species the pathway of introduction is unidentified.

Figure 52: Pathways of introduction for non-native species of mammals introduced to the Baltic region



All introductions of alien species of mammals in the region are either intentional (N=1) or registered as intentional & unintentional (N=9, see figure 53).

Figure 53: Types of introduction (intentional or intentional & unintentional) for alien species of mammals in the Baltic region



Microorganisms

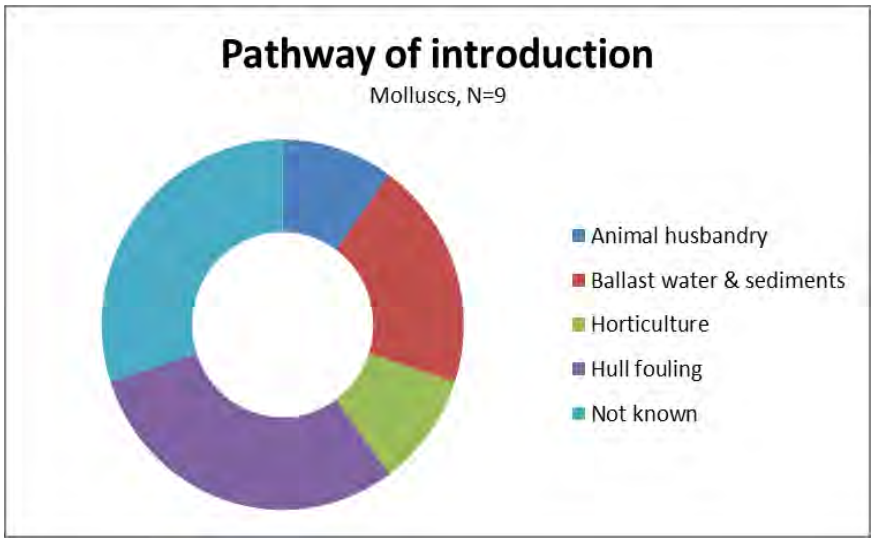
There are presently identified one non-native species of microorganisms in the NOBANIS database for the Baltic region. *Phytophthora ramorum* is registered as an alien species in Estonia. The pathway of introduction is unknown and the introduction is registered as unintentional.

Molluscs

There are presently identified 9 non-native species of molluscs in the NOBANIS database for the Baltic region.

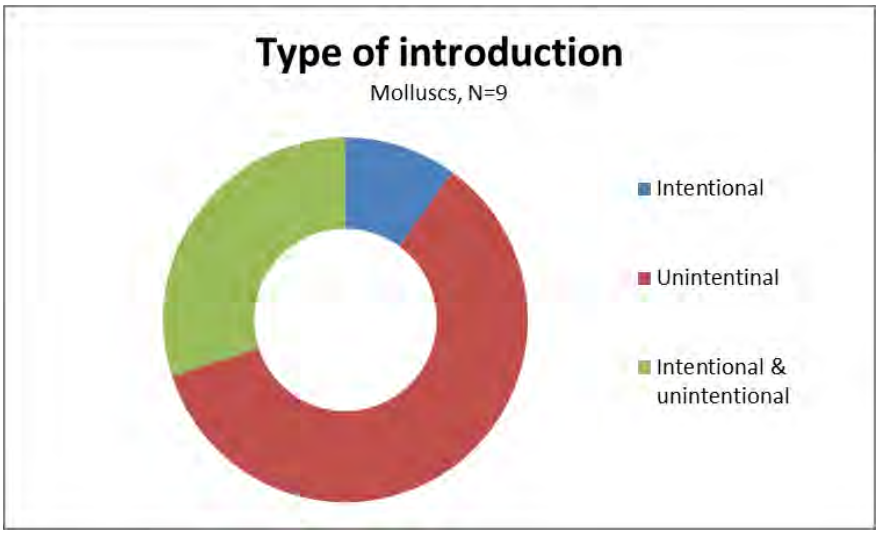
A total of four pathways of introduction are currently recorded for the group (see figure 54) and the most frequently registered pathway of introduction is hull fouling (N=3). For three species the pathway of introduction is unidentified.

Figure 54: Pathways of introduction for non-native species of molluscs introduced to the Baltic region



The majority of the introductions of alien species of molluscs in the region are unintentional (N=9, see figure 55), and for a few species the type of introduction is unknown (N=3).

Figure 55: Types of introduction (intentional, unintentional or both) for alien species of molluscs in the Baltic region

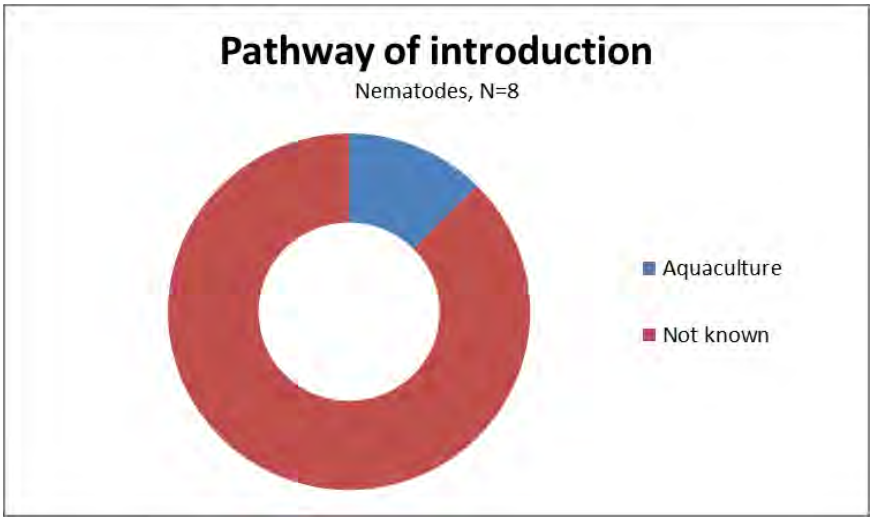


Nematodes

There are presently identified 8 non-native species of nematodes in the NOBANIS database for the Baltic region.

Aquaculture is the only pathway of introduction recorded for the group (N=1, see figure 56), but for the majority of the species the pathway of introduction is unknown (N=7). All of the introductions are registered as unintentional.

Figure 56: Pathways of introduction for non-native species of nematodes introduced to the Baltic region



Phytoplankton
There are presently identified one non-native species of phytoplankton in the NOBANIS database for the Baltic region. *Prorocentrum minimum* is registered as an alien species in Estonia and Lithuania, and the introductions are registered as unintentional by ballast water & sediments (N=1) and hull fouling (N=1).

Reptiles and amphibians
There are presently identified two non-native species of reptiles and amphibians in the NOBANIS database for the Baltic region. The species *Rana ridibunda* and *Trachemys scripta* are both registered as alien species in Estonia, and are introduced intentionally & unintentionally by aquaria (N=2).

4.3.3 Islands of the North Atlantic Ocean

The pathways of introduction are shown for each group of species registered in the islands of the North Atlantic Ocean. The type of introduction – intentional and/or unintentional, as well as unknown – is also presented for each taxonomic group. The introductions of both types – intentional & unintentional – may be registered with both types in one country, or as unintentional in one country and as intentional in another.

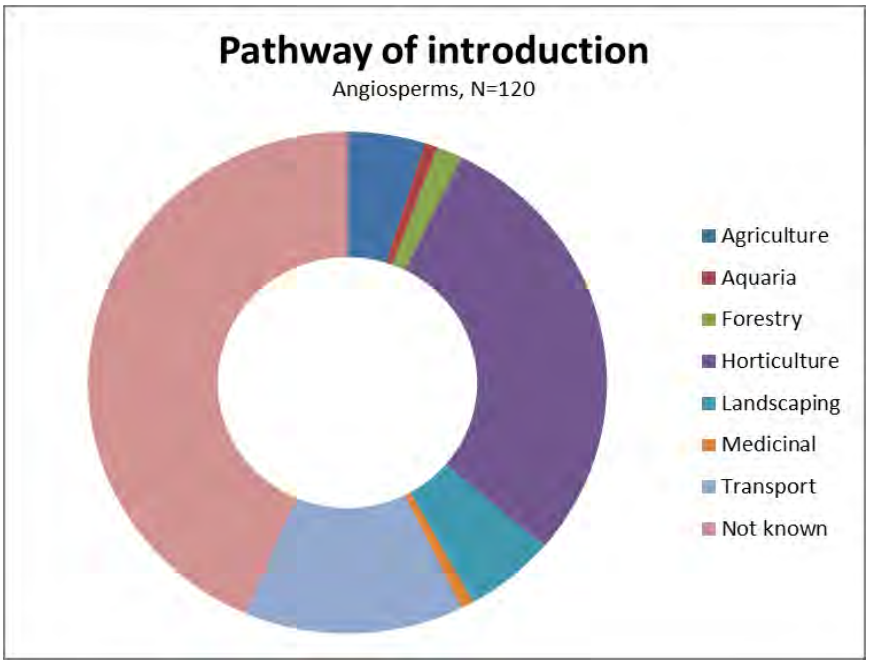
A total of 13 taxonomic groups are represented: angiosperms, annelids, arthropods, birds, bryophytes, coniferous plants, fish, flatworms, fungi, macroalgae, mammals, microorganism and molluscs.

A total of 14 pathways of introduction are represented: agriculture, animal husbandry, aquaculture, aquaria, ballast water & sediments, escapes, fisheries, forestry, horticulture, hull fouling, medicinal, ornamental, secondary introduction and transport. Each species may have multiple pathways of introductions.

Angiosperms
There are presently identified 120 non-native species of angiosperms in the NOBANIS database for the islands of the North Atlantic Ocean.

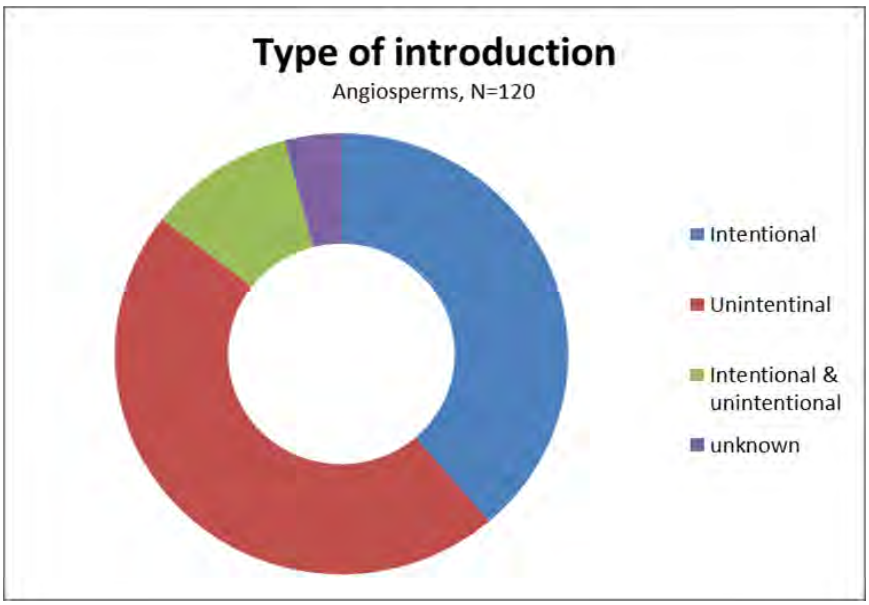
A total of 7 pathways of introduction are currently recorded for the group (see figure 57) and the most frequently registered pathway of introduction is horticulture (N=36), followed by transport (N=17). For 54 introductions the pathway of introduction is unidentified.

Figure 57: Pathways of introduction for non-native angiosperms introduced to the islands of the North Atlantic Ocean



48 of the introductions are intentional (see figure 58) while 58 are unintentional. For only a few introductions (N=5) the type of introduction is unknown.

Figure 58: Types of introduction (intentional, unintentional, both or unknown) for alien species of angiosperms in the islands of the North Atlantic Ocean

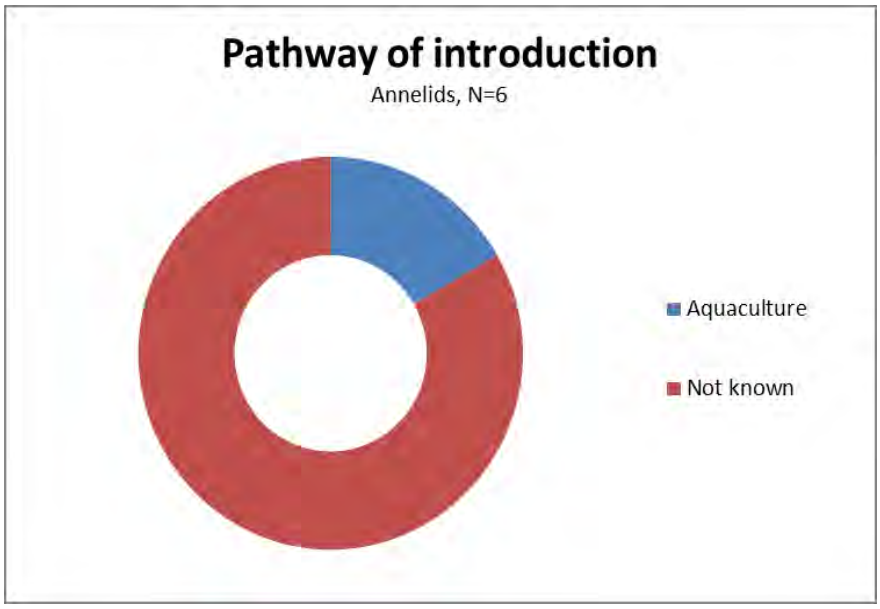


Annelids

There are presently identified 6 non-native species of annelids in the NOBANIS database for the islands of the North Atlantic Ocean.

The only pathway of introduction registered for the group is aquaculture (see figure 59), which is used in only one introduction. For the remaining introductions of annelids both the pathway and type of introduction are unknown.

Figure 59: Pathways of introduction for non-native annelids introduced to the islands of the North Atlantic Ocean

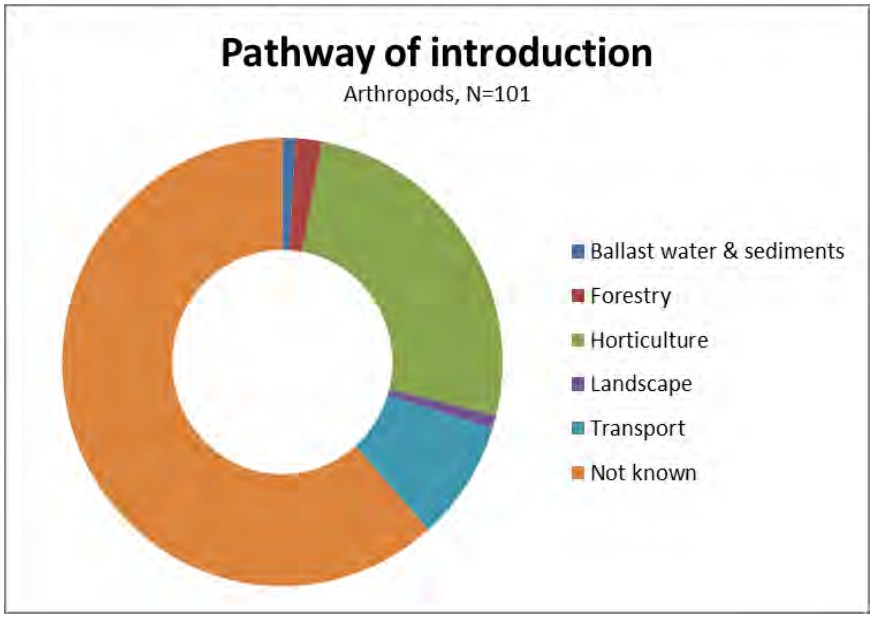


Arthropods

There are presently identified 101 non-native species of arthropods in the NOBANIS database for the islands of the North Atlantic Ocean.

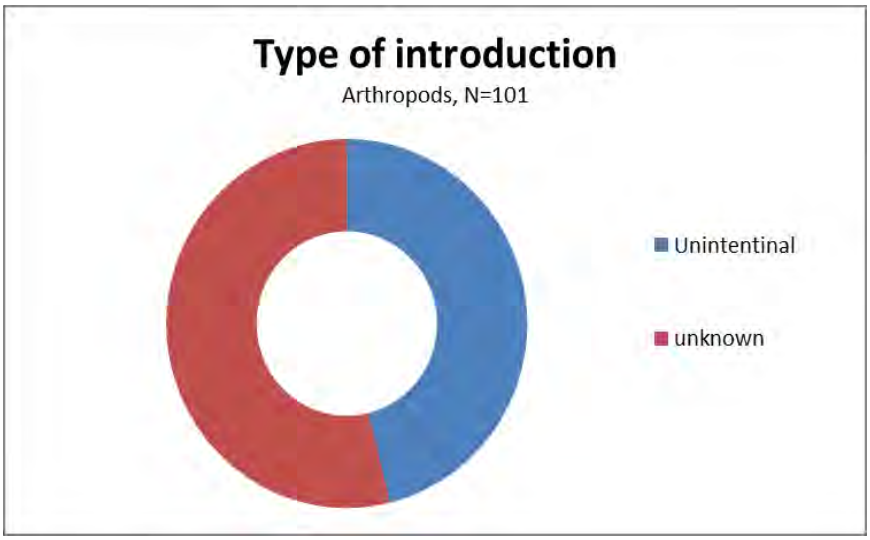
A total of 5 pathways of introduction are currently recorded for the group, but for many introductions the pathways are unknown (N=64, see figure 60). Of the 5 pathways currently recorded for the group the main pathway of introduction is horticulture (N=27).

Figure 60: Pathways of introduction for non-native arthropods introduced to the islands of the North Atlantic Ocean



For species of arthropods registered with a pathway of introduction, the main type of introduction is unintentional, while for most introductions with no pathway registered the main type of introduction is also unknown (see figure 61).

Figure 61: Types of introduction (unintentional or unknown) for alien species of arthropods in the islands of the North Atlantic Ocean

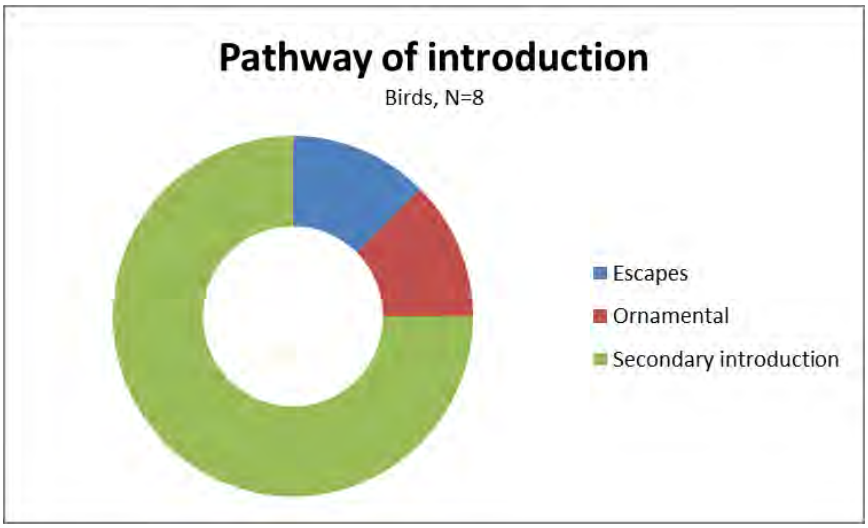


Birds

There are presently identified 8 non-native species of birds in the NOBANIS database for the islands of the North Atlantic Ocean.

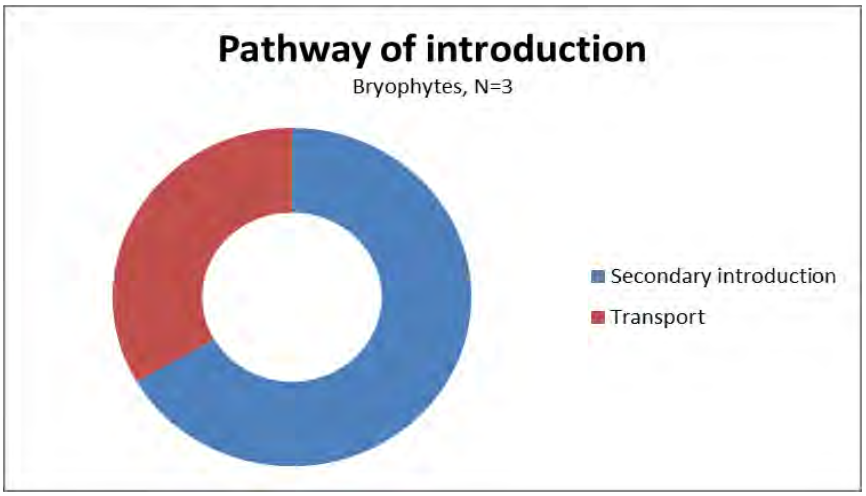
A total of three pathways of introduction are currently recorded for group (see figure 62) and the main pathway of introduction is secondary introduction (N=6).

Figure 62: Pathways of introduction for non-native birds introduced to the islands of the North Atlantic Ocean



The main type of introduction is unintentional (N=6), and only a few introductions are registered as intentional (N=2, see figure 63).

Figure 63: Types of introduction (intentional or unintentional) for alien species of birds in the islands of the North Atlantic Ocean

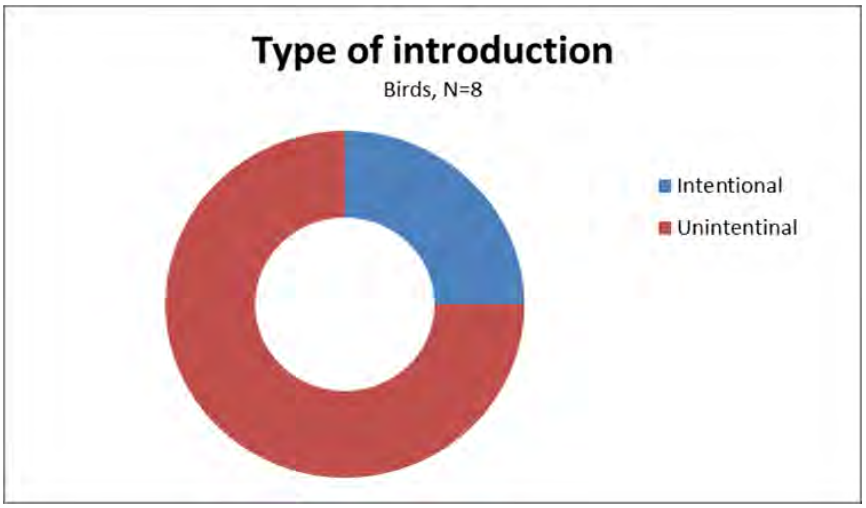


Bryophytes

There are presently identified three non-native species of bryophytes in the NOBANIS database for the islands of the North Atlantic Ocean.

Two pathways of introduction are currently recorded for the group (see figure 64), where most are introduced by secondary introduction (N=2). All introductions are registered as unintentional.

Figure 64: Pathways of introduction for non-native bryophytes introduced to the islands of the North Atlantic Ocean



Coniferous plants

There are presently identified three non-native species of coniferous plants in the NOBANIS database for the islands of the North Atlantic Ocean.

Forestry is the only pathway of introduction currently recorded for the group, and all introductions are considered to be intentional.

Fish

There are presently identified two non-native species of fish in the NOBANIS database for the islands of the North Atlantic Ocean. *Oncorhynchus mykiss* was introduced intentionally by aquaculture and *Oncorhynchus gorbuscha* was introduced unintentionally by secondary introduction.

Flatworms

There are presently identified one non-native species of flatworm in the NOBANIS database for the islands of the North Atlantic Ocean. The species *Arthurdendyus triangulates* is registered as unintentionally introduced by agriculture.

Fungi

There are presently identified 10 non-native species of fungi in the NOBANIS database for the islands of the North Atlantic Ocean.

Forestry is the only pathway of introduction currently recorded for the group, and all introductions are considered to be unintentional.

Macroalgae

There are presently identified two non-native species of macroalgae (*Bonnemaisonia hemifera & Codium fragile)* in the database for the islands of the North Atlantic Ocean.

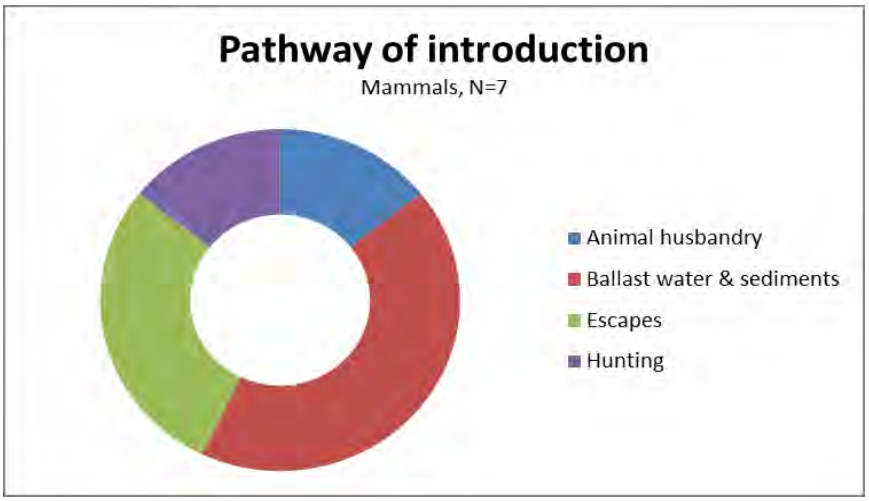
The pathways of introduction are currently unknown (N=2), and the type of introduction is considered to be unintentional (N=2).

Mammals

There are presently identified 7 non-native species of mammals in the NOBANIS database for the islands of the North Atlantic Ocean.

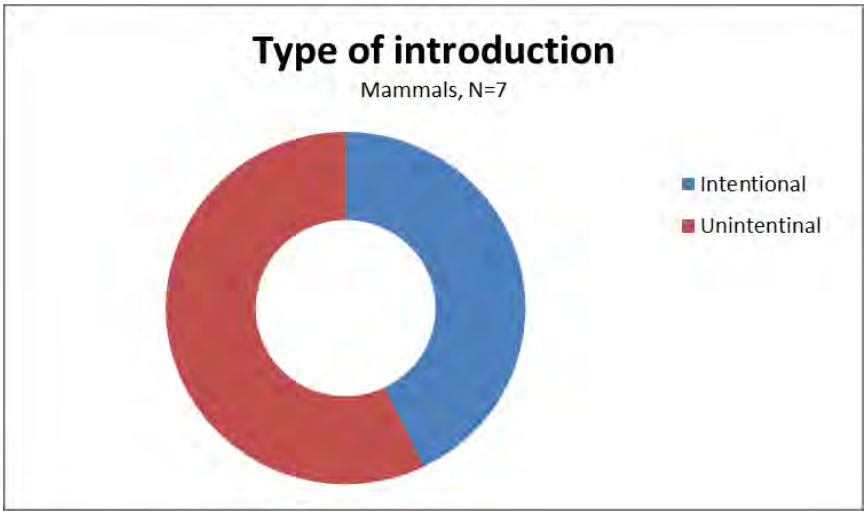
Four pathways of introduction are recorded for the group (see figure 65), and ballast water & sediment (N=3) is the most frequently registered pathway, followed by escapes (N=2).

Figure 65: Pathways of introduction for non-native mammals introduced to the islands of the North Atlantic Ocean



The type of introduction is either intentional (N=3) or unintentional (N=4, see figure 66).

Figure 66: Types of introduction (intentional or unintentional) for alien species of mammals in the islands of the North Atlantic Ocean



Microorganisms

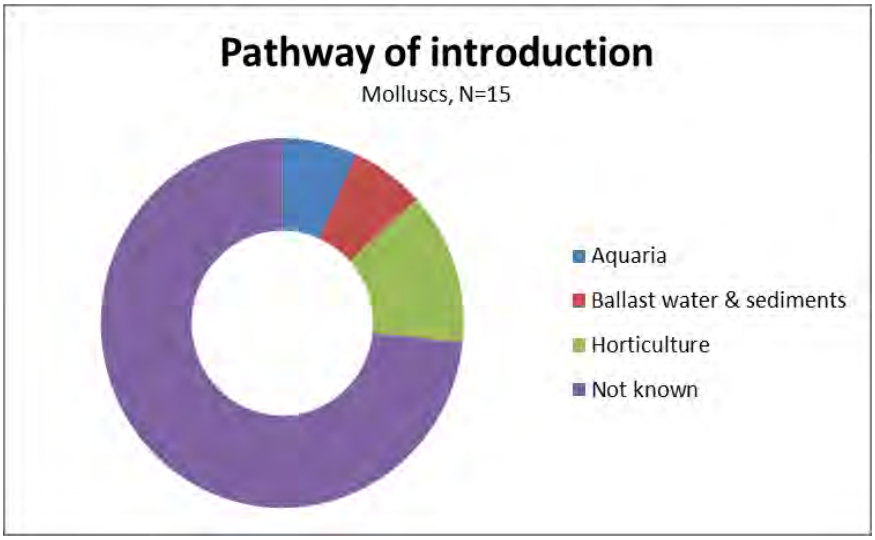
There is presently identified one non-native species of microorganisms in the NOBANIS database for the islands of the North Atlantic Ocean. The species *Aeromonas salmonicida* is registered as being unintentionally introduced, but the pathway of introduction is unknown.

Molluscs

There are 15 non-native species of molluscs presently identified in the NOBANIS database for the islands of the North Atlantic Ocean.

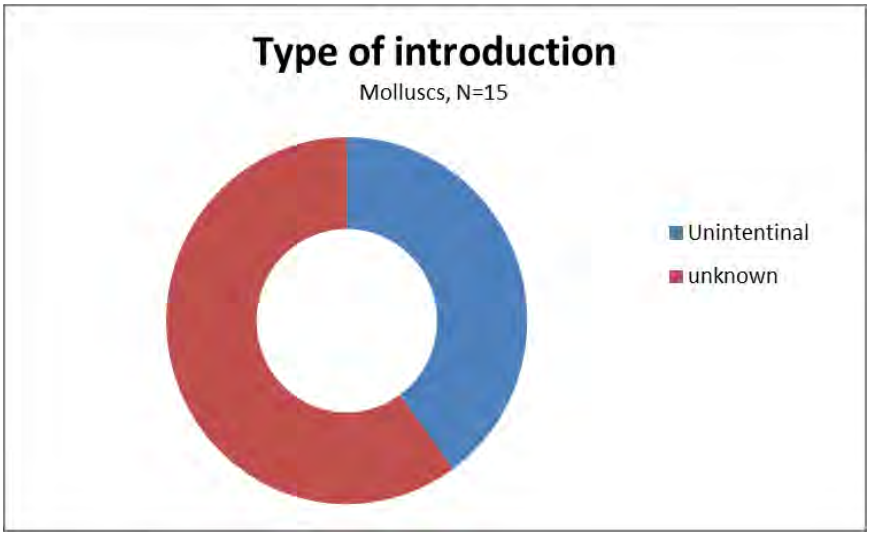
A total of three pathways of introduction are currently registered for the group, but for the majority of species the pathway of introduction is unknown (N=11, see figure 67). Horticulture is the most frequently used pathway (N=2).

Figure 67: Pathways of introduction for non-native molluscs introduced to the islands of the North Atlantic Ocean



The type of introduction is unintentional (N=6) or unknown (N=9, see figure 68). Especially for species with unidentified pathway of introduction the type of introduction is rarely known.

Figure 68: Types of introduction (unintentional or unknown) for alien species of molluscs in the islands of the North Atlantic Ocean



4.3.4 Summary

Nordic region

Based on the data from the NOBANIS database for the Nordic region, the pathway analysis shows that the main pathways of introduction vary between the different taxonomic groups.

The group with the largest number of alien species is the angiosperms, with a total of 3,272 alien species registered for the Nordic region. The most common pathway for the angiosperms is horticulture, followed by agriculture and transport.

The second largest group is the arthropods with 928 alien species registered. The main pathways of introductions for the arthropods are horticulture, transport and forestry, followed by a wide range of other pathways. The wide range of pathways reflects the diversity within the arthropods, covering both terrestrial and marine species.

The two groups, angiosperms and arthropods share horticulture as their main pathway of introduction. Horticulture is also a main pathway of introduction for other groups: coniferous plants, ferns, fungus, microorganisms and molluscs.

For marine species, aquaculture and ballast water & sediments are the main pathways of introduction for: annelids, cnidarians, comb jellies, fish, flatworms, macroalgae and phytoplankton. Other chordates, other invertebrates and protozoans are also registered with aquaculture and/or ballast water & sediments as their main pathways. However there are only a few of these alien species registered.

Molluscs also have aquaculture, ballast water & sediments and horticulture as main pathways. This reflects the high diversity within the group, covering both terrestrial and marine & freshwater habitats.

For birds, mammals and reptiles & amphibians the analysis shows that their main pathway of introduction is escape and/or secondary introduction. Furthermore, a high proportion of introductions by escape is intentional.

Some taxonomic groups have a large percentage of registrations with unknown pathway: angiosperms, annelids, arthropods, birds, fungi, microorganisms and nematodes. Some of these groups – fungi, microorganisms and nematodes – are registered with over 50% unknown pathways. Overall, 39% of the alien species in the Nordic region is registered with unknown pathways.

The types of introduction also vary between the different groups. Unintentional introductions are dominant in the groups: angiosperms, annelids, arthropods, birds and molluscs. In other groups most introductions are intentional: coniferous plants, fish, mammals and reptiles & amphibians.

Two groups have a high degree of unknown types of introduction: fungi and microorganisms. For these types of introductions, little is known about the pathways of introductions as well.

Baltic region

Based on the data from the NOBANIS database for the Baltic region, the pathway analysis shows that the main pathway of introduction varies between the different taxonomic groups.

The group with the highest number of alien species represented is the angiosperms. A total of 1,069 alien species of angiosperms are recorded for the Baltic region. The main pathway for the group is horticulture, followed by agriculture and transport.

The second largest group is the arthropods with 164 alien species registered. Both the angiosperms and the arthropods have a diverse composition of pathways registered. The analysis also showed that the pathway of introduction for many arthropods still is unidentified (N=125).

For alien species of coniferous plants the analysis shows that three pathways are responsible for the introductions (forestry, horticulture

and landscaping), but with horticulture as the main pathway. All introductions of coniferous plants are registered as being intentional.

For alien species of fish registered in the region, the main pathway of introduction is aquaculture and almost all of the introductions are intentional.

For the alien species of birds registered in the region the main pathway is escapes.

For species of molluscs the introductions are unintentional and by hull fouling.

For some taxonomic groups (cnidarians, bryophytes, ferns, flatworms, mammals, microorganisms, nematodes, phytoplankton and reptiles & amphibians) identifying the main pathway of introduction has proven to be a challenge, due to the small amount of data available.

The analysis also shows that for 23% of the species registered in the NOBANIS database for the Baltic region no pathway of introduction is registered.

Islands of the North Atlantic Ocean

Based on the data available in the NOBANIS database for islands of the North Atlantic Ocean the analysis shows that the main pathway of introduction varies between the different taxonomic groups. The group with the highest number of alien species represented is the angiosperms. A total of 120 alien species of angiosperms are recorded for the region, and the main pathways for the angiosperms are horticulture and transport.

The second largest taxonomic group in the region is arthropods with 101 alien species registered. The primary pathway of introductions for the arthropods is horticulture.

Birds are mainly introduced to the region by secondary introduction.

For some taxonomic groups (bryophytes, fish, flatworms, macroalgae, microorganisms and molluscs) no main pathway of introduction is identified.

The analysis shows that the pathway of introduction for many angiosperms, arthropods and molluscs is unknown. For 48% of all species registered in the NOBANIS database for the region, no pathway of introduction is registered.

The type of introduction also varies between the different groups. The unintentional introductions are dominant in the groups: angiosperms, birds, bryophytes, fish, flatworms, fungi, macroalgae, mammals and microorganisms, while all coniferous plants are introduced intentional.

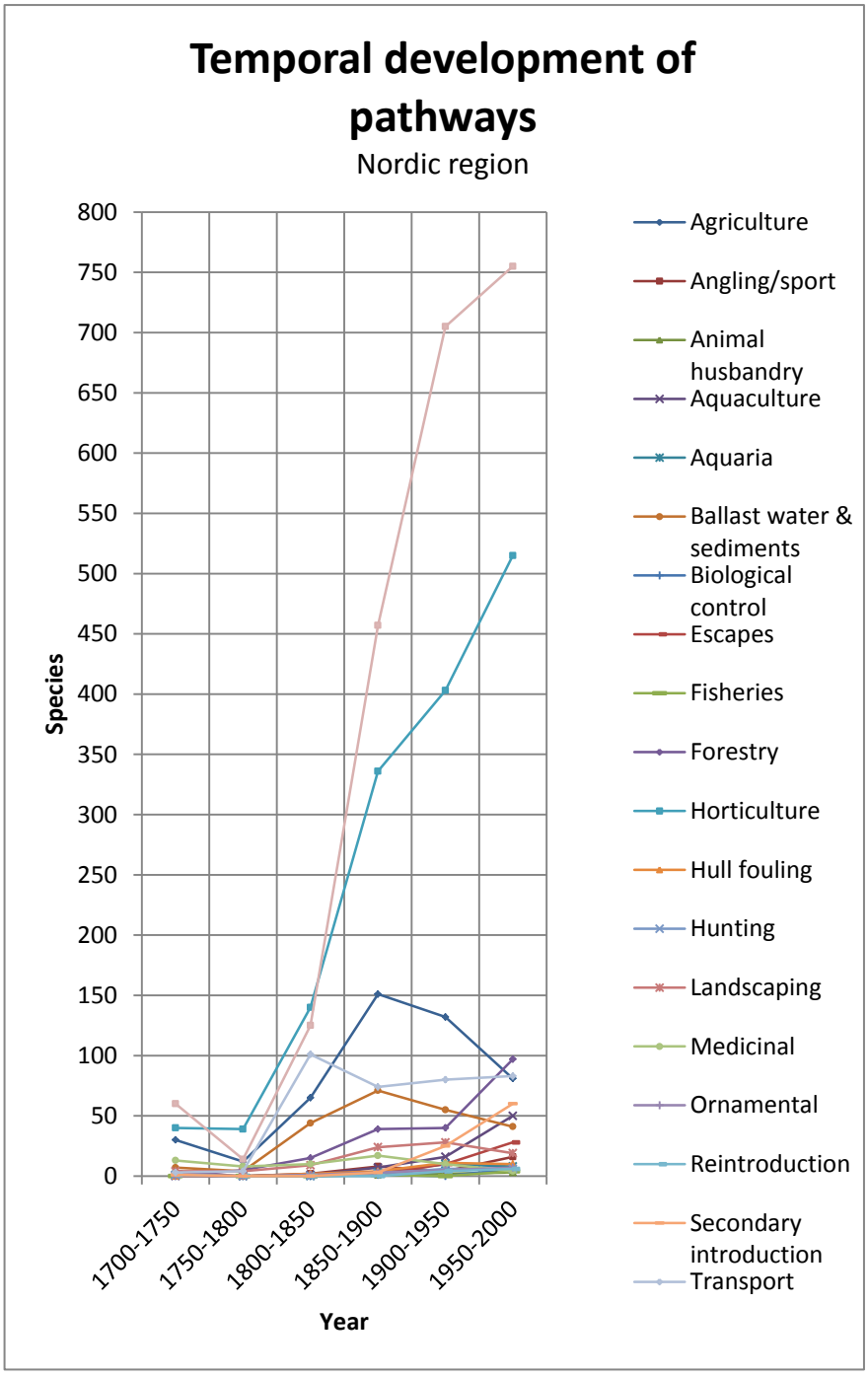
Two groups have a high degree of unknown type of introduction: arthropods and molluscs. For these introductions, little is known about the pathways as well.

4.4 Temporal development of pathways

For many of the alien species in the NOBANIS database, year of first arrival and pathway of introduction are known, which can give an indication of the development of pathways over time.

Nordic region
In the Nordic region the number of registered introductions are increasing over time (see figure 69 and table in appendix 4). The increase in introductions is especially seen in the pathways: angling/sport, aquaculture, escapes, forestry, horticulture and secondary introduction. Furthermore, the number of species with unknown pathways increases over time.

Figure 69: Temporal development of registrations of pathways of alien species in the Nordic region. Note that data from 2000–2014 is not included here



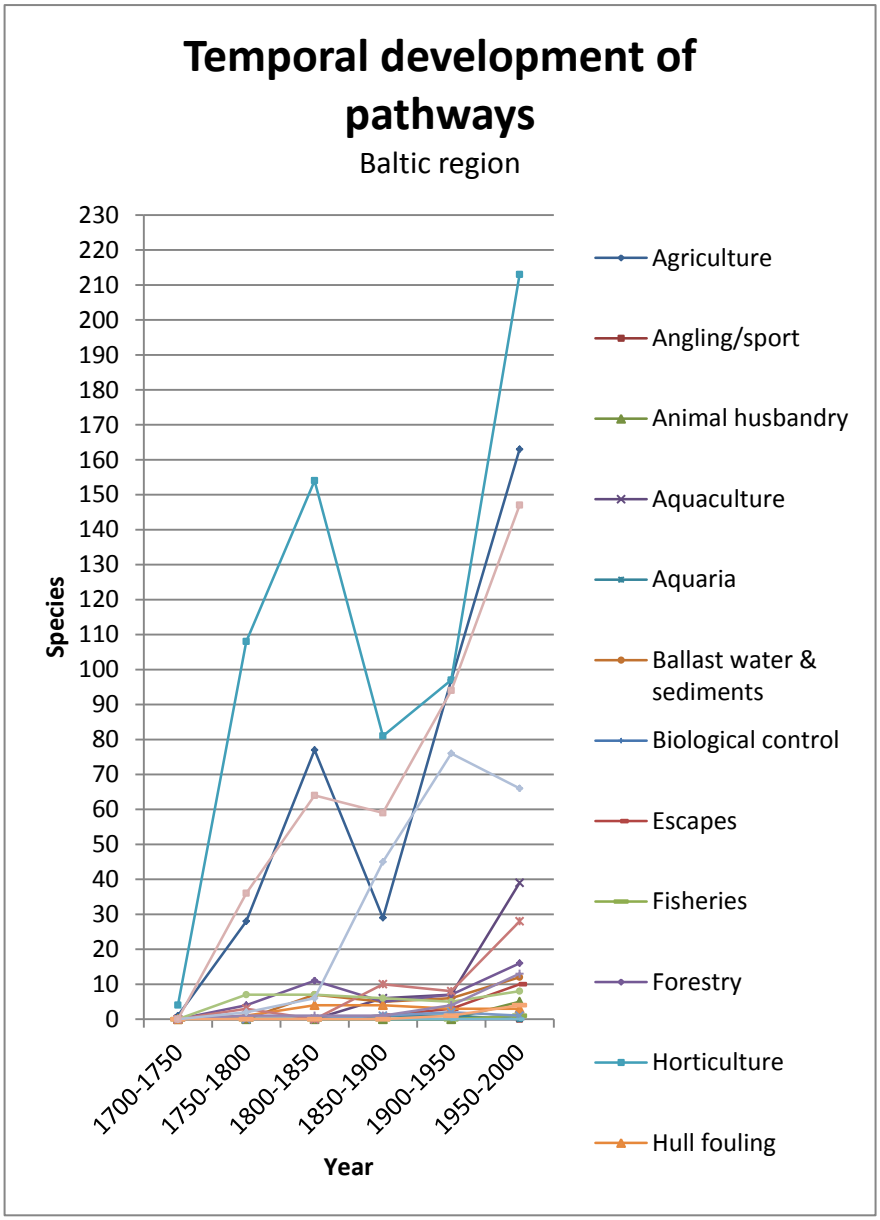
Landscaping has been registered since the beginning of this time frame (1700's) and has increased over the years, but the number of registrations from 2000 and until now (see table in appendix 4) is already higher than the numbers from the earlier fifty year periods.

Agriculture, medicinal and ballast water & sediments are the main pathways where the number of registered introductions has decreased since 1900.

Baltic region

In the Baltic region the number of registered introductions is increasing over time (see figure 70 and table in appendix 5). The increase in introductions is especially seen in the pathways: agriculture, aquaculture, ballast water & sediments, forestry, horticulture and transport. Furthermore, the number of species with unknown pathways has increases over time.

Figure 70: Temporal development of registrations of pathways of alien species in the Baltic region. Note that data from 2000–2014 is not included here



Agriculture, forestry and horticulture are increasing over the time frame, but have decreased briefly between 1850 and 1900.

Some pathways have first been registered after 1900: animal husbandry, biological control, fisheries and secondary introduction.

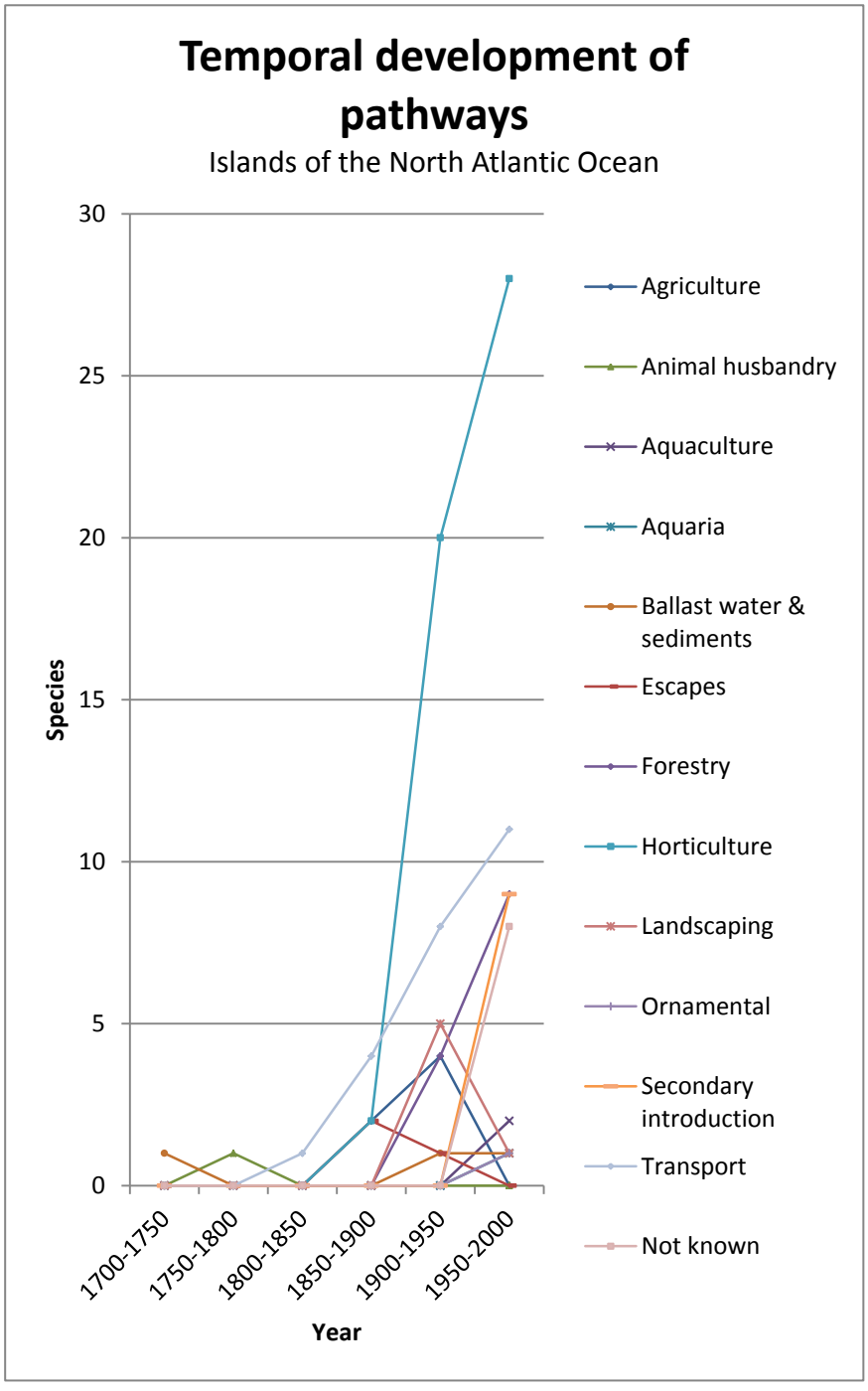
No pathways have markedly fewer introductions of alien species over time in the Baltic region.

Islands of the North Atlantic Ocean

As mentioned in *chapter 3.2* only data from Iceland is used in the temporal analysis, since no data regarding "year of introduction" is registered for the Faroe Islands in the NOBANIS database.

In Iceland the overall number of registered introductions is increasing over time (see figure 71). The largest increase is seen for horticulture and transport.

Figure 71: Temporal development of registrations of pathways of alien species in the Islands of the North Atlantic Ocean. Note that data from 2000–2014 is not included here



The use of agriculture, escapes and landscaping as pathways of introducetion has increased up to 1950 and then decreased afterwards.

Some pathways have first been registered after 1900: aquaculture, aquaria, forestry, landscaping, ornamental and secondary introduction.

4.4.1 Summary

Nordic region

The analysis shows that the number of introductions and the importance of different pathways vary over time. The importance of angling/sport, aquaculture, escapes, forestry, horticulture, secondary introduction and unknown pathway has increased in time. Furthermore, the number of registrations for landscaping from 2000 and until now (see table in appendix 4) is already higher than the numbers from the earlier fifty year periods.

The use of the pathways agriculture, medicinal and ballast water & sediments has decreased.

Baltic region

In the Baltic region the number of registered introductions is increasing over time. The increasingly registered pathways are agriculture, aquaculture, ballast water & sediments, forestry, horticulture and transport. Furthermore, the number of species with unknown pathways increases over time.

The importance of the different pathways varies over time, hence some pathways have not been important in the beginning of this time frame, but have become important after 1900: animal husbandry, biological control, fisheries and secondary introduction.

No pathways have markedly fewer introductions of alien species over time in the Baltic region.

Islands of the North Atlantic Ocean

In Iceland the overall number of registered introductions is increasing over time. The largest increase is seen for horticulture and transport, while the use of agriculture, escapes and landscaping has increased up to 1950 and then decreased afterwards.

Like in the Baltic region some pathways have not been important in the beginning of this time frame, but have become important after 1900: aquaculture, aquaria, forestry, landscaping, ornamental and secondaryintroduction.

4.5 Species origin and the pathway of introduction

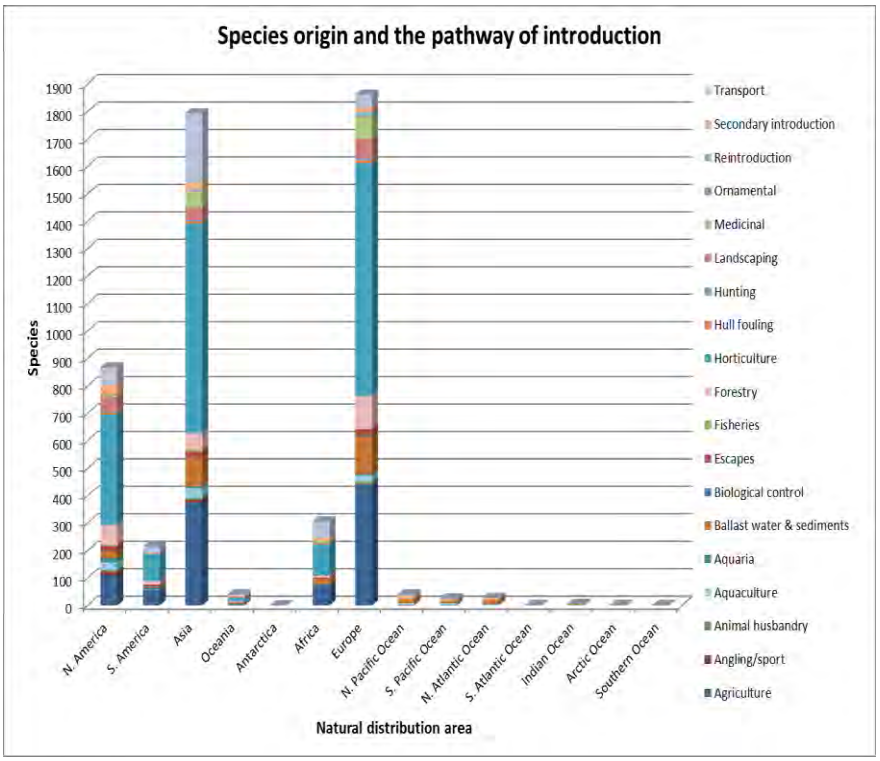
In this subanalysis the area of origin for the introduced species and their pathway of introductions are examined. The analysis is made both for all the species combined and for each taxonomic group. The results are presented for the three regions combined.

In the NOBANIS terminology 14 natural distribution areas are described. The natural distribution areas are seven continents (Africa, Antarctica, Asia, Europe, N. America, Oceania and S. America) and seven oceans (Arctic Ocean, Indian Ocean, N. Atlantic Ocean, S. Atlantic Ocean, N. Pacific Ocean, S. Pacific Ocean and Southern Ocean). See *chapter 3.2* for further details on the delimitations of the natural distribution areas.

As shown in figure 72, most non-native species registered in the participating countries and territories originates from Europe, Asia or North America, and the main pathway of introduction is horticulture.

Species originating from Europe are mainly introduced by horticulture and agriculture, but also ballast water & sediments and forestry are widely used pathways of introduction. The same pathways apply to species native to Asia, except that transport also is a widely used pathway of introduction. For species native to North America the main pathway of introduction is horticulture.

Figure 72: The area of origin for introduced species in the NOBANIS database and their pathways of introduction



Species that originated from Africa or South America are mainly introduced by horticulture and agriculture and for species native to Africa also by transport. Only a few non-native species originate from Oceania, Antarctica, North Pacific Ocean, South Pacific Ocean, North Atlantic Ocean, South Atlantic Ocean, Indian Ocean, Arctic Ocean and the Southern Ocean.

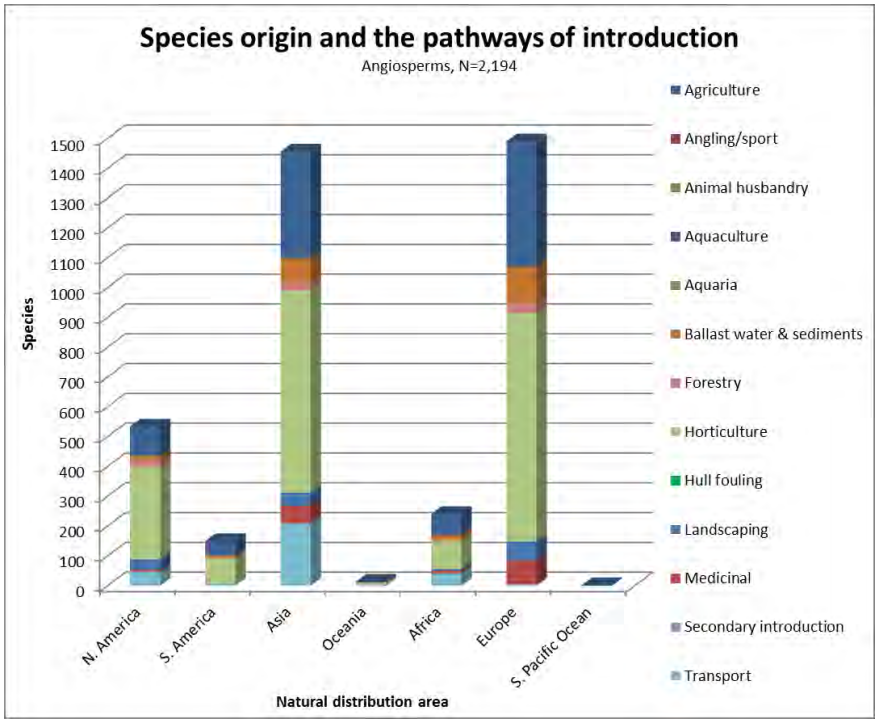
Note that one species may have multiple pathways of introduction into the various countries and territories participating in the project, as well as having more than one area of origin.

For Protozoans registered for the participating countries and territories no information was available on pathway of introduction or place of origin.

Angiosperms

For the species of angiosperms seven natural distribution areas are registered for the group and 13 pathways of introduction (see figure 73).

Figure 73: The area of origin for introduced angiosperms and their pathways of introduction



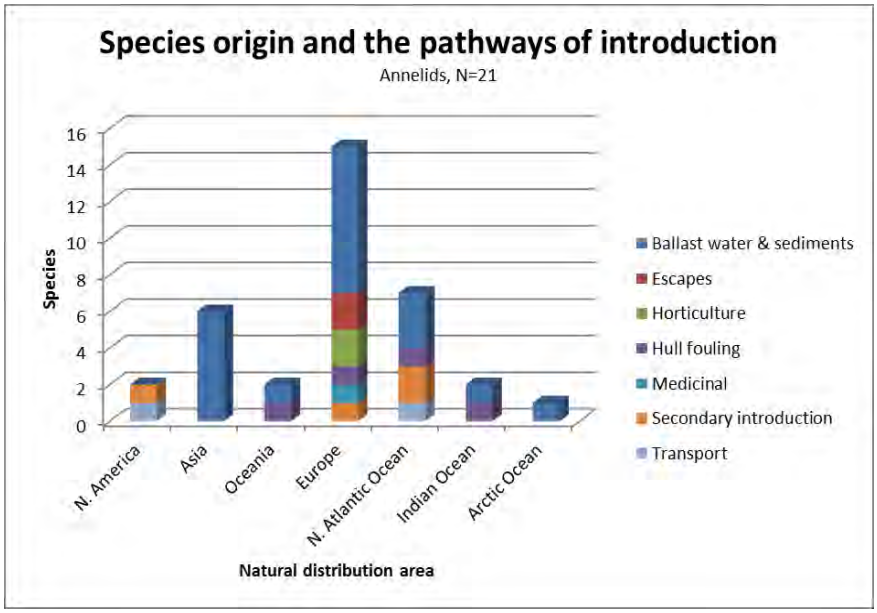
For the majority of the non-native species of angiosperms the natural distribution area is registered as Europe or Asia, and the main pathway of introduction is horticulture, followed by agriculture. For species originating from North America, South America and Africa, horticulture is the main pathway of introduction.

Annelids

For the species of annelids, 7 natural distribution areas are registered for the group and 7 pathways of introduction (see figure 74).

The majority of the non-native species of annelids originates from Europe and is introduced by ballast water & sediments. Species registered as originating from Asia are only introduced by ballast water & sediments, while species originating from North America are introduced by transport and secondary introduction. For species with a natural distribution in the North Atlantic Ocean, ballast water & sediment and secondary introduction are the main pathways of introduction.

Figure 74: The area of origin for introduced annelids and their pathways of introduction



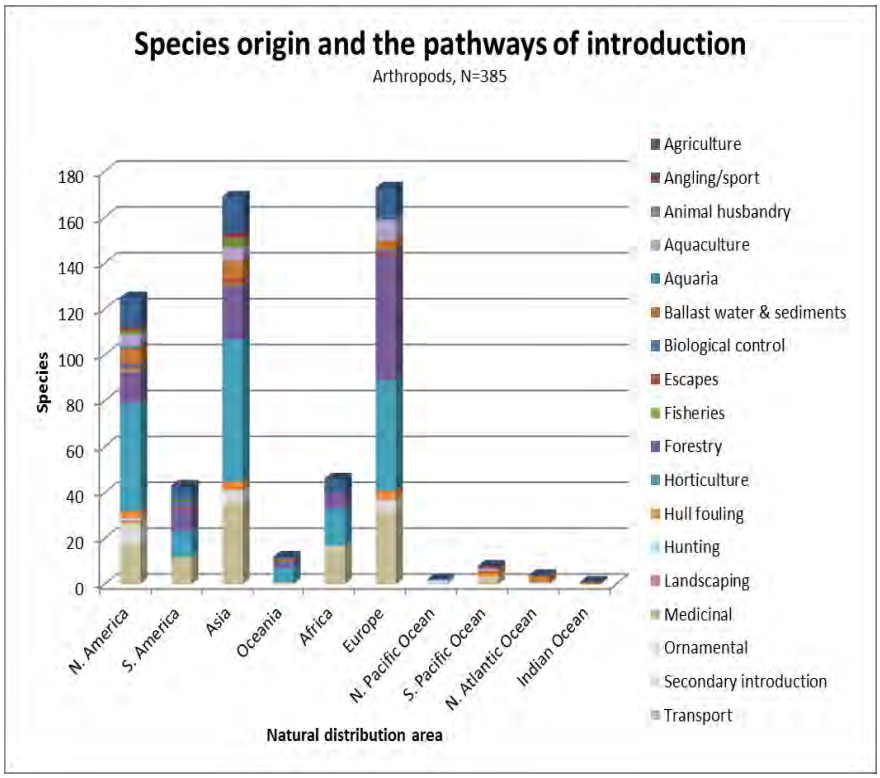
Arthropods

For the species of arthropods 10 natural distribution areas are registered for the group and 18 pathways of introduction (see figure 75).

For the majority of the non-native species of arthropods the natural distribution area is registered as Europe or Asia, but also North America is well represented. The main pathway of introduction for species originating from Europe is forestry, but also horticulture is registered for many species. For species originating from Asia and North America horticulture is the main pathway, followed by forestry and transport.

For species originating from South America and Africa horticulture, forestry and transport are the most registered pathways of introduction.

Figure 75: The area of origin for introduced arthropods and their pathways of introduction

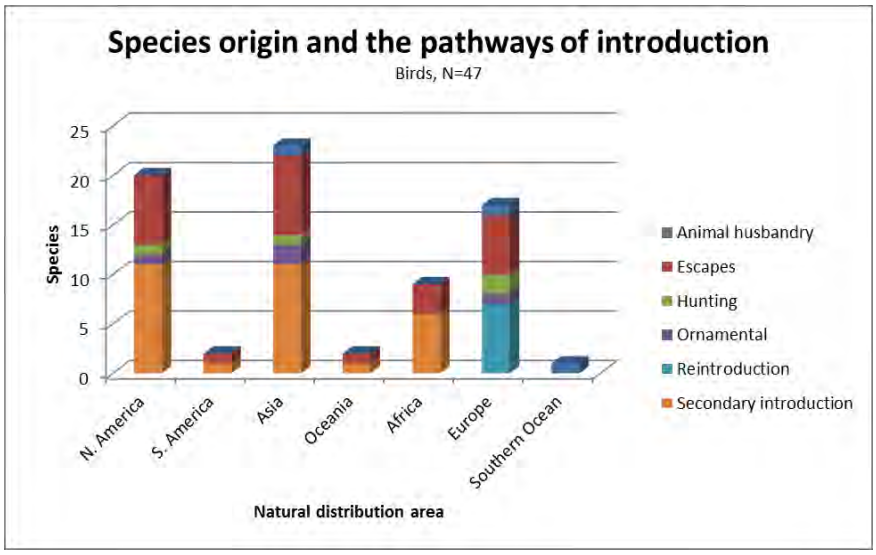


Birds

For the species of birds, 7 natural distribution areas are registered for the group and 6 pathways of introduction (see figure 76).

The majority of the non-native species of birds originates from Asia, North America and Europe. Species originating from Asia or North America are mainly introduced by secondary introduction and escape, while species originating from Europe are mainly introduced by reintroduction and escape.

Figure 76: The area of origin for introduced birds and their pathways of introduction

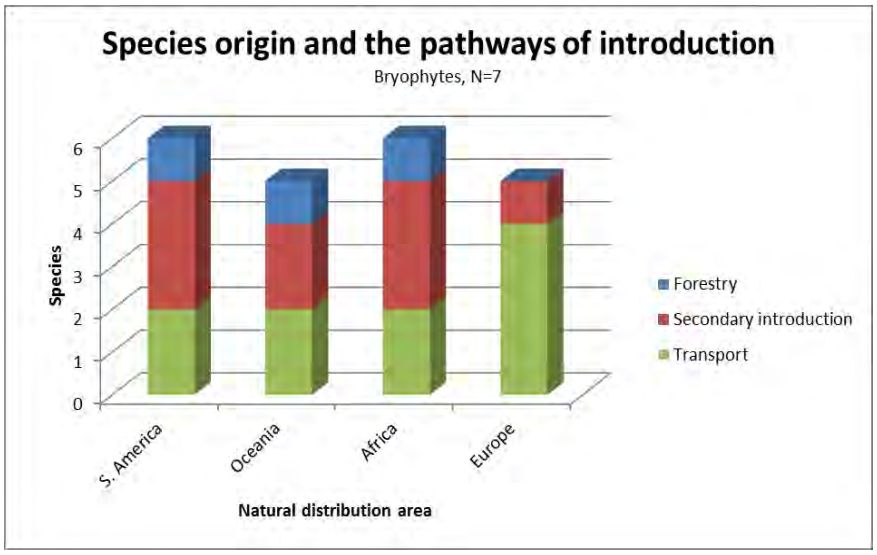


Bryophytes

For the species of bryophytes, four natural distribution areas are registered for the group and three pathways of introduction (see figure 77).

Species originating from South America, Oceania, or Africa are mainly introduced by secondary introduction, while species originating from Europe are mainly introduced by transport.

Figure 77: The area of origin for introduced bryophytes and their pathways of introduction

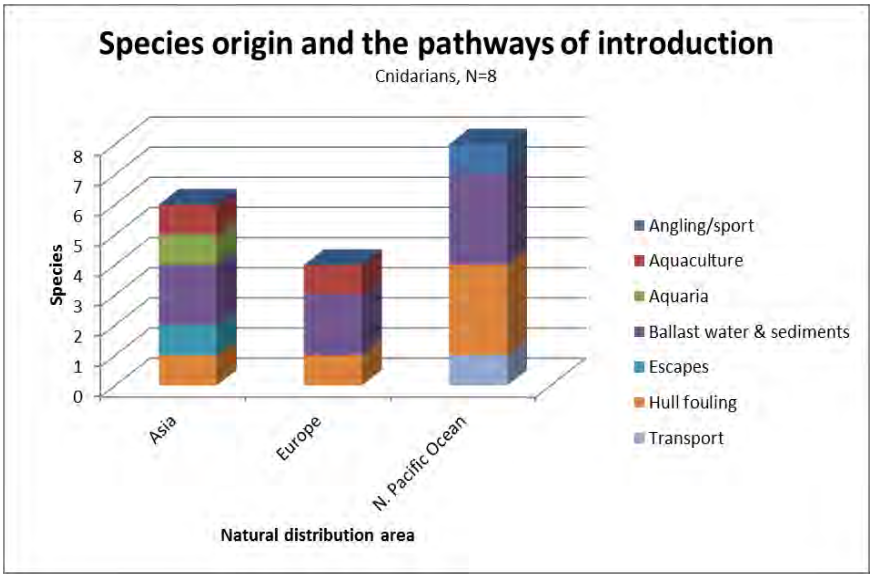


Cnidarians

For the species of cnidarians, three natural distribution areas were registered for the group and seven pathways of introduction (see figure 78).

The majority of the non-native species of cnidarians originates from the North Pacific Ocean, where the main pathway of introduction is by hull fouling and ballast water & sediments.

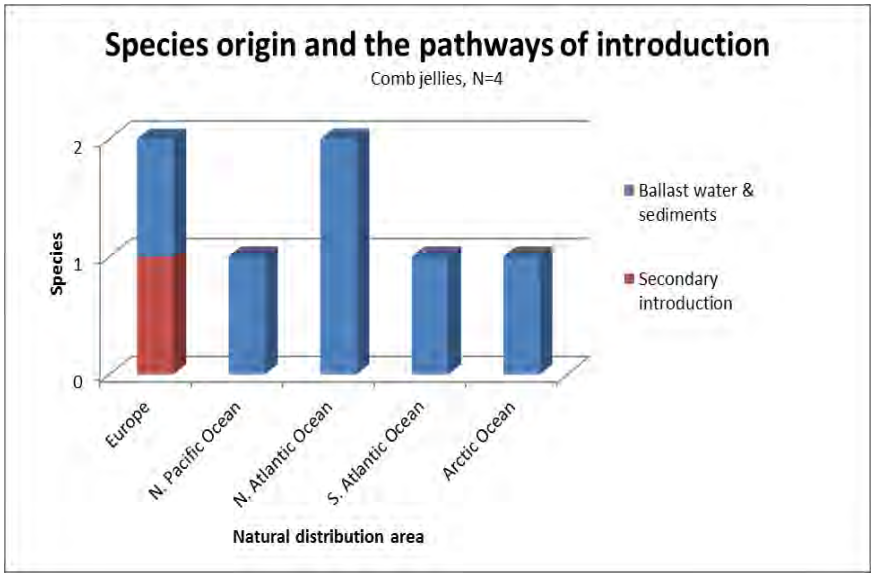
Figure 78: The area of origin for introduced cnidarians and their pathways of introduction



Comb jellies

For the species of comb jellies, five natural distribution areas are registered for the group and two pathways of introduction (see figure 79).

Figure 79: The area of origin for introduced comb jellies and their pathways of introduction



The majority of the non-native species of comb jellies originates from the North Atlantic Ocean and Europe, where the main pathways of introduction are by ballast water & sediments and secondary introduction.

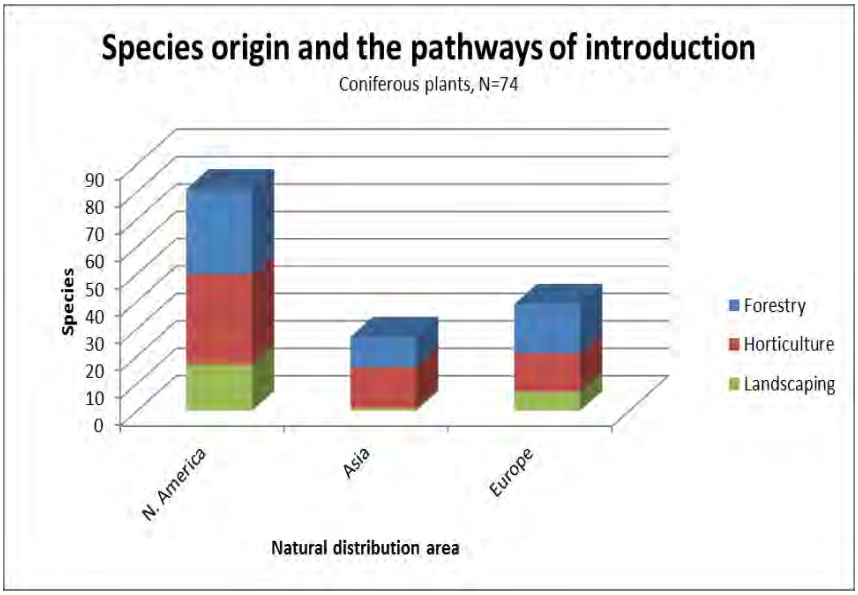
Of species originating from the North Pacific Ocean, South Atlantic Ocean and Arctic Ocean the majority are introduced by ballast water & sediments.

Coniferous plants

For the species of coniferous plants, three natural distribution areas are registered for the group and three pathways of introduction (see figure 80).

The majority of the non-native species of coniferous plants originates from North America, where the main pathways of introduction are by horticulture and forestry. For species originating from Europe and Asia the main pathways of introduction are also horticulture and forestry.

Figure 80: The area of origin for introduced coniferous plants and their pathways of introduction

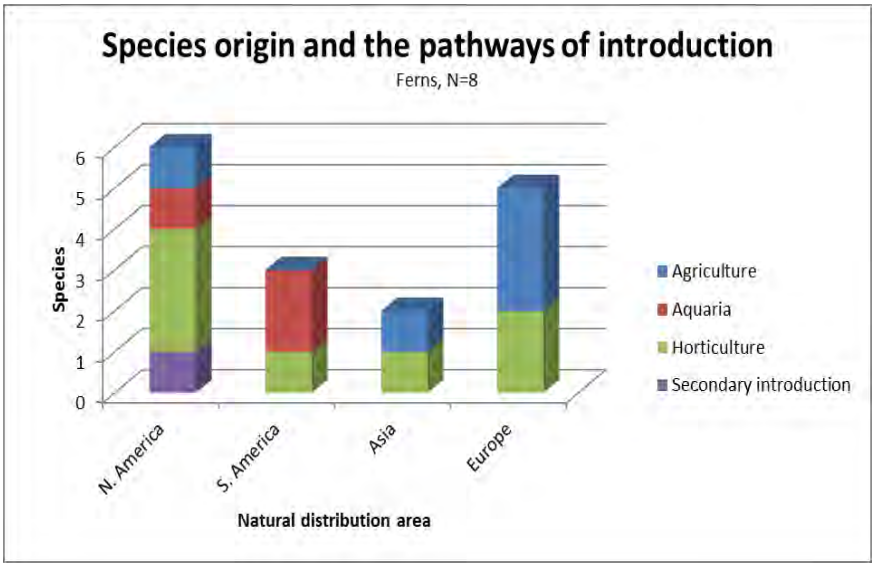


Ferns

For the species of ferns, four natural distribution areas are registered for the group and four pathways of introduction (see figure 81).

The majority of the non-native species of ferns originates from North America and Europe. The main pathway of introduction for species originating from North America is horticulture, while for species originating from Europe it is mainly agriculture. For species originating from South America the pathway is mainly aquaria.

Figure 81: The area of origin for introduced ferns and their pathways of introduction

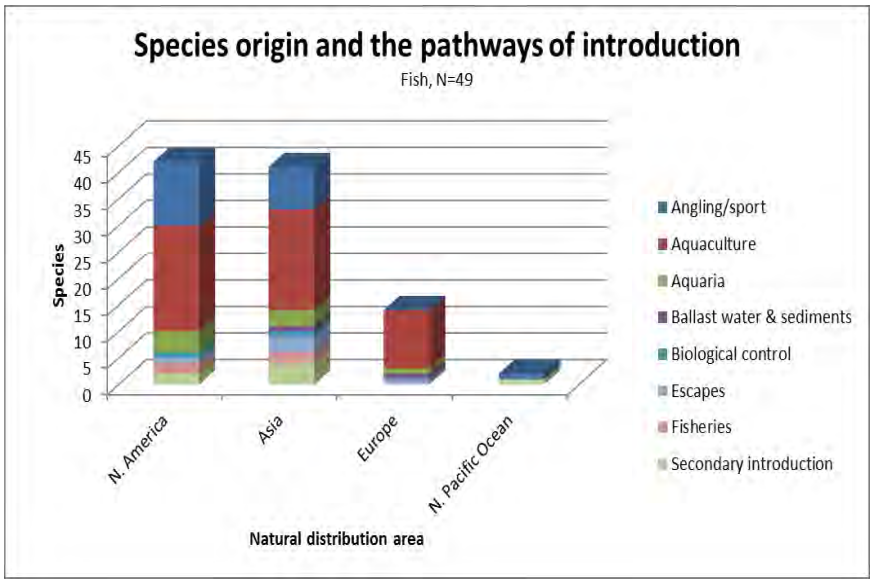


Fish

For the species of fish, four natural distribution areas are registered for the group and 9 pathways of introduction (see figure 82).

The majority of the non-native species of fish originates from Asia and North America, where the main pathway of introduction is aquaculture. For the species originating from Europe the main pathway of introduction is also aquaculture, while species originating from the North Pacific Ocean are introduced by secondary introduction and angling/sport.

Figure 82: The area of origin for introduced fish and their pathways of introduction

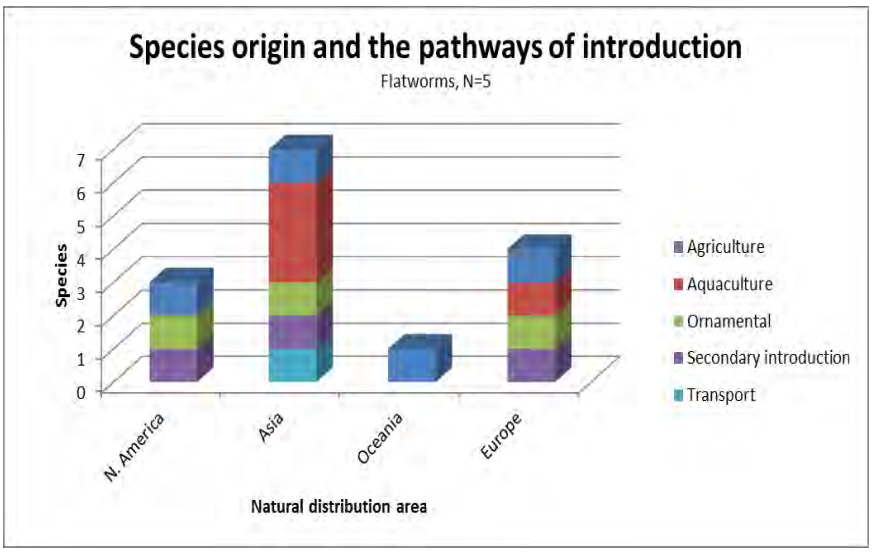


Flatworms

For the species of flatworms, four natural distribution areas are registered for the group and five pathways of introduction (see figure 83).

The majority of the non-native species of flatworms originates from Asia, where the main pathway of introduction is aquaculture. For the species originating from Europe and North America, no main pathway of introduction is identified, and for species originating from Oceania only agriculture is identified as a pathway of introduction.

Figure 83: The area of origin for introduced flatworms and their pathways of introduction

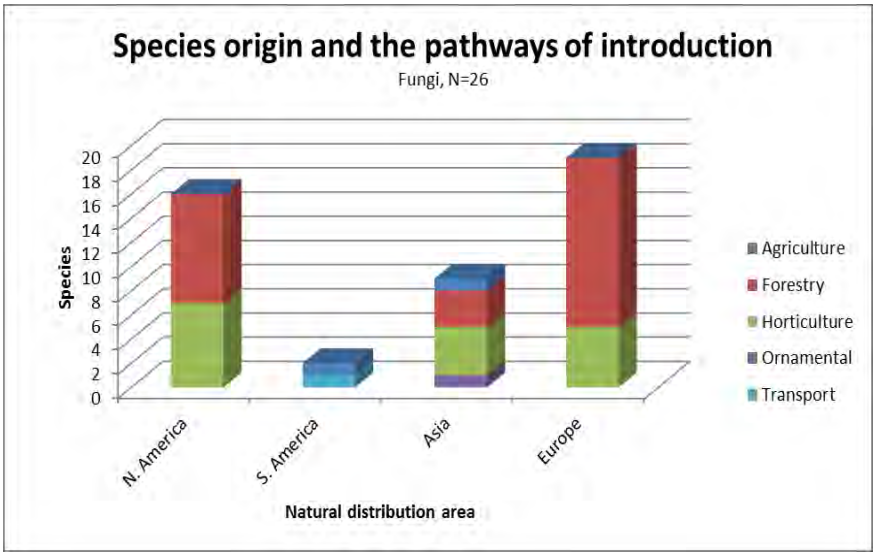


Fungi

For the species of fungi, four natural distribution areas are registered for the group and five pathways of introduction (see figure 84).

The majority of the non-native species of fungi originates from Europe and North America, where the main pathway of introduction is forestry. Species originating from Asia are introduced mainly by horticulture and forestry, while species from South America are introduced by transport and agriculture.

Figure 84: The area of origin for introduced fungi and their pathways of introduction



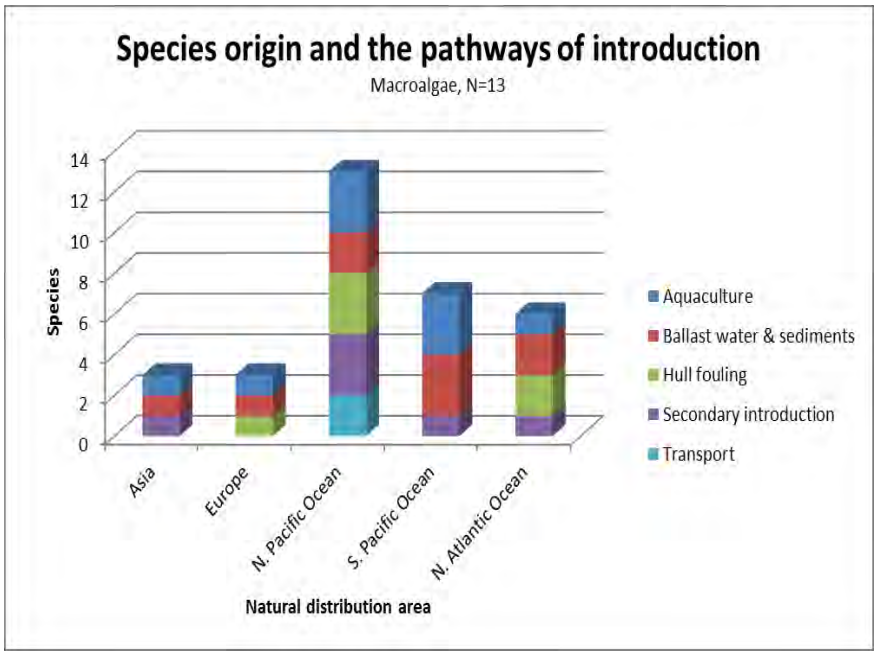
Macroalgae

For the species of macroalgae, five natural distribution areas are registered for the group and five pathways of introduction (see figure 85).

The majority of the non-native species of macroalgae originates from the North Pacific Ocean, where the most registered pathways of introduction are aquaculture, hull fouling and secondary introduction.

For species originating from the South Pacific Ocean the majority is introduced by ballast water & sediments and aquaculture, while species originating from the N. Atlantic Ocean are introduced by ballast water & sediments and hull fouling.

Figure 85: The area of origin for introduced macroalgae and their pathways of introduction

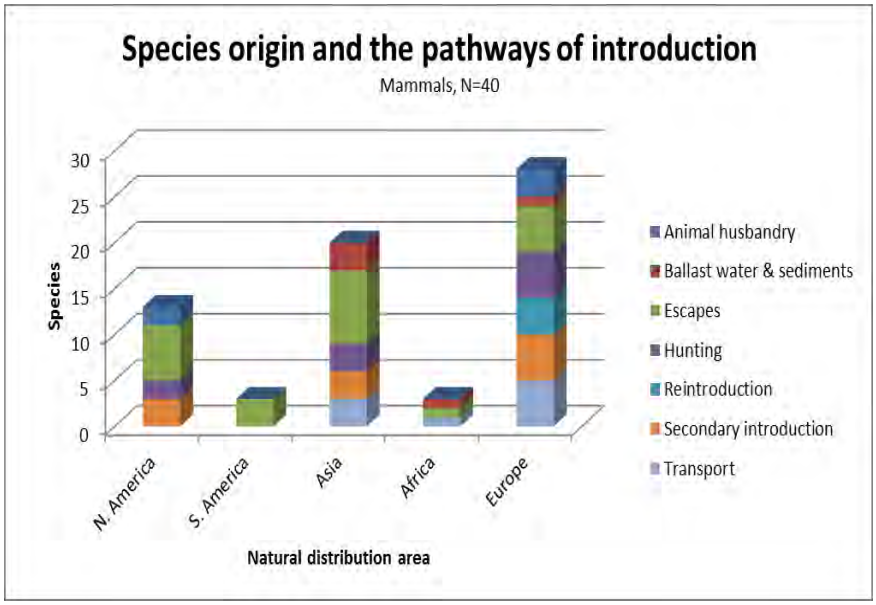


Mammals

For the species of mammals, five natural distribution areas are registered for the group and 7 pathways of introduction (see figure 86).

The majority of the non-native species of mammals originates from Europe, where the most registered pathways of introduction are escape, hunting and secondary introduction. Also reintroduction is registered for a number of the species of mammals originating from Europe. Species originating from Asia are mainly introduced by escape which is also the case for species originating from North America.

Figure 86: The area of origin for introduced mammals and their pathways of introduction

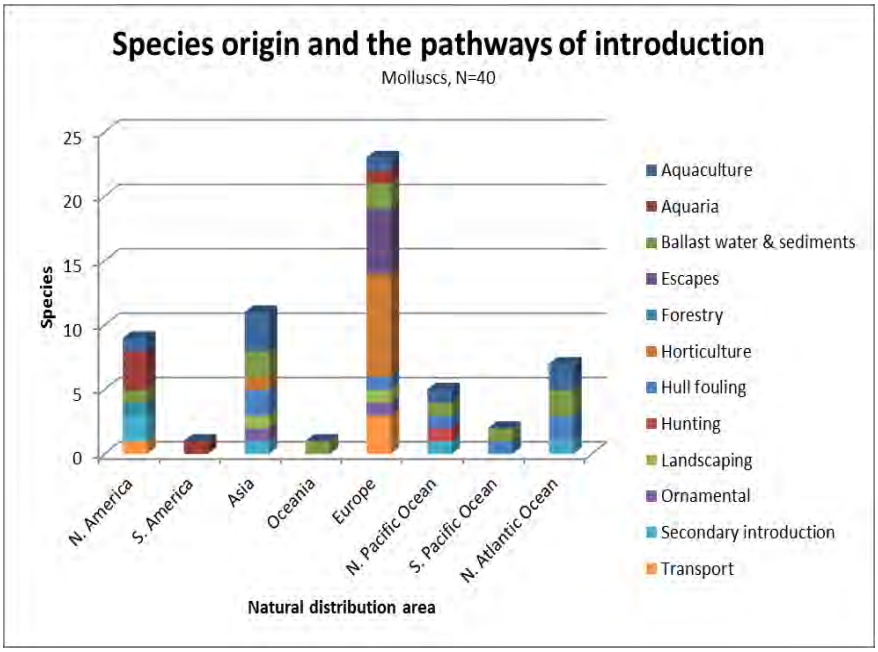


Molluscs

For the species of molluscs, 8 natural distribution areas are registered for the group and 12 pathways of introduction (see figure 87).

The majority of the non-native species of molluscs originates from Europe, where the main pathway of introduction is horticulture. Species originating from Asia are mostly introduced by aquaculture, ballast water & sediments and hull fouling, while species from North America are mainly introduced by aquaria and secondary introduction.

Figure 87: The area of origin for introduced Molluscs and their pathways of introduction



Microorganisms

Only one species of microorganisms is registered with the relevant information concerning natural distribution area and a pathway of introduction. *Aeromonas salmonicida* originates from North America and the pathway of introduction is registered as aquaculture.

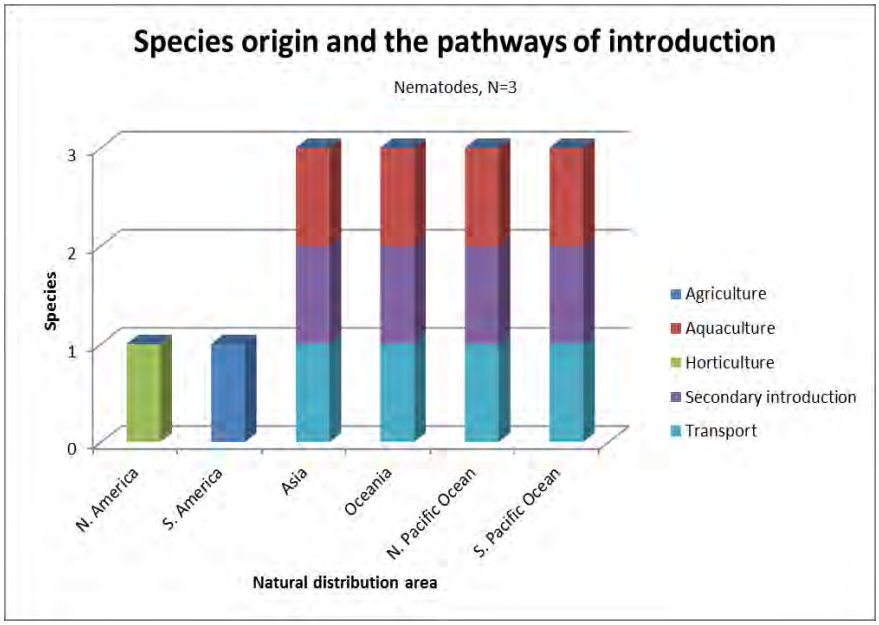
Nematodes

For the species of nematodes, 6 natural distribution areas are registered for the group and five pathways of introduction (see figure 88).

The majority of the non-native species of nematodes originates from Asia, Oceania, the North Pacific Ocean and the South Pacific Ocean. Aquaculture, secondary introduction and transport are the pathways of

introduction for the species of non-native nematodes when introduced to the participating countries and territories. For species originating from North America the majority of introductions occur through horticulture, and for species originating from South America, agriculture is the pathway of introduction.

Figure 88: The area of origin for introduced nematodes and their pathways of introduction



Other chordates

Only two species of other chordates are registered with the relevant information concerning natural distribution area and a pathway of introduction. *Molgula manhattensis* originates from North America by ballast water & sediments and hull fouling, while *Styela clava* originates from Asia and is introduced by four different pathways of introductions: ballast water & sediments, hull fouling, secondary introduction and transport.

Other invertebrates

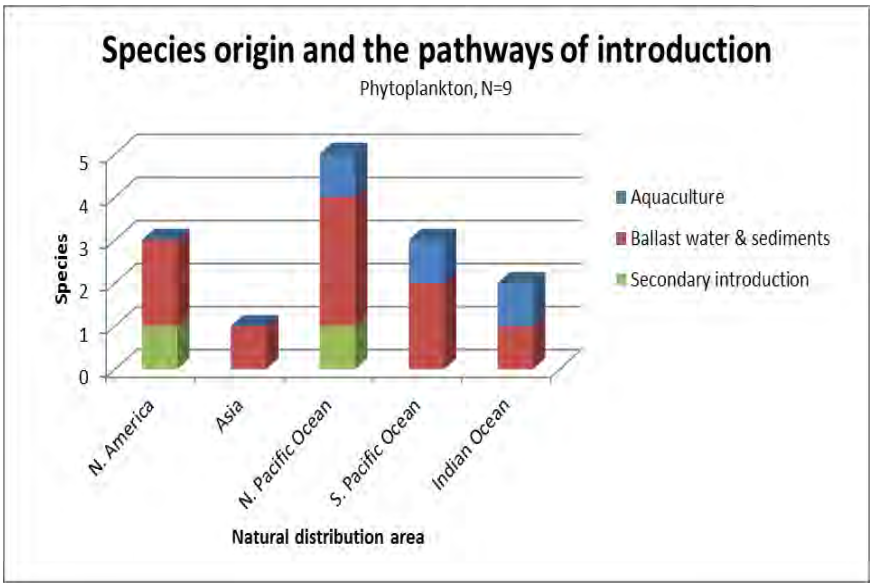
Only two species of other invertebrates have the relevant information concerning natural distribution area and a pathway of introduction. *Bugula neritina* and *Victorella pavida* both originate from Europe and the pathways of introductions are aquaculture, biological control and hull fouling.

Phytoplankton

For the species of phytoplankton, five natural distribution areas are registered for the group and three pathways of introduction (see figure 89).

The majority of the non-native species of phytoplankton originates from the North Pacific Ocean, and ballast water & sediments is the main pathway of introduction. Ballast water & sediments is also used as a pathway of introduction for species originating from North America, Asia, the South Pacific Ocean and the Indian Ocean.

Figure 89: The area of origin for introduced phytoplankton and their pathways of introduction

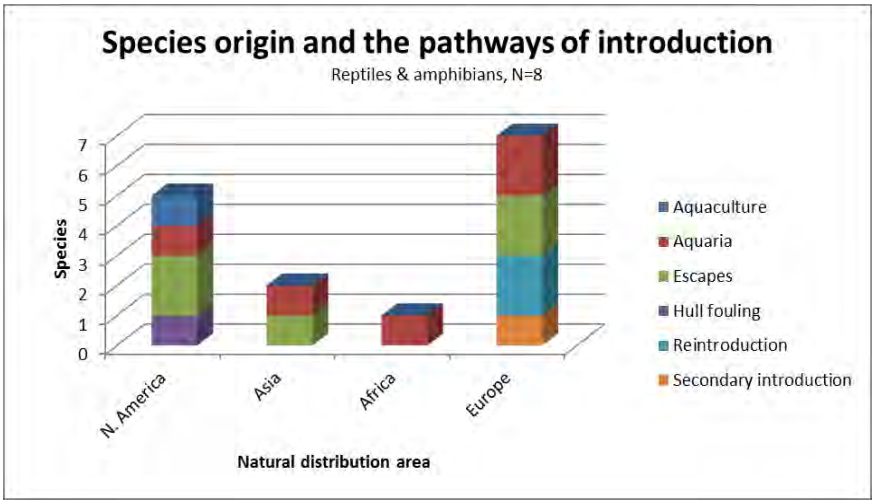


Reptiles and Amphibians

For the species of reptiles and amphibians, four natural distribution areas are registered for the group and 6 pathways of introduction (see figure 90).

The majority of the non-native species of reptiles and amphibians originates from Europe, and aquaria, escapes and reintroduction are the main pathways. For the species that originate from North America, the pathway of introduction is escape, followed by hull fouling, aquaria and aquaculture.

Figure 90: The area of origin for introduced reptiles and amphibians and their pathways of introduction



Summary

Most of the non-native species registered in the participating countries and territories originate from Europe and Asia, followed by North America.

Species originating from Europe are mainly introduced by horticulture and agriculture, but also ballast water & sediments and forestry are widely used pathways of introduction. For a large proportion of the taxonomic groups Europe is the main area of origin for the non-native species. These groups are angiosperms, annelids, arthropods, fungi, mammals, molluscs, other invertebrates and reptiles & amphibians.

The same pathways (horticulture, agriculture, ballast water & sediments and forestry) apply to species native to Asia, except that transport is also a widely used pathway of introduction. The groups with species primarily from Asia are birds and flatworms.

For species native to North America the main pathway of introduction is horticulture. The groups with species primarily from North America are coniferous plants, ferns and fish.

Species that originated from Africa or South America are mainly introduced by horticulture and agriculture and for species native to Africa also by transport. Only one group of non-native species originates primarily from Africa and South America, namely bryophytes where an equal number of species is from Africa and South America.

Only a few non-native species originate from Oceania, Antarctica, North Pacific Ocean, South Pacific Ocean, North Atlantic Ocean, South Atlantic Ocean, Indian Ocean, Arctic Ocean and the Southern Ocean. However, some groups largely originate from the North Pacific Ocean, these being: cnidarians, macroalgae and phytoplankton.

5. Horizon scanning

In the horizon scanning 414 potentially invasive species (*door knocker species*) from 22 taxonomic groups were assessed by experts. The assessments were made to establish the species risk of arriving, establishing and having a negative impact. These assessments are the basis for the calculations that subsequently categorise the species as high, medium or low risk species (see the risk categorisations in the box and in chapter 3.3).

Risk categories

High risk species (A) are species that were assessed to having one of these two scenarios:

- A high risk of arrival in the region of concern, and a medium risk of establishing and having an impact.
- A medium or high risk of arrival in the region of concern, and a high risk of establishing and having a negative impact.

Medium risk species (B) are species that were assessed to having one of three scenarios:

- A high risk of arrival in the region of concern, but a low risk of establishing and having an impact.
- A medium risk of arrival in the region of concern, and a medium risk of establishing and having an impact.
- A low risk of arrival in the region of concern, but a high risk of establishing and having an impact.

Low risk species (C) are species that were assessed to having one of these two scenarios:

- A low risk of establishing and having an impact, and a low or medium risk of arrival in the region of concern.
- A medium risk of establishing and having an impact, but a low risk of arrival in the region of concern.

This horizon scanning contains lists and figures of the species assessed as high risk and medium risk species. The analysis is conducted for each region.

The lists of experts are available in appendix 2, and the complete list of assessed species is available in appendix 18. For the full expert assessments please contact the NOBANIS secretariate.

The number of high risk species (A) for the three regions combined is 43 (see table 18 and species list in appendix 6), while the number of medium risk species (B) is 78 (see table 19 and species list in appendix 7).

Some species were not possible for experts to assess (N=58 for the regions combined, see appendix 8), and is therefore not present in the further analysis. Not assessed means that it has not been possible for the expert to asses all the criterias and these species are therefore taken out of the further analysis.

The species categorised as low risk species (C) are not further discussed in this report, but are listed in appendices 15–17.

Table 18: Number of high risk species (A) in each taxonomic group for the regions combined

Group	Number
Amphibians	1
Angiosperms	3
Arthropods	20
Birds	1
Fish	1
Mammals	3
Molluscs	1
Plant-parasitic nematodes	2
Parasitic nematodes	2
Pathogenic fungi	5
Reptiles	4
Total	*43*

Table 19: Number of medium risk species (B) in each taxonomic group for the regions combined

Group	Number
Amphibians	2
Angiosperms	29
Arthropods	21
Birds	5
Fish	6
Mammals	2
Molluscs	2
Plant-parasitic nematode	1
Non-pathogenic fungi	4
Parasitic nematode	1
Pathogenic fungi	2
Reptiles	3
Total	*78*

Note that the pathways that are assigned to each species in the horizon scanning are either from the expert assessments, or from NOBANIS data from countries in the NOBANIS network that are not participating in this project.

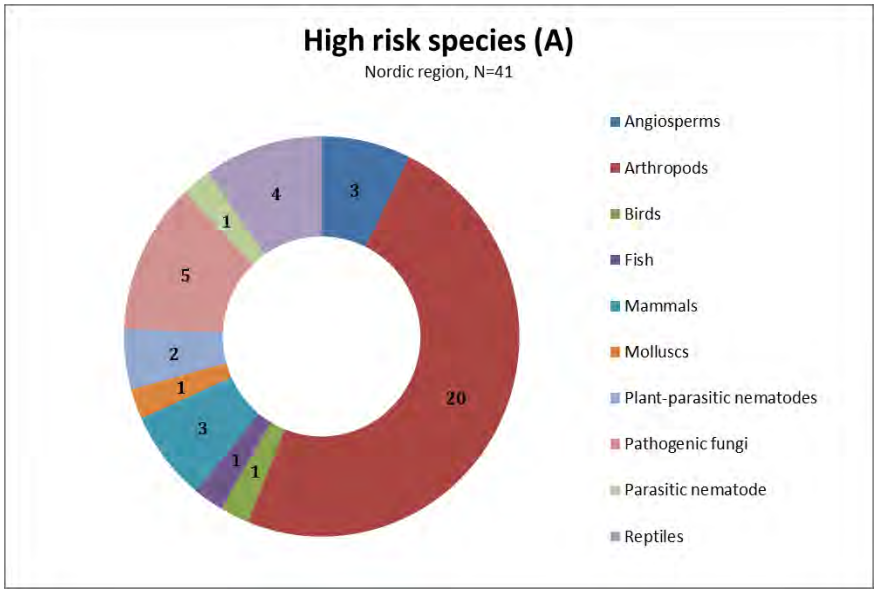
The assigned pathways are either a known pathway for the species, a known pathway for closely related species or the best estimate of a potential pathway. It is important to remember that one species can have several pathways assigned.

5.1 Nordic region

5.1.1 High risk species (A)

41 species are categorised as high risk (A) of having a negative impact in the Nordic region (see list in appendix 9). The species originate from 10 different taxonomic groups (see figure 91).

Figure 91: Taxonomic groups of species that are of high risk (A) of having a negative impact in the Nordic region

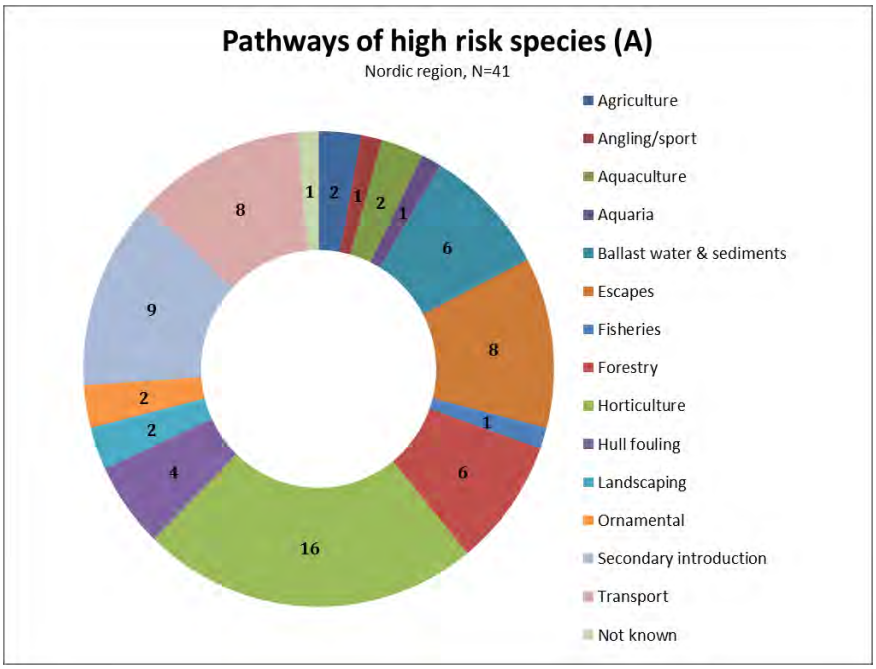


The majority of the high risk species are arthropods, where most are coleoptera (N=6), pathogenic fungi (N=5) and reptiles (N=4). The pathway[3] of most of the coleopteran is horticulture, while it for pathogenic fungi is horticulture and forestry. The reptiles have escape as their pathway of introduction.

The second largest groups is marine crabs[4] (N=3) and diptera (N=3) combined where the probable pathways of introductions for marine crabs are by ballast water & sediments and hull fouling and for the species of diptera it is transport.

The high risk species for the Nordic region have 14 different pathways. Horticulture is the most likely pathway for high risk species (N=16, see figure 92), and is a pathway for angiosperms, arthropods, fungi, molluscs and plant-parasitic nematodes.

Figure 92: Pathways of introduction of species that are of high risk (A) of having a negative impact in the Nordic region



[3] The pathways that are assigned to each species in the horizon scanning are from expert assessments or from the NOBANIS database. The assigned pathways are either a known pathway for the species, a known pathway for closely related species or the best estimate for potential pathway.

[4] One species of marine crab *Hemigrapsus penicillatus* is assessed as a high risk species (A) due to high risk of arrival and establishment, but has a low risk in the assessment of impact.

Secondary introduction is a probable pathway for 8 high risk species of arthropods and one species of mammal, while transport is a pathway of introduction for 5 species of arthropods and for one species of angiosperm, one parasitic nematode and one mollusc.

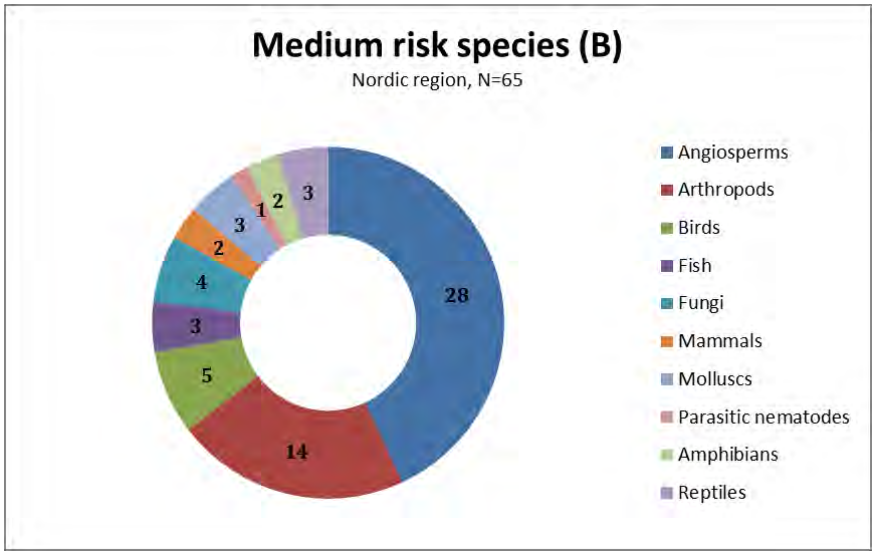
Escapes is a pathway for 8 of the species here which are reptiles (N=4), mammals (N=3) and one species of bird[5].

Another likely used pathway by the high risk species is ballast water & sediments (N=6) which is a probable pathway for arthropods (amphipods, marine crabs, tanaidacea and prawn).

5.1.2 Medium risk species (B)

65 species are categorised as medium risk (B) of having a negative impact in the Nordic region (see list in appendix 10). The species are from 10 taxonomic groups (see figure 93).

Figure 93: Taxonomic groups of species that are of medium risk (B) of having an impact in the Nordic region



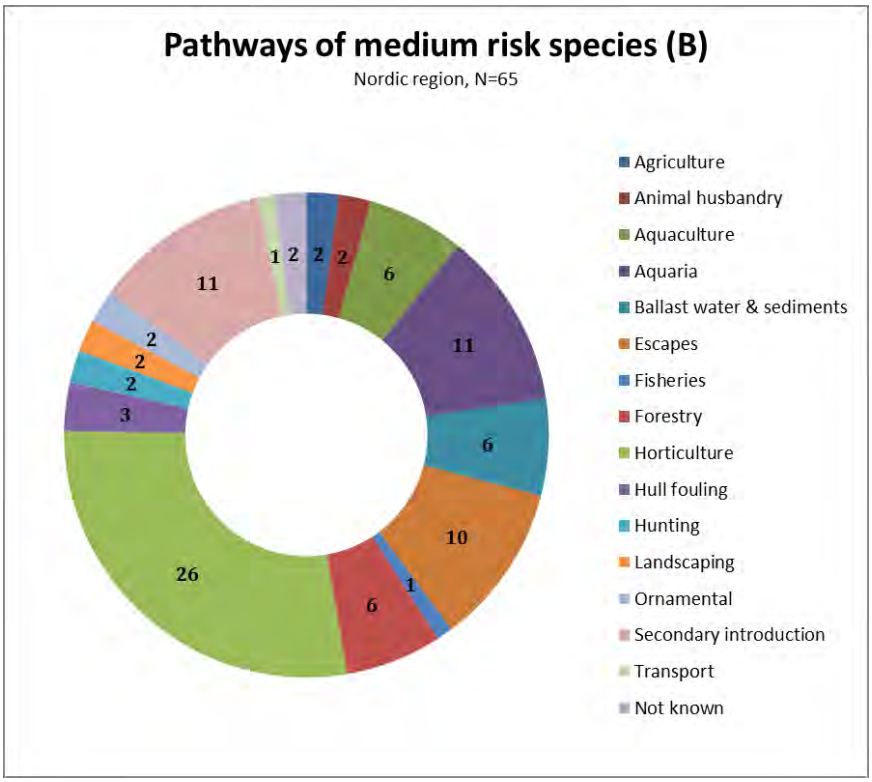
[5] This species of birds *Myiopsitta monachus* is assessed as a high risk species (A) due to high risk of arrival and establishment, but has a low risk in the assessment of impact.

The largest group of the medium risk species is angiosperms (N=28). Most of the angiosperms are likely to disperse by horticulture (N=20), and also by aquaria (N=8), landscaping (N=2) and agriculture (N=1).

The second largest group is arthropods (N=14) of several types with several probable pathways. The freshwater crayfish (N=3) are most likely to use aquaria, and for species of lepidoptera (N=3) it is horticulture.

The medium risk species for the Nordic region are using 15 different pathways. Horticulture is the most likely pathway (N=26, see figure 94) for medium risk species, and is a probable pathway for angiosperms (N=20), arthropods (N=4) and fungi (N=2).

Figure 94: Pathways of introduction of species that are of medium risk (B) of having an impact in the Nordic region



Another likely used pathway by the medium risk species is aquaria (N=11) which is a probable pathway for angiosperms (N=8) and arthropods (N=3, freshwater crayfish). Secondary introduction (N=11) which is a probable pathway for arthropods (N=6), molluscs (N=2), fish (N=1), fungi (N=1) and reptiles (N=1) is another likely used pathway for medium risk species.

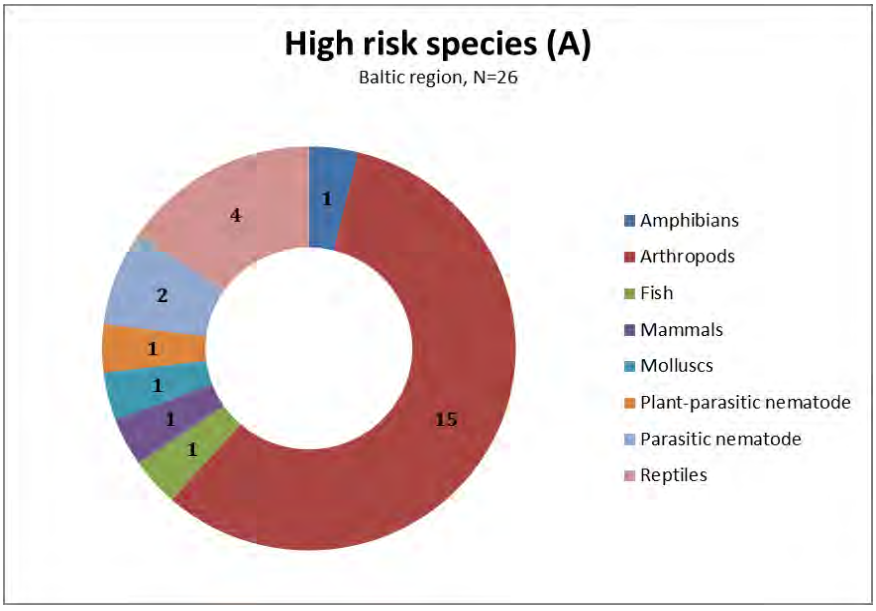
Escapes is a probable pathway for 10 of the species here, which are reptiles (N=3), birds (N=2), mammals (N=2), amphibians (N=2) and arthropods (N=1).

5.2 Baltic region

5.2.1 High risk species (A)

26 species are categorised as high risk (A) of having a negative impact in the Baltic region (see list in appendix 11). The species originate from 8 taxonomic groups (see figure 95).

Figure 95: Taxonomic groups of species that are of high risk (A) of having a negative impact in the Baltic region



The majority of the high risk species are arthropods (N=15), where most are coleoptera (N=6) and diptera (N=3). Most of the coleopteran have horticulture (N=4) as a propable pathway[6], while the species of diptera have transport (N=2).

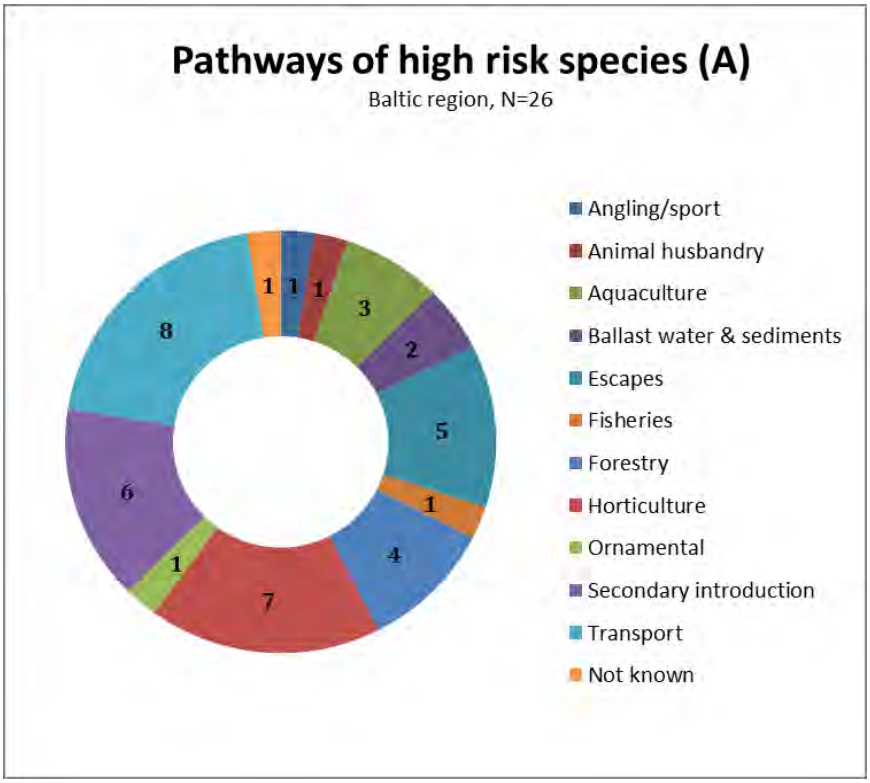
[6] The pathways that are assigned to each species in the horizon scanning are from expert assessments or from the NOBANIS database. The assigned pathways are either a known pathway for the species, a known pathway for closely related species or the best estimate for potential pathway.

The second largest group is reptiles (N=4), where all the species have escape as the probable pathway of introduction.

The high risk species for the Baltic region have 11 different pathways. Transport is the most likely pathway for high risk species in the Baltic region (N=8 see figure 96) to use. Especially species of arthropods (N=5) may use transport as the most likely pathway of introduction, but also for one species of molluscs and one parasitic nematode it is a possible pathway of introduction.

Horticulture is also a pathway for many high risk species in the Baltic region (N=7, see figure 96), and is a probable pathway for species of arthropods (N=5), as well as plant-parasitic nematodes (N=1) and molluscs (N=1).

Figure 96: Pathways of introduction of species that are of high risk (A) of having a negative impact in the Baltic region

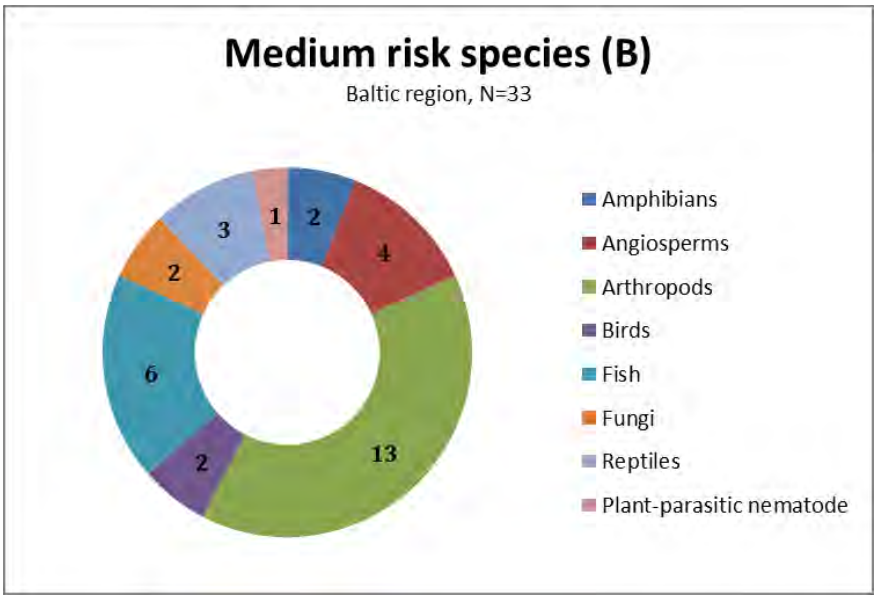


Secondary introduction is a pathway of introduction for 6 species: 5 arthropods and one species of amphibians. Another likely used pathway by the high risk species is escape (N=5) which is a probable pathway of introduction for four species of reptiles and one species of mammals.

5.2.2 Medium risk species (B)

33 species are categorised as medium risk (B) of having a negative impact in the Baltic region (see list in appendix 12). The species originate from 8 taxonomic groups (see figure 97).

Figure 97: Taxonomic groups of species that are of medium risk (B) of having an impact in the Baltic region

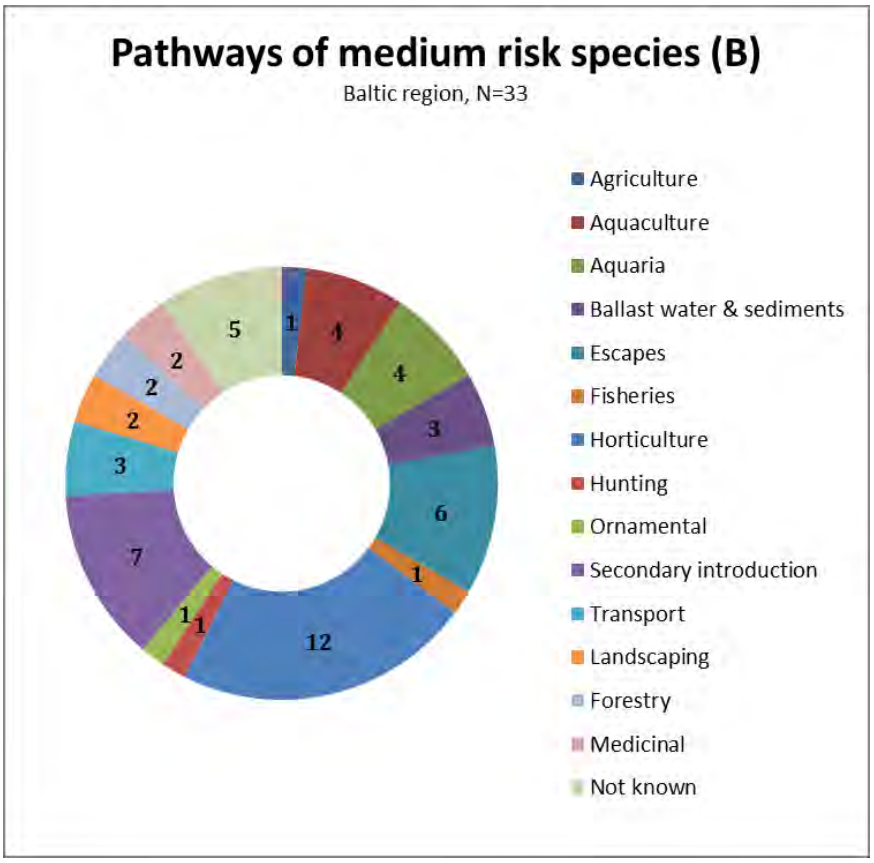


The majority of the medium risk species are arthropods (N=13), where most are lepidoptera (N=4) and diptera (N=3). Most of the species of lepidoptera and diptera may use horticulture (N=3, N=1) as a propable pathway. For two of the diptera species, no pathway of introduction into the Baltic region was suggested.

The second largest group is fish (N=6), where the most probable pathways are ballast water and sediments (N=3) and secondary introduction (N=3).

The medium risk species for the Baltic region have 14 different pathways. Horticulture is the most likely pathway for medium risk species to use (N=12, see figure 98) and is a probable pathway for arthropods (N=6), angiosperms (N=3) and fungi (N=2).

Figure 98: Pathways of introduction of species that are of medium risk (B) of having an impact in the Baltic region



Secondary introduction is a propable pathway for 7 species. Particulary arthropods (N=3), fish (N=3) and one species of reptile may be introduced by secondary introduction, while escape is a propable pathway for 6 species: 3 reptiles, 2 amphibians and one species of arthropod.

5.3 Islands of the North Atlantic Ocean

5.3.1 High risk species (A)

Only two species are categorised as high risk (A) of having a negative impact in the Islands of the North Atlantic Ocean (see list in table 20 or appendix 13). The species originate from two taxonomic groups which are using two pathways each.

The arthropod (*Vespa velutina*) has transport and secondary introduction as its pathway[7], while the mammal (*Sciurus carolinensis*) has escapes and ornamental as a probable pathway of introduction.

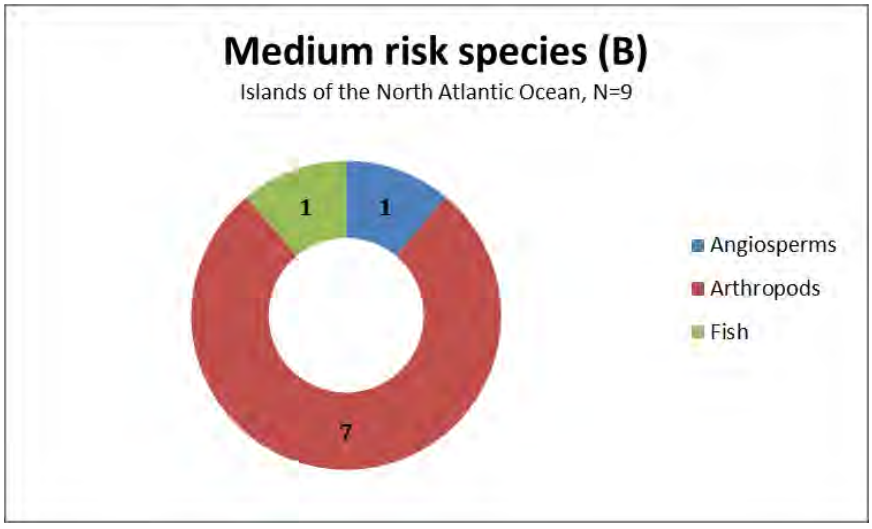
Table 20: High risk species (A) of the Islands of the North Atlantic Ocean

Taxonomic group	Species	Pathway
Mammals	Sciurus carolinensis	Ornamental, Escapes
Arthropods/wasp	Vespa velutina	Secondary introduction, Transport

5.3.2 Medium risk species (B)

9 species are categorised as medium risk (B) of having a negative impact in the Islands of the North Atlantic Ocean (see list in appendix 14). The species originate from three taxonomic groups (see figure 99).

Figure 99: Taxonomic groups of species that are of medium risk (B) of having an impact in the Islands of the North Atlantic Ocean

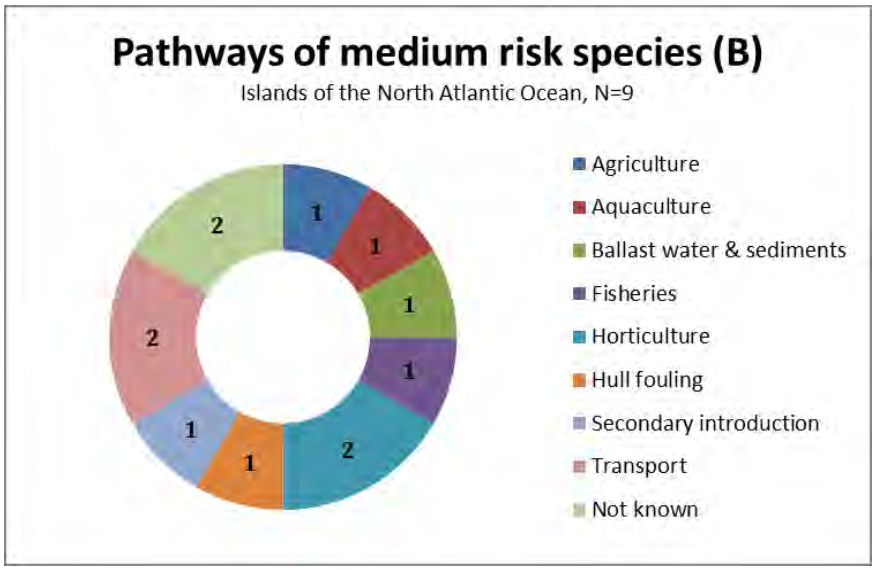


The majority of the medium risk species are arthropods (N=7), where most are species of diptera (N=5). The other two organisms are an angiosperm and a fish.

[7] The pathways that are assigned to each species in the horizon scanning are from expert assessments or from the NOBANIS database. The assigned pathways are either a known pathway for the species, a known pathway for closely related species or the best estimate for potential pathway.

The medium risk species for the Islands of the North Atlantic Ocean has 8 different pathways. Horticulture (N=2, see figure 100) and transport (N=2) are the most likely used pathways, and the main species probable to be introduced by these are arthropods.

Figure 100: Pathways of introduction of species that are of medium risk (B) of having an impact in the Islands of the North Atlantic Ocean



5.4 Summary

The number of different high risk species (A) for the three regions combined is 43, while the Number of medium risk species (B) is 78.

In the Nordic and Baltic region the arthropods are the largest group of the high risk species (A), and in the Islands of the North Atlantic Ocean one of the two high risk species is an arthropod. The most probable pathways for them to use are horticulture, secondary introduction and transport, but a number of other pathways are also likely to be used by the high risk species.

The medium risk species (B) in the regions are mostly angiosperms and arthropods. The most probable pathway for them to use is also horticulture, along with secondary introduction.

5.4.1 Nordic region

41 species are categorised as high risk (A) of having a negative impact in the Nordic region. The largest group is arthropods, followed by pathogenic fungi and reptiles.

The high risk species for the Nordic region may use 14 different pathways. Horticulture is the most likely pathway, followed by secondary introductions, transport, escape, forestry and ballast water & sediments.

65 species are categorised as medium risk (B) of having an impact in the Nordic region. The largest group is angiosperms, followed by arthropods.

The medium risk species for the Nordic region may use 15 different pathways. Horticulture is the most probable used pathway, but also aquaria, secondary introduction and escape are likely to be used by several species.

5.4.2 Baltic region

26 species are categorised as high risk (A) of having a negative impact in the Baltic region. The majority of the high risk species are arthropods, followed by reptiles.

The high risk species for the Baltic region may use 11 different pathways. Transport is the most probable used pathway, along with horticulture and secondary introduction.

33 species are categorised as medium risk (B) of having an impact in the Baltic region. The majority of the species are arthropods (N=13), followed by fish (N=6).

The medium risk species for the Baltic region may use 14 different pathways. Horticulture is the most probable pathway to be used, but also secondary introduction and escape are likely to be used by several species.

5.4.3 Islands of the North Atlantic Ocean

Two species are categorised as high risk (A) of having a negative impact in the Islands of the North Atlantic Ocean. The species are an arthropod (*Vespa velutina*) which most likely will be introduced by transport and secondary introduction, and a mammal (*Sciurus carolinensis*) which most likely will be introduced by escape and ornamental use.

9 species are categorised as medium risk (B) of having a negative impact in the Islands of the North Atlantic Ocean. The majority of these are arthropods, while the others are an angiosperm and a fish.

The medium risk species for the region may use 8 different pathways of introduction, where horticulture and transport are the most likely used pathways.

6. Discussions

6.1 Pathway analysis

The results from the pathway analysis are based on the current data available in the NOBANIS database, and since the environment and the species within it are dynamic, the information available will change over time. The new species and information that will be registered in the database are not definitive, but rather a current view, so further studies should be made.

6.1.1 Pathways of introduced species

This analysis shows that the main pathway of introduction in all three regions is horticulture, followed by agriculture, transport, forestry and ballast water & sediments, but also that there are variations between the regions. The differences may reflect the difference in the countries' or territories' political history and trade traditions that can affect the use of pathways due to differences in import policy, trading relations and the handling of goods.

For some species with known pathways of introduction, it could be suitable to define the pathway of introduction on a smaller scale, or revise the pathway classifications as globalisation increases and new trading relations evolve (Essl *et al*. (in revision)). These initiatives may facilitate more thorough registration and management of certain pathways, to reduce introduction of invasive alien species of concern.

The analysis also shows that the majority of species introduced has an unidentified pathway of introduction. The missing information may reflect the challenge of identifying pathway of introduction for species that are unintentionally introduced. Furthermore, differences in percentage of unknown pathways between the regions may be caused by differences in method and degree of data collection.

6.1.2 Invasiveness of introduced species

When examining the results of this analysis the groups with the highest number of invasive or potentially invasive species are angiosperms and arthropods. But looking at the percentage distribution, the groups with the highest degree of invasive or potentially invasive species differ between the regions. In the Nordic region microorganisms, flatworms and fungi are the groups with highest percentage of invasive species, while for the Baltic region it is species of annelids and fish. For Islands of the North Atlantic Ocean it was not possible, due to limited dataset, to identify the taxonomic groups with most invasive species present, but birds and mammals were the groups with most introductions of potentially invasive species. This inconsistency among the three regions may be due to differences in trading and import.

Looking at the pathways with the most introductions of species with high invasiveness, horticulture is again the main pathway of concern, followed by agriculture, transport, ballast water & sediments and forestry. These results correspond with the results in *Pathways of introduced species* (chapter 4.1) and the result from the Danish study by Madsen *et al*. (2014), where horticulture also was the main pathway of introduction for non-native species. On the other hand, when looking at the percentage of introductions that are invasive, the numbers are low for horticulture and agriculture, showing that the pathways with the highest number of introductions not always are the ones with the largest number of invasive alien species. This shows that the most frequently used pathways not necessarily contribute with the highest number of invasive species.

6.1.3 Taxonomic groups of introduced species

In this analysis, angiosperms are the group with the highest number of alien introductions and arthropods are the group with the second highest number of introductions in all three regions. The high number of introductions of angiosperms, which is primarily by horticulture, and as seen in the subanalysis *Temporal development of pathways* (chapter 4.4), introduction by horticulture has increased markedly since the 1700, which corresponds to the high number of introductions of angiosperms.

For the arthropods, the high number of introductions may reflect that the group is highly diverse and therefore, has a wide range of pathways for dispersal. This means that prioritising pathways of concern can be challenging and costly and further studies of arthropods and specific subgroups and their pathways of introductions are needed. This is also the case for the molluscs representing marine, freshwater and terrestrial

species, making it difficult to prioritise pathways of concern, when dealing with the different types of habitats and environment. Prioritisation of pathways when dealing with diverse groups of species with a high number of pathways can therefore be facilitated by using the results from the other analyses in this project, e.g. percentage of invasive species with each pathway and *door knocker species*.

Microorganisms and phytoplankton have been registered with a relatively few species in the participating countries and territories and in the NOBANIS database in general. Many small organisms can be challenging to detect, due to their small size and perhaps their use of vectors or hosts (primarily microorganisms), and it is possible that some of these species of smaller organisms already are present, but not registered in the NOBANIS database. In general, plant and animal pathogens are believed not to be fully represented in the NOBANIS database, due to these being in a grey zone between influence on plant and animal health and impact on biodiversity. Many of these organisms are identified in databases focusing on plant and animal health. The lack of consistency regarding registrations of plant and animal pathogens in the NOBANIS database can be minimized by defining clear guidelines for which species is registered in which database.

The type of introduction (intentional or unintentional) varies between the different groups, and knowledge on these differences is an important element when planning measures of control. Many introductions of species are intentional, for example for most introductions of coniferous plants, fish, and mammals. In these cases information campaigns can be part of the preventive initiatives applied. On the other hand, unintentional introductions are more challenging to prevent, because there are uncertainties about where to apply preventive initiatives.

Many species are registered in the NOBANIS database as introduced both intentionally and unintentionally, as they may be of different type within a country or of different type in each of the countries in the regions. These introductions should be managed like both types, to ensure that all new introductions are prevented or reduced.

Secondary introduction is a pathway, which is difficult to manage in order to prevent further introduction and spread of species across borders, due to the fact that these introductions are unintentional. In these cases, an early warning system (see the chapter 8 *Recommendations*) can assist in reducing these introductions, by neighbouring countries alerting each other (see chapter 8.2 *Early warning system* later in the report) regarding new species of concern (NOBANIS 2010).

6.1.4 Temporal development of pathways

The registrations of introductions of alien species are increasing in all three regions. Especially the pathways horticulture, aquaculture, transport and forestry are increasing in the regions. The overall increase in registered introductions may reflect both the increase in globalisation, but also the global awareness concerning invasive alien species and the negative impact they have on native biodiversity, socio-economic concerns and in some cases human health.

There is, however a decrease in registrations over time for some of the pathways of introduction. Introductions by agriculture, medicinal and ballast water & sediments have decreased in the Nordic region while agriculture, escapes and landscaping have decreased in Iceland.

The decrease in introductions by agriculture in the Nordic region may reflect that import of crops for food consumption etc. has expanded over the last 100 years. So instead of cultivating crops on the field, we import cultivated food items from outside the region. More restrictions when importing seed mixtures (Commission Regulation (EU) 2011) and seed in general for cultivation etc. may prevent some species of stowaways, and also the use of certain hybrid species (F1) for cultivation may prevent/minimize the spread of crops from fields into the wild.

The reductions in the number of registrations of the medicinal pathway may be caused by new knowledge and development in the medical field, and that the use of animals and plants in medicine is closely monitored.

The reduction in the use of ballast water & sediments as a pathway of introduction can indicate an increase in awareness in recent years. Hopefully the reduction in alien species entering with ballast water & sediments will continue with the convention "International Convention for the Control and Management of Ships Ballast Water & Sediments" of 2004. In Iceland, restrictions on import of all animals may cause the decrease in introduction of alien species by escapes.

The current period from the year 2000 and until now is not finished and therefore not comparable to the other periods. It is therefore not shown in the graphs. If we also look at the data from 2000–2014 (shown in appendices 4 and 5) we can see the currently active pathways, but not whether there is an increase or decrease in introductions in recent times. However, there is a tendency for development in the landscaping pathway. The number of registrations for landscaping in the Nordic region from 2000 and until now is already higher than the sum from the previous fifty year periods, so it is certain that there is now an increase, which may further accelerate in the future.

6.1.5 Species origin and the pathways of introduction

Most of the non-native species registered in the participating countries and territories originate from Europe and Asia, followed by North America, which primarily is due to the similarities in the biogeographic zones between Europe, Asia and North America, making it possible for alien species to establish. The high number of introduction of European species may also be due to the closeness of the area of origin to the area of introduction, and the high degree of trading within the European countries and territories.

The high number of introduction of Asian species, which is primarily by horticulture and agriculture, can be explained by the high percentage of import of Asian goods to the participating countries and territories. There is also a high degree of import from North America e.g. coniferous plants, which may explain the introductions of species native to North America (WTO 2014).

Looking at the different taxonomic groups and their areas of origin, and comparing them with the results obtained in *Invasiveness of introduced species* (chapter 4.2), the majority of the taxonomic groups with many invasive or potentially invasive species originates from Europe, Asia and North America. This again reflects the high degree of import from these parts of the world, which leads to a high number of introductions where some species may become invasive.

For all countries and territories in this study there are species where information regarding pathway of introduction, invasiveness etc. is missing. This missing information may mean that pathways of introductions are undetected, that new pathways may need to be defined, or that the degree of invasiveness is unclear. Additional studies and scientifically validated data are needed in order to identify pathways of introduction, as well as to clarify the invasive status of some non-native species registered in the regions. Further study of those particular species may increase the amount of information, and give us a more comprehensive understanding of invasive alien species to help prevent introduction, and to manage and eradicate the species. However, it will never be possible to obtain all relevant information due to the unpredictability of species in new environments etc.

6.2 Horizon scanning

The large number of arthropods that are of high risk of arriving, establishing and having an impact on native biodiversity etc. in the regions, reflects the high diversity of the group. Several probable pathways of introduction make management initiatives a challenging task. There are some pathways that are more likely to be used by several species than others, and these can form the basis for management plans.

The medium risk species in the regions are mostly angiosperms and arthropods. The angiosperms, as well as the arthropods, are also a relatively diverse group with both terrestrial and aquatic habitats. The main pathway of introduction for the high and medium risk species of angiosperms is horticulture. For medium risk species of arthropods, horticulture and secondary introduction are the main pathways of introduction.

Making management initiatives for horticulture in general is likely to have a significant effect towards preventing high risk species and medium risk species of angiosperms and arthropods to be introduced in the regions.

Introductions by secondary introductions may be more challenging to manage. For the management of the secondary introductions an early warning system may be the best option. Here countries in the regions can warn each other about new invasive species and share information regarding prevention, management etc.

6.2.1 Nordic region

The Nordic region has a large group of high risk arthropods. The different types of arthropods have different probable pathways of introduction to the region, but primarily secondary introductions, ballast water & sediments and horticulture are pathways of importance. These differ from the historic pathways seen for arthropods in the Nordic region in *Taxonomic groups of introduced species* (chapter 4.3), where the pathways horticulture, transport and forestry stand out. This indicates that there is a need for continuously adapting management initiatives to the current situation. Reduction of high risk arthropods may also reduce the introductions of medium risk arthropods.

The Nordic region has the largest number of medium risk angiosperms, which are introduced primarily by horticulture. The history of introductions of angiosperms by horticulture is supported by the subanalysis *Taxonomic groups of introduced species* (see chapter 4.3), although the invasiveness of these species is relatively low, compared to the other taxonomic groups in *Invasiveness of introduced species* (see

chapter 4.2). Furthermore, in the subanalysis *Temporal development of introductions* (see chapter 4.4) there has been an increase of introductions by horticulture over time.

Management of introductions by horticulture in the Nordic region may also reduce the introductions of other groups, i.e. non-pathogenic fungi, pathogenic fungi and plant-parasitic nematodes, depending on the type of initiatives.

6.2.2 Baltic region

As seen in the Nordic region, the Baltic region also has a large group of high risk arthropods. The different types of arthropods have different pathways, but mostly secondary introductions, transport and horticulture are pathways of importance.

If we look at the historic pathways seen for arthropods in the Baltic region in *Taxonomic groups of introduced species* (chapter 4.3), the majority of the introductions are by unknown pathway. Also the invasiveness is unknown for the majority of the arthropods introduced to the Baltic, reflecting that knowledge concerning non-native arthropods in the Baltic is limited, and that further studies need to be made. This analysis of the most probable pathways of door knocker species, along with the historic pathways of introduction to the other regions, gives us valuable information regarding pathways of introduction for arthropods that can form the basis for management initiatives.

Management of the pathways for the high risk arthropods (horticulture and transport) may also reduce the introductions of the medium risk arthropods and other groups of door knocker species, e.g. medium risk angiosperms, fungi, fish and nematodes.

Attention on escapes in the Baltic region may also contribute to reduction of both high and medium risk species. This is due to the presence of four reptiles and one mammal on the high risk list, and three reptiles and one arthropod on the medium risk list. These 9 species are most likely to be introduced by escapes, and awareness campaigns on the negative effect of releasing pets and exotic animals into the wild might prevent some introductions.

6.2.3 Islands of the North Atlantic Ocean

Only two species are categorised as high risk (A) for the Islands of the North Atlantic Ocean. The species are an arthropod (*Vespa velutina*) most likely to be introduced by transport and secondary introduction,

and a mammal (*Sciurus carolinensis*) most likely to be introduced by escapes and ornamental use. Therefore, only four pathways are important for management of the high risk species.

Even though the formerly introduced species of arthropods have had a low invasiveness (see chapter 4.2 *Invasiveness of introduced species*), the arthropod mentioned above is categorised as a high risk species. Furthermore, managing transport to prevent the introduction of the species may handle some species on the medium risk list as well. The invasiveness of the formerly introduced mammals is relatively high, although the results are based on only a few species.

The other medium risk species (primarily arthropods) might use a number of probable pathways, but with horticulture and transport as pathways of high importance. Horticulture is also a pathway of importance in the historic data on arthropods in *Taxonomic groups of introduced species* (chapter 4.3) and an increasingly important pathway in *Temporal development of introductions* (chapter 4.4), so initiatives towards horticulture may reduce further and new introductions of invasive and alien species of arthropods in the region.

6.2.4 Methods

For some species it was not possible for the expert(s) to make the assessments, due to the lack of knowledge and/or information on the particular species. The unassessed species may become threats in the future, because their invasiveness and pathways are unknown and therefore unmanaged, so new knowledge is continuously needed to evaluate the potential *door knocker species*.

The species that are assessed as low risk (C) are not considered to be immediate threats right now, but they may become threats in future (near, medium and long term). In the near future we might see changes in the type of goods transported, trading relations, habitats and dispersal of species etc. On a longer term we may expect changes in our climate which may change our environments to a great extent. This change in factors may be beneficial for some species, which then may be able to arrive, establish and become invasive.

In the horizon scanning the species are assigned pathways based on registrations in the NOBANIS database, along with expert assessments of known or probable pathways of the species or closely related species. These assigned pathways may not be all the pathways the species may use. Therefore, focus on the pathways is still needed as they may change over time.

The horizon scanning was designed to be sensitive to species with a risk of having a negative impact, to prevent invasive species from receiving a too low risk assessment. Therefore, two species that scored high in arrival and establishment, but low in each of the three impact scores were assessed as high risk species, despite their low impact scores.

Making measures to control potential *door knocker* species in the marine environment may pose a great challenge in the future, and the assessment of some of the marine species in this project may have some uncertainties due to the difference in the coastal environment among the countries. E.g. Finland is part of the Nordic region in this analysis, due to terrestrial parameters, but the marine environment is more similar to the Baltic Sea than the marine environment along the coast of Denmark and Norway. Therefore, the marine environment in Finland has more in common with the countries in the Baltic region, i.e. brackish water with low salinity (Matz Berggren, pers. comm.).

The division of the three regions, where countries and territories, with different positions both regarding geographical position and climate are joined together, could give some uncertainty in the assessments results for the potentially *door knocker* species. But as mentioned in the methods, the division of the participation countries and territories is based on several attributes, and not only the geographical position and climate. Also topography, political history and the trading/import of goods (indirect influence the pathway of introduction) has been taking into account.

Potential *door knocker species* were eliminated from the final list when established in one or more of the participating countries and territories. By doing this, we may have excluded alien species on the final list that may be important *door knockers* for some participating countries and territories.

The environment and the species within it are dynamic and the assessments made by experts are based on the presently available information. The results in this analysis are therefore based on the current situation and experts' best estimates. We therefore recommend that the species on the horizon list are further examined, and by several experts, to get broader assessments of the species ability to arrive, establish and the impact they may have on biodiversity, human health and socio economic concerns.

7. Prioritisation of pathways

In the process of prioritising pathways of concern, we looked at the results from the pathway analysis. The prioritisation was done based on:

- Number of introduced invasive species by the pathway.
- Number of introductions through the pathway.

Subsequently, other parameters from the pathway analysis and the horizon scanning were taken into account to make adjustments to the prioritisation of the pathways:

- Invasive introductions (%).[8]
- Number of high risk (A) *door knocker species* that is assigned to the pathway.
- Number of medium risk (B) *door knocker species* that is assigned to the pathway.
- Number of potentially invasive introductions.
- Temporal development of pathways.

Pathways with less than 25 registrations of introduction were not considered to be pathways of concern in this report, and were therefore not included in the prioritised list, unless other of the parameters above showed that the pathway was of concern.

The list of prioritised pathways is the guideline for future management, and is presented for each region while the arguments for the prioritisation are described afterwards.

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[8] Invasive introductions (%) = (invasive introductions by that pathway/all introductions by that pathway) x 100).

7.1 Nordic region

The prioritised list of pathways of concern for the Nordic region is presented in table 21.

Table 21: Prioritised list of pathways of concern for the Nordic region

Priority	Pathway	
1	**Horticulture**	
	Invasive introductions	282 (16%)
	Number of introductions	1763
	High risk species (A)	16
	Medium risk species (B)	26
	Number of potentially invasive introductions	251
2	**Transport**	
	Invasive introductions	109 (32%)
	Number of introductions	342
	High risk species (A)	8
	Medium risk species (B)	1
	Number of potentially invasive introductions	61
3	**Ballast water & sediments**	
	Invasive introductions	72 (29%)
	Number of introductions	250
	High risk species (A)	6
	Medium risk species (B)	6
	Number of potentially invasive introductions	57
4	**Agriculture**	
	Invasive introductions	86 (15%)
	Number of introductions	561
	High risk species (A)	2
	Medium risk species (B)	2
	Number of potentially invasive introductions	63
5	**Secondary introduction**	
	Invasive introductions	43 (40%)
	Number of introductions	108
	High risk species (A)	9
	Medium risk species (B)	11
	Number of potentially invasive introductions	23
6	**Forestry**	
	Invasive introductions	48 (21%)
	Number of introductions	225
	High risk species (A)	6
	Medium risk species (B)	6
	Number of potentially invasive introductions	39
7	**Landscaping**	
	Invasive introductions	41 (35%)
	Number of introductions	117
	High risk species (A)	2
	Medium risk species (B)	2
	Number of potentially invasive introductions	27

Priority	Pathway	
8	**Aquaculture**	
	Invasive introductions	30 (42%)
	Number of introductions	71
	High risk species (A)	2
	Medium risk species (B)	6
	Number of potentially invasive introductions	11
9	**Escapes**	
	Invasive introductions	22 (32%)
	Number of introductions	68
	High risk species (A)	8
	Medium risk species (B)	10
	Number of potentially invasive introductions	11
10	**Hull fouling**	
	Invasive introductions	19 (54%)
	Number of introductions	35
	High risk species (A)	4
	Medium risk species (B)	3
	Number of potentially invasive introductions	11
11	**Aquaria**	
	Invasive introductions	8 (30%)
	Number of introductions	27
	High risk species (A)	1
	Medium risk species (B)	11
	Number of potentially invasive introductions	3
12	**Angling/sport**	
	Invasive introductions	16 (52%)
	Number of introductions	31
	High risk species (A)	1
	Medium risk species (B)	0
	Number of potentially invasive introductions	8

Horticulture is a pathway of concern in the Nordic region. The highest number of known introductions of both invasive and potentially invasive species to the Nordic region is introduced through horticulture (see chapter 4.2 *Invasiveness of introduced species*). It is also a pathway of importance for many of the taxonomic groups (see chapter 4.3 *Taxonomic groups of introduced species*), and is historically the most frequently used pathway for all of the three regions (see chapter 4.1 *Pathways of introduced species*). Furthermore, there has been an increase in introductions by horticulture since the year 1750 (see chapter 4.4 *Temporal development of pathways*).

A range of species may be targeted by management of horticulture. 16 of the 41[9] high risk species (A) for the Nordic region have horticulture as a pathway (see appendix 9). These species are angiosperms, arthropods, pathogenic fungi, molluscs and plant-parasitic nematodes. Also a range of medium risk species (B) can be targeted when managing horticulture. These medium risk species are angiosperms, arthropods and non-pathogenic fungi.

Transport and ballast water & sediments are also pathways of concern in the Nordic region with high numbers of introductions of invasive and potentially invasive alien species. Transport and ballast water & sediments are also pathways used by many different taxonomic groups (see chapter 4.3 *Taxonomic groups of introduced species*), and a range of high risk species and medium risk species may be targeted by management of these pathways (see appendix 9 and 10).

Ballast water & sediments is already a pathway of concern on an international scale, and through implementation of the "International Convention for Control and Management of Ships' Ballast Water and Sediments" it will be a pathway where action has been taken, while transport in general may result in more non-native introductions due to increasing globalisation.

The pathways agriculture, forestry and landscape are present on the prioritised list due to the high number of invasive introductions and the high and medium risk species related to the pathways. The three pathways have many alien species in common, i.e. many non-native species that are introduced to the Nordic region are registered for more than one of these three pathways.

The marine and freshwater pathways aquaculture, hull fouling, aquaria and angling/sport are pathways of concern. This is due to the number of invasive species introduced and the high percentage of invasive introductions. Furthermore, there are specific challenges in managing non-native marine and freshwater species when they are established, due to the limitations in eradication measures (see chapter 8 *Recommendations*).

Secondary introduction is also a challenging pathway, due to dispersal of non-native species from neighbouring countries (see chapter 8 *Recommendations*). The pathway is of concern for the Nordic region due to the high number of invasive introductions and high and medium risk

[9] D*oor knocker species* may have been assigned multiple pathways of introduction, and therefore the numbers of high risk and medium risk species in the tables are higher than the total number of *door knockers* for the regions.

species. Furthermore, it is a pathway that is increasingly registered over time (see chapter 4.4 *Temporal development of pathways*).

The list contains a number of pathways related to release and escape, e.g. aquaculture, escapes, aquaria and angling/sport, which have high numbers of invasive introductions and an increasing number of introductions of non-native species in the past 50 years (see chapter 4.4 *Temporal development of pathways*).

These pathways are registered for many of the taxonomic groups e.g. birds, fish, flatworms, macroalgae, mammals and reptiles & amphibians (see chapter 4.3 *Taxonomic groups of introduced species*), where flatworms, macroalgae and mammals have a high percentage of invasive alien species (see chapter 4.2 *Invasiveness of introduced species)*.

Medicinal is not part of the prioritised list of pathways for the Nordic region, though the number of introductions is relatively high, along with a relatively high number of invasive species registered. This is due to the results in the *Temporal development of pathways* (see chapter 4.4) which show that the use of *medicinal* as a pathway has declined over the last 100 years, and is no longer a pathway of concern. This decline may be due to the development and restrictions in the medical field.

7.2 Baltic region

The prioritised list of pathways of concern for the Baltic region is presented in table 22.

Table 22: Prioritised list of pathways of concern for the Baltic region

Priority	Pathway	
1	**Horticulture**	
	Invasive introductions	67 (12%)
	Number of introductions	551
	High risk species (A)	7
	Medium risk species (B)	12
	Number of potentially invasive introductions	81
2	**Transport**	
	Invasive introductions	21 (11%)
	Number of introductions	196
	High risk species (A)	8
	Medium risk species (B)	3
	Number of potentially invasive introductions	14
3	**Forestry**	
	Invasive introductions	23 (52%)
	Number of introductions	44
	High risk species (A)	4
	Medium risk species (B)	2
	Number of potentially invasive introductions	20

Priority	Pathway	
4	**Agriculture**	
	Invasive introductions	34 (10%)
	Number of introductions	336
	High risk species (A)	0
	Medium risk species (B)	1
	Number of potentially invasive introductions	30
5	**Aquaculture**	
	Invasive introductions	16 (33%)
	Number of introductions	48
	High risk species (A)	3
	Medium risk species (B)	4
	Number of potentially invasive introductions	22
6	**Landscaping**	
	Invasive introductions	21 (47%)
	Number of introductions	45
	High risk species (A)	0
	Medium risk species (B)	2
	Number of potentially invasive introductions	9
7	**Ballast water & sediments**	
	Invasive introductions	7 (25%)
	Number of introductions	28
	High risk species (A)	2
	Medium risk species (B)	3
	Number of potentially invasive introductions	17
8	**Secondary introduction**	
	Invasive introductions	3 (43%)
	Number of introductions	7
	High risk species (A)	6
	Medium risk species (B)	7
	Number of potentially invasive introductions	5
9	**Escapes**	
	Invasive introductions	4 (31%)
	Number of introductions	13
	High risk species (A)	5
	Medium risk species (B)	6
	Number of potentially invasive introductions	3

In the Baltic region horticulture is also the main pathway of concern. The highest number of known introductions of both invasive and potentially invasive species to the Baltic region is introduced through horticulture (see chapter 4.2 *Invasiveness of introduced species*). It is also a pathway of importance for many of the taxonomic groups (see chapter 4.3 *Taxonomic groups of introduced species*), and is historically the most frequently used pathway for all three regions (see chapter 4.1 *Pathways of introduced species*). Furthermore, there has been an increase in introductions by horticulture in the Baltic region over the past 150 years (see chapter 4.4 *Temporal development of pathways*). Depending on the specific measures applied, management of horticulture may target a range

of high and medium risk species of angiosperms, arthropods, fungi, molluscs and nematodes (see appendix 11 and 12).

Transport is also a pathway of concern for the Baltic region, since there are a high number of introductions by transport (see chapter 4.1 *Pathways of introduced species)* and a high number of introductions of both invasive and potentially invasive species. It is also a pathway of importance for many of the taxonomic groups (see chapter 4.3 *Taxonomic groups of introduced species*). Furthermore, there has been an increase in introductions by transport to the Baltic region over the past 100 years (see chapter 4.4 *Temporal development of pathways*). As for horticulture, managing transport could target many high and medium risk *door knocker species* from the following groups: Amphibians, arthropods, fish, molluscs and parasitic nematodes.

Agriculture, forestry and landscaping are also pathways of concern for the Baltic region, based on the number of introductions of non-native species and the number of introductions of invasive and potentially invasive species. For all three pathways the number of registrations has increased over the past 100 years (see *chapter 4.4 Temporal development of pathways)*. Agriculture is a main pathway for many of the taxonomic groups, while forestry and landscape are mostly connected to species of angiosperms and coniferous plants (see chapter 4.3 *Taxonomic groups of introduced species*). Furthermore, the number of high and medium risk species that would most likely use these pathways has contributed to the prioritisation.

The pathway aquaculture is a pathway of concern, due to the number of introductions of invasive species, the number of introductions and the number of high and medium risk species. Furthermore, there are specific challenges in managing both marine and freshwater alien species when they are established, due to the limitations in eradication measures (see chapter 8 *Recommendations*).

Ballast water & sediments is already a pathway of concern on an international scale, and through implementation of the "International Convention for Control and Management of Ships' Ballast Water and Sediments" it will be a pathway where action has been taken.

For the Baltic region we have chosen to prioritize secondary introduction and escapes as pathways of concern, despite the low number of introduced alien species and invasive species. This is due to the high number of high and medium risk species that would most likely use these pathways for introduction (see appendix 11 and 12).

The registrations of *medicinal* has not been declining over time, but has been relatively static since the first registrations around 1750–1800. However, medicinal is not on the prioritised list of pathways for the Baltic region, due to the developments in the medical field that will most likely decrease the importance of the medicinal pathway, as for the Nordic region.

7.3 Islands of the North Atlantic Ocean

The prioritised list of pathways of concern for the islands of the North Atlantic Ocean is presented in table 23.

Table 23: Prioritised list of pathways of concern for the islands of the North Atlantic Ocean

Priority	Pathway	
1	**Horticulture**	
	Invasive introductions	3[10]
	Number of introductions	65
	High risk species (A)	0
	Medium risk species (B)	2
	Number of potentially invasive introductions	8
2	**Transport**	
	Invasive introductions	1
	Number of introductions	27
	High risk species (A)	1
	Medium risk species (B)	2
	Number of potentially invasive introductions	0
3	**Secondary introduction**	
	Invasive introductions	1
	Number of introductions	9
	High risk species (A)	1
	Medium risk species (B)	1
	Number of potentially invasive introductions	4
4	**Escapes**	
	Invasive introductions	1
	Number of introductions	3
	High risk species (A)	1
	Medium risk species (B)	0
	Number of potentially invasive introductions	1
5	**Ornamental**	
	Invasive introductions	0
	Number of introductions	1
	High risk species (A)	1
	Medium risk species (B)	0
	Number of potentially invasive introductions	1

Five pathways out of 14 registered pathways for the region are on the prioritised list. Horticulture has the highest number of introductions, invasive introductions and potentially invasive introductions, while transport has the second highest number of introductions, one high risk species and two medium risk species.

[10] The percentages of the registered introductions of each invasiveness category for each pathway have not been calculated for the islands of the North Atlantic Ocean, due to the small amount of data available for this region.

The pathways secondary introduction, escapes and ornamental have only few introductions, invasive introductions and potentially invasive introductions registered, but are present on the prioritised list due to the high risk *door knocker species* (see appendix 13). In Iceland, the current restrictions on import of all animals may prevent the introduction of high risk species that has escape and ornamental as a probable pathway.

8. Recommendations

8.1 Pathways of concern

In this chapter we present general recommendations for further work on reducing alien introductions by the pathways of concern (see chapter 7 prioritisation *of pathways)*. The recommendations are shown in table 24 and described afterwards.

Table 24: Recommendations for reducing alien introductions by pathways of concern

Challenges	Recommendations
All	Gathering of new knowledge Early warning system Horizon scannings on a regular basis
Intentional introductions	Restrictions on import and trade Restrictions on release Information campaigns
Unintentional introductions	Obligations to importers or exporters Restrictions on import Sample control or screening Quarantines Treatments
Secondary introduction	Early warning system Reduction of introductions in general Reduction of individuals introduced by other pathways
Marine ecosystems	Prevention of introduction by ballast water & sediments Reduction of introductions by angling/sport and aquaculture.

In the continuing work towards reducing alien introductions, new knowledge on alien species and pathways is needed to keep management initiatives up-to-date and effectful. Furthermore, an early warning system (see chapter 8.2 *Early warning system* later in the report) and completion of a horizon scanning on a regular basis are important tools for staying updated on potential threats.

This analysis shows that horticulture is the main pathway of concern in all three regions. Many alien species from different taxonomic groups are registered with horticulture as a pathway, and introductions by horticulture are registered as both intentional and unintentional. Another pathway of concern in all three regions seems to be transport, which is also registered as a pathway for many different taxonomic groups. The majority of the introductions by transport are registered as unintentional.

8.1.1 Intentional introductions

Reduction of intentional and unintentional introductions of alien species requires different measures. To reduce intentional introduction of invasive alien species, e.g. angiosperms and reptiles, a cost-effective measure can be implementation of restrictions on import and trade by implementing the EU regulations on invasive alien species. The restrictions can target certain non-native species that are known to be invasive in other parts of the world with a compatible climate, or species that have a habitat range that includes habitats found in the importing region. Restrictions on release of non-native organisms into the wild could benefit management if coupled with information campaigns regarding the probable negative impact of the species. Angling/sport, aquaculture, escapes, horticulture and landscaping are the pathways of concern that mostly facilitate intentional introductions.

8.1.2 Unintentional introductions

When reducing unintentional introductions, e.g. arthropods and molluscs by horticulture, other measures are appropriate. A way of reducing unintentional introductions is to impose obligations on importers or exporters of commodities. The obligations can be reduction or elimination of the species or groups of organisms of concern that can be found in certain commodities as stowaways. Another measure of reducing unintentional introductions can be restrictions of import of goods or organisms that can act as hosts or vectors of the species of concern. Also sample control or screening of imported commodities may reduce unintentional introduction, as well as imposing the use of quarantine when dealing with import of certain living organisms. Quarantine periods can also be coupled with treatment procedures for some goods or organisms, e.g. treatment of im-

ported wooden items to eradicate potential stowaways. Agriculture, aquaria, forestry, horticulture and transport are pathways of concern that mostly facilitate unintentional introductions.

8.1.3 Secondary introduction

Other pathways of concern may require other management measures. Secondary introduction of non-native species dispersing from neighbouring countries is challenging to reduce or prevent. This is due to the fact that the introduction can happen without human interference, and is therefore not a result of specific activities that can be targeted. With secondary introduction, an early warning system is a way of alerting other countries about possible introductions, so countermeasures can be implemented. Furthermore, keeping the overall number of introductions low, as well as the number of individuals, may reduce secondary introduction.

8.1.4 Marine ecosystems

Alien species in the marine ecosystem can be challenging to manage, because measures to control them after introduction are limited or non-existing. Therefore, prevention is the most appropriate tool for reducing introductions of marine alien species by ballast water & sediments and hull fouling, e.g. by ratifying and implementing the "International Convention for Control and Management of Ships' Ballast Water and Sediments", which focuses on preventing introduction of marine alien species. Further measures to reduce introduction of marine alien species might be reduction of introductions from angling/sport and aquaculture as mentioned above.

8.2 Early warning system

An early warning system for introductions of species can have a range of layers. The NOBANIS collaboration of 20 countries and territories has an early warning system with an alert mechanism, a database on introduced species, and mechanisms of dialogue with scientific experts, environmental managers and policy makers.

The alert mechanism is activated when a participating country becomes aware that a new alien species has been found in their country, and a warning is sent to the other participating countries and posted on the NOBANIS website. This is an efficient way for countries to warn and

inform each other of new species of concern, making it possible for the countries and territories to have a rapid response and to take measures to prevent the introduction and possible spread of high risk species.

Unlike the horizon scanning in this project, the early warning system in itself does not inform about the newly introduced species' ability to become established, become invasive or what the risks to biodiversity might be in the countries where it is not yet present. This is information that is necessary in order to assess the risks of an introduced species, what measures are possible and respond to the possible invasion in an effective and feasible way.

The NOBANIS database contains information on invasive alien species already present in the NOBANIS region. The information on alien species in the NOBANIS database includes: distribution, frequency, invasive status, pathway of introduction, reported impact and other relevant information. It is a dynamic database that is frequently updated and under continuous development. To keep the database updated, NOBANIS has been in close cooperation with scientific communities across Europe over the years. In this way the database is continuously updated and can improve our ability to predict if an alien species will become established and invasive, and assist the participating countries and territories in reducing introductions of the non-native species.

The NOBANIS contact persons in each of the participating countries or territories are scientific experts or environmental managers, and are able to act on incoming alerts. Also in the NOBANIS steering committee, researchers, environmental managers and policy makers form a network to actively integrate new knowledge in the management of alien species in the membering countries and territories across Europe.

On the basis of the horizon scanning in this report, new aspects of the alert mechanism might be relevant to implement. When communicating a species alert, the NOBANIS secretariat can inform the participating countries and territories about whether the new species is listed as a high or medium risk species in one of the regions. Furthermore, the species alert can contain information on where the introductions may occur and therefore where measures of prevention are appropriate.

Other parts of the NOBANIS collaboration can be improved. In the NOBANIS database there are challenges in standardization of the data, e.g. in the invasiveness status terminology, species names and species synonyms. To increase the standardization in the database a "Technical manual for the NOBANIS database" has been developed, where the protocols and standards for the data are described. Furthermore, the NOBANIS homepage and database is now undergoing improvement

during which some of the standardization challenges are handled, the update and search mechanisms are improved, and a range of other functions are improved or added.

To ensure that an early warning system is active in the future, we need to make sure that mechanisms of species alerts, the databases and continuous accumulation of relevant knowledge are active and contemporary. Furthermore, we need to maintain, and perhaps improve, the dialogue between the countries and territories, and between researchers, environmental managers and policy makers.

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10. Summary (NO)

En av de viktigste driverne bak tapet av biologisk mangfold er invaderende fremmede arter. For å planlegge kostnadseffektive tiltak for å hindre introduksjon av skadelige invaderende fremmede arter, må vi vite på hvilken måte de blir introdusert. Hittil har tiltak for å forhindre skade på naturlige miljøer og biologisk mangfold i de nordiske og baltiske landene, inkl. Island og Færøyene, i hovedsak har vært reaktive metoder basert på kunnskap om invaderende fremmede arter som allerede finnes. Denne tilnærmingen har vist seg å være en kostbar og ineffektiv måte å håndtere invaderende fremmede arter.

Forebygging av introduksjon av nye invaderende fremmede arter kan forbedres gjennom å samle ny kunnskap om invasive og potensielt invaderende arter og deres spredningsveier. Dette inkluderer også planlegging og gjennomføring av hensiktsmessige kontroll tiltak, slik som: overvåking, tidlig oppdagelse og varsling, og umiddelbar iverksettelse av tiltak mot arten.

Formålet med dette prosjektet var å gjennomføre en spredningsveianalyse og en "horizon scanning". Analysen ble gjort for å identifisere og prioritere spredningsveier i forhold til hvilke fremmede arter (særlig invasive fremmede arter) som har blitt innført til Norden og Baltikum, i tillegg til Island og Færøyene. "Horizon scanningen" ble gjennomført for å identifisere potensielle dørstokkarter som i fremtiden kan bli introdusert over de viktigste spredningsveiene.

NOBANIS Nettverket ble initiert med finansiering fra Nordisk ministerråd. NOBANIS databasen inneholder informasjon over fremmede arter i 20 land og territoriene i Nord- og Sentral-Europa, som har samarbeidet med å dele informasjon om fremmede arter. 10 av disse landene og territoriene har deltatt i dette prosjektet: Danmark, Estland, Færøyene, Finland, Island, Latvia, Litauen, Norge (inkludert Svalbard) og Sverige. Dataene i NOBANIS databasen har dannet grunnlaget for spredningsveianalysen, og hvert deltakende land har oppdatert sine nasjonale data med relevant informasjon ved hjelp av relevant litteratur og artikler, samt gjennom bruk av nasjonale eksperter.

Spredningsveianalysen og "horizon scanningen" i dette prosjektet er gjennomført på et regionalt nivå, hvor de deltakende land og territorier ble delt inn i tre regioner:

- En nordisk region bestående av Danmark, Finland, Norge og Sverige (for spredningsveianalysen også Svalbard).
- En baltisk region bestående av Estland, Latvia og Litauen.
- En region bestående av øyene i Nord-Atlanteren representert ved Island og Færøyene.

I tillegg inneholder spredningsveianalysen følgende delanalyser for de introduserte artene:

- Spredningsvei.
- Invasivitet.
- Taksonomiske gruppe.
- Utvikling av spredningsveien over tid.
- Opprinnelsesområde og spredningsvei.

Resultatene viste at den viktigste veien for introduksjon var hagebruk, etterfulgt av landbruk, transport, skogbruk og ballastvann og sedimenter, men det var variasjoner mellom regionene.

For å undersøke hvilke nye arter som kan bli introdusert og etablert i de tre regionene i fremtiden, ble en rekke potensielle dørstokkarter vurdert.

Eksperter fra de deltakende land og territorier vurderte listen over 414 potensielle dørstokkarter. Av de 414 artene, så ble 43 vurdert som arter med høy risiko og 78 som middels risiko i regionene.

I denne rapporten så blir også en prioritert liste over spredningsveier presentert, sammen med retningslinjer og generelle anbefalinger på mulige tiltak ovenfor ulike spredningsveier i regionen, samt råd for et tidlig varslingssystem.

11. Summary (FI)

Yksi keskeinen syy luonnon monimuotoisuuden vähenemiselle ovat haitalliset vieraslajit – Invasive Alien species (IAS), jotka leviävät ja aiheuttavat negatiivisia vaikutuksia kotoperäisille lajeille ja elinympäristöille. Haitallisten vieraslajien kustannustehokkaan torjunnan suunnittelu ja toteutus edellyttää sitä, että tiedämme mahdollisimman paljon niiden leviämisväylistä ja saapumistavoista.

Tähän mennessä torjuntatoimet haitallisten lajien biodiversiteettiin ja luonnonympäristöön kohdistuvien vaikutusten estämiseksi Pohjoismaissa ja Baltian maissa mukaan lukien Islanti ja Färsaaret on aloitettu ja toteutettu vasta kun lajit ovat jo saapuneet ja niiden vaikutukset on tunnistettu. Tämä lähestymistapa on sekä kallis että tehoton. Torjunnat tulisi aloittaa ennen kun lajit saapuvat ja muodostavat pysyvän kannan.

Uusien haitallisten vieraslajien saapuminen voidaan torjua tehokkaammin tunnistamalla ja keräämällä uutta tietoa haitallisista sekä tarkkailtavista ja paikallisesti haitallisista vieraslajeista sekä niiden leviämisväylistä. Lisäksi ennaltaehkäisy-, torjunta- ja valvontatoimet on suunniteltava ja toimeenpantava. Keskeisiä toimia ovat seuranta, ennakkovaroitus, aikainen havaitseminen ja haitallisen vieraslajin välitön poistaminen.

Tämän hankkeen tavoitteena oli tunnistaa ja asettaa tärkeysjärjestykseen leviämisväylät, joiden kautta haitalliset vieraslajit saapuvat Pohjoismaihin, Baltiaan sekä Islantiin ja Färsaariin. Toinen keskeinen tavoite oli kartoittaa ja tunnistaa (horizontal scanning) lajit, jotka ovat tulossa jo tunnistettujen tärkeiden leviämisväylien kautta.

NOBANIS-verkosto perustettiin Pohjoismaisen ministerineuvoston rahoituksella. NOBANIS tietokanta sisältää tietoja vieraslajeista 20 maasta ja alueesta Pohjois- ja Keski-Euroopassa. NOBANIS-verkostoon kuuluvat maat ovat tehneet yhteistyötä haitallisten vieraslajien aiheuttamien haittavaikutusten vähentämiseksi jakamalla toisilleen NOBANIS-tietokannan aineistoja vieraslajien esiintymisestä eri maissa.

Yhteensä 10 ”NOBANIS- maata” (Tanska, Eesti, Latvia, Liettua, Norja Suomi, Islanti ja Färsaaret (mukaan lukien Huippuvuoret) sekä Ruotsi osallistuivat hankkeeseen, jossa arvioitiin leviämisväyliä NOBANIS-tietokannan pohjalta. Nämä maat päivittivät tietokannan kansalliset lajitiedot keräämällä tietoja kirjallisuudesta ja ottamalla yhteyttä kansallisiin asiantuntijoihin.

Tässä projektissa tehdyt arviot toteutettiin kolmella eri alueella:

- Pohjoismaissa: Tanska, Suomi, Norja (mukaan lukien Huippuvuoret) ja Ruotsi.
- Baltian alue: Eesti, Latvia ja Liettua.
- Pohjoisatlantin saaret: Islanti ja Färsaaret.

Leviämisväyläselvitys koostui seuraavista osista:

- Saapuneiden lajien leviämisväylät.
- Saapuneiden lajien invasiivisuus.
- Saapuneiden lajien taksonomiset ryhmät.
- Leviämisväylien muutos ajassa.
- Lajien alkuperät ja saapumisreitit.

Leviämisväylien kartoitus osoitti, että vieraslajien keskeisin saapumisreitti on puutarhaviljely ja seuraavaksi tärkeimpiä ovat maatalous, liikenne, metsätalous ja painolastinvesi sekä sedimentit, mutta leviämisväylät vaihtelevat alueiden välillä.

Jotta voitaisiin ennakoida mahdolliset uudet vieraslajit, jotka ovat tulossa ja voisivat tulevaisuudessa muodostaa pysyvän kannan alueelle, kartoitettiin keskeiset leviämisväylät ja arvioitiin potentiaaliset uudet tulokkaat nk. ”door knocker species”. Osallistujamaiden asiantuntijat kartoittivat yhteensä 414 lajia, jotka voisivat aiheuttaa haittaa tulevaisuudessa. Näistä 43 lajia arvioitiin korkean riskin ja 78 keskimääräisen riskin lajeiksi.

Raportissa on luettelo haitallisten vieraslajien leviämisväylistä tärkeysjärjestyksessä ja siinä annetaan suosituksia sekä esitetään keinoja keskeisten Pohjoismaihin ja Baltian maihin suuntautuvien leviämisreittien valvomiseksi. Raportissa annetaan myös suosituksia alueellisen ennakkovaroitusjärjestelmän perustamiseksi.

Appendices

Appendix 1: Classification of pathways in Norway

Intentional introductions	Unintentional spread – from	Unintentional introductions – with
Aesthetic planting	Agriculture	Animal foodstuff
Animals used for increased possibilities of hunting and catching	Aquaculture	Ballast sand/soil
Biological pest control	Aquaria	Ballast water
For production of honey	Botanical gardens	Bark
Illegal dumping/ introduction into the wild	Construction and building	Construction materials
Management actions towards other species	Export/trade	Corn products
Plants used for shelter or shade	Fisheries	Dried fruit/fruit in general
Production of green decorations	Forestry	Filings
Restoration attempts	Garden centers	Fish
Species for cultivation, in gardens, indoors and game animals	Gardening	Food
	Greeneries	Goods from garden centers and nurseries
	Hunting and fishing	Holiday and leisure equipment
	Industry	Imported production material
	Leisure boats	Invertebrates
	Nurseries	Leisure boats
	Private gardens	Mammals
	Private individuals' activities	Masses
	Research	Means of transportation
	Secondary spread from neighboring countries	Nuts

Intentional introductions	Unintentional spread – from	Unintentional introductions – with
	Tourism	Soil
	Unknown pathway	Packaging
	Zoological gardens	Plants
		Plants from gardens
		Plants with soil/potted plants
		Private vehicles
		Processed wood
		Refugees from garden centers and nurseries
		Round timber without bark
		Seeds and cones etc.
		Ship fouling
		Textiles and shoes
		Trains
		Transport by road
		Timber
		Unknown
		Vegetables
		Wood chippings

Appendix 2: List of experts

List of experts / Horizon scanning		
Organism group	**Expert**	
Ants	Jes Søe Pedersen	Associate Professor, Department of Biology, University of Copenhagen, Denmark
Birds	Michael Borch Grell	Biologist, the Danish Nature Agency, Ministry of the Environment, Denmark
	Knud N. Flensted	Danish Ornithological Society, Denmark
Bryophytes	Tomas Hallingbäck	Co-chair of the IUCN Bryophytes specialist group, Swedish University of Agriculture, Sweden
	Ib Johnsen	Associate Professor, Ecology and Evolution, University of Copenhagen, Denmark
Crustaceans (marine/freshwater, crabs, crayfish, prawn, barnacles)	Matz Berggren	Researcher, Swedish University of Agricultural Sciences, Department of Aquatic Resources, Institute of Marine Research, Sweden
Crustaceans (marine, prawn, Amphipoda, crabs and tanaids)	Maiju Lehtiniemi	Senior Researcher, Finnish Environment Institute, Marine Research Center, Finland
Diptera	Øivind Gammelmo	Entomologist, BioFokus, Norway
Insects (Coleoptera, wasps & trips)	Karl H. Thunes	PhD, Norwegian Forest and Landscape Institute, Norway
Insects (Coleoptera, Lepidoptera and wasps)	Åke Lindelöw	Entomologist, Swedish University of Agricultural Sciences Department of ecology, Forest Entomology, Sweden
Invertebrates (marine, Chordates, Cnidarians and starfish)	Ole Secher Tendal	Emeritus, Natural History Museum of Denmark, Denmark
Fish (freshwater)	Odd Terje Sandlund	Research Director, Norwegian Institute for Nature Research, Department of Aquatic Ecology, Norway
Fish (marine, Nordic region)	Rupert M. Wienerroither	Senior Engineer, Institute of Marine Research, Bergen, Norway
	Kjell Nedreaas	Researcher, Institute of Marine Research, Bergen, Norway
Fish (marine)	Henrik Carl	Natural History Museum of Denmark, Denmark
Fungi (pathogenic and non-pathogenic, Nordic region)	Christian Lange	Natural History Museum of Denmark, Denmark

List of experts / Horizon scanning		
Organism group	**Expert**	
Fungi (non-pathogenic, Baltic region)	Teele Jairus	Researcher, Department of Botany, Institute of Ecology and Earth Sciences, University of Tartu, Estonia
	Inita Daniele	Head of Botanical department, mycologist, Museum of Natural History, Latvia
	Ernestas Kutorga	Vilnius University, Department of Botany and Genetics, Lithuania
Gastropoda (terrestrial)	Ted Von Proschwitz	Göteborgs Naturhistoriska Museum, Sweden
Lepidoptera	Jan Fischer Rasmussen	Biologist, Oddsherred Kommune, Denmark
Macroalgae	Ruth Nielsen	Lector emeritus, Natural History Museum of Denmark, Denmark
Mammals (Nordic region and IS & FO)	Thomas Secher Jensen	Researcher, Natural History Museum Aarhus, Denmark
Mammals	Linas Balčiauskas	Leading Researcher, Nature Research Centre, Laboratory of Mammalian Ecology, Lithuania
Molluscs (marine/freshwater, mussels and snails)	Kathe Jensen	Researcher, Natural History Museum of Denmark, Denmark
Nematodes (plant--parasitic nematodes)	Christer Magnusson	Senior Researcher, Norwegian Institute for Agriculture and Environmental Research, Norway
Nematodes (parasitic)	Tor Atle Mo	Head of Section of Parasitology, Norwegian Veterinary Institute, Norway
Reptiles and amphibians	Merike Linnamagi	Senior Officer, Ministry of Environment of Estonia, Estonia
	Thorbjørn Koch Christoffersen	The Danish Nature Agency, Ministry of the Environment, Denmark
Tanaids	Dr. Kim Larsen (DK)	Aquatic, Ecology and Evolution Department CIIMAR in Portugal
Vascular plants	Arto Kurtto	Curator, Finnish Museum of Natural History in Helsinki, Finland
	Paweł Wąsowicz	Botanist, the Icelandic Institute of Natural History, Iceland
Wasps	Lars Vilhelmsen	Associate Professor, the Natural History Museum of Denmark, Denmark

Appendix 3: Assessment scores and criteria

Assessment scores	
Score	**Description**
0	Not possible to assess
1	Low risk
2	Medium risk
3	High risk

Assessment criteria and scoring system for potential *door knocker species* not yet established in DK, FI, NO, SE, IS, FO, LV, LT & EE

Assessment form					
Species name					
Pathway of introduction					
Factor	*Assessment criteria*	*Score*			*Comments and/or references*
		DK, FI, NO & SE	*IS & FO*	*LV, LT & EE*	
Arriving	What is the possibility that the species will arrive?				
Establishment	What is the possibility that the species will become established?				
Impact assessment	Does the species pose a threat to biodiversity? Does the species pose a risk to human health? Does the species pose a risk regarding socio-economic concerns?				

Appendix 4: Temporal development of pathways in the Nordic region

Temporal development of pathways / Nordic region							
	Time periods						
Pathway	**1700–1750**	**1750–1800**	**1800–1850**	**1850–1900**	**1900–1950**	**1950–2000**	**2000–**
Agriculture	30	12	65	151	132	81	12
Angling/sport	0	0	2	8	4	16	5
Animal husbandry	0	0	1	1	2	3	0
Aquaculture	0	0	1	7	16	50	11
Aquaria	1	0	0	3	10	8	8
Ballast water & sediments	7	4	44	71	55	41	35
Biological control	0	0	0	1	0	6	1
Escapes	3	0	0	2	10	28	6
Fisheries	0	0	0	1	0	4	0
Forestry	0	5	15	39	40	97	13
Horticulture	40	39	140	336	403	515	131
Hull fouling	0	0	2	4	11	10	11
Hunting	1	0	0	2	6	6	2
Landscaping	4	4	9	24	28	19	39
Medicinal	13	8	10	17	10	4	0
Ornamental	0	0	1	3	5	7	4
Reintroduction	1	0	0	0	4	6	0
Secondary introduction	1	0	0	3	25	60	22
Transport	3	4	101	74	80	83	18
Not known	60	14	125	457	705	755	306
Total	*164*	*90*	*516*	*1,204*	*1,546*	*1,799*	*624*

Appendix 5: Temporal development of pathways in the Baltic region

Temporal development of pathways / Baltic region							
	Time periods						
Pathway	**1700–1750**	**1750–1800**	**1800–1850**	**1850–1900**	**1900–1950**	**1950–2000**	**2000–**
Agriculture	1	28	77	29	97	163	0
Angling/sport	0	0	0	0	0	0	0
Animal husbandry	0	0	0	0	0	5	0
Aquaculture	0	0	0	6	7	39	4
Aquaria	0	0	0	1	1	0	1
Ballast water & sediments	0	0	7	5	6	12	2
Biological control	0	0	0	0	0	1	0
Escapes	0	0	0	1	3	10	1
Fisheries	0	0	0	0	0	1	0
Forestry	0	4	11	5	7	16	0
Horticulture	4	108	154	81	97	213	2
Hull fouling	0	1	4	4	3	3	2
Hunting	0	0	0	1	2	1	0
Landscaping	0	3	0	10	8	28	0
Medicinal	0	7	7	6	5	8	0
Ornamental	0	1	1	1	4	13	0
Reintroduction	0	0	0	0	0	0	0
Secondary introduction	0	0	0	0	1	4	0
Transport	0	2	6	45	76	66	1
Not known	0	36	64	59	94	147	7
Total	*5*	*190*	*331*	*254*	*411*	*730*	*20*

Appendix 6: High risk species for all regions

Amphibia (Taxonomic group)

Species	Pathway
Alytes obstetricans	Secondary introduction, Transport

Angiosperms (Taxonomic group)

Species	Pathway
Amorpha fructicosa	Horticulture, Landscaping
Gunnera tinctoria	Horticulture
Pueraria montana var. lobata (Syn. P. lobata)	Horticulture, Agriculture, Transport

Arthropods / Prawn (Taxonomic group)

Species	Pathway
Palaemon macrodactylus	Ballast water & sediments, Secondary introduction

Arthropods / Amphipods (Taxonomic group)

Species	Pathway
Dikerogammarus villosus	Ballast water & sediments

Arthropods / Ants (Taxonomic group)

Species	Pathway
Lasius neglectus	Horticulture, Landscaping

Arthropods / Coleoptera (Taxonomic group)

Species	Pathway
Agrilus planipennis	Forestry
Diabrotica virgifera	Agriculture, Transport, Secondary introduction
Luperomorpha xanthodera	Horticulture
Otiorhynchus liguricus (Syn. O. salicicola)	Horticulture
Phloeosinus aubei	Horticulture
Phloeosinus rudis	Horticulture

Arthropods / Diptera (Taxonomic group)

Species	Pathway
Aedes albopictus	Transport
Coenosia attenuata	
Ochlerotatus japonicus	Transport

Arthropods / Freshwater crayfish (Taxonomic group)

Species	Pathway
Orconectes virilis	Aquaculture, Aquaria with Secondary introduction

Arthropods / Lepidoptera (Taxonomic group)

Species	Pathway
Dendrolimus sibiricus	Horticulture, Forestry

Arthropods / Marine crab (Taxonomic group)

Species	Pathway
Hemigrapsus penicillatus	Ballast water & sediments, Hull fouling, Secondary introduction
Hemigrapsus takanoi	Ballast water & sediments, Hull fouling, Secondary introduction
Hemigrapsus sanguineus	Ballast water & sediments, Hull fouling, Secondary introduction

Arthropods / Tanaidacea (Taxonomic group)

Species	Pathway
Sinelobus stanfordi	Ballast water & sediments, Hull fouling

Arthropods / Wasp (Taxonomic group)

Species	Pathway
Sirex ermak	Forestry, Transport, Seconday introduction
Vespa velutina	Seconday introduction, Transport

Birds (Taxonomic group)

Species	Pathway
Myiopsitta monachus	Escapes, Ornamental

Fish / Freshwater (Taxonomic group)

Species	Pathway
Ameiurus melas	Angling/sport, Aquaculture, Fisheries

Fungus / Pathogen (Taxonomic group)

Species	Pathway
Ceratocystis fagacearum	Forestry
Cryphonectria parasitica	Horticulture
Cryptostroma corticale	Forestry, Horticulture
Monilinia fructicola	Horticulture
splanchnonema platani	Horticulture

Mammal (Taxonomic group)

Species	Pathway
Callosciurus erythraeus	Secondary introduction, Escapes
Muntiacus reevesi	Escapes
Sciurus carolinensis	Ornamental, Escapes

Mollusca / Terrestrial gastropoda (Taxonomic group)

Species	Pathway
Tandonia budapestensis	Horticulture, Transport

Plant-parasitic nematode (Taxonomic group)

Species	Pathway
Meloidogyne chitwoodi	Horticulture
Meloidogyne fallax	Horticulture

Parasitic nematode (Taxonomic group)

Species	Pathway
Ashworthius sidemi	Animal husbandry
Bursaphelenchus xylophilus	Forestry, Transport

Reptilia (Taxonomic group)

Species	Pathway
Chelydra serpentina	Escapes
Chrysemys picta	Escapes
Graptemys pseudogeographica	Escapes
Macrochelys temminckii	Escapes

Appendix 7: Medium risk species for all regions

Amphibia (Taxonomic group)

Medium risk species (B) / All regions combined	
Species	**Pathway**
Bufo marinus	Escapes
Xenopus laevis	Escapes

Angiosperms (Taxonomic group)

Medium risk species (B) / All regions combined	
Species	**Pathway**
Acacia melanoxylon	Horticulture
Akebia quinata	Horticulture
Allium triquetrum	Horticulture
Amorpha fructicosa	Horticulture, Landscaping
Cortaderia selloana	Horticulture
Gaultheria mucronata (Syn. Pernettya mucronata)	Horticulture
Gymnocoronis spilanthoides	Aquaria
Hakea sericea	Landscaping, Horticulture
Hedychium gardnerianum	Horticulture
Hydrocotyle ranunculoides	Aquaria
Hygrophila polysperma	Aquaria
Imperata cylindrica	Horticulture
Lagarosiphon major	Aquaria
Lemna minuta	Aquaria
Libertia chilensis (Syn. Libertia Formosa)	Horticulture
Ligustrum lucidum	Horticulture
Ligustrum sinense	Horticulture
Morella faya	Horticulture
Myriophyllum aquaticum	Aquaria
Paulownia tomentosa	Horticulture
Phormium tenax	Horticulture
Pistia stratiotes	Aquaria
Pittosporum undulatum	Horticulture
Rhus radicans (Syn. Toxicodendron radicans)	Horticulture, Landscaping
Rosa bracteata	Horticulture
Sagittaria graminea	Aquaria
Sasa palmata	Horticulture
Sicyos angulatus	Agriculture, Horticulture
Spathodea campanulata	Horticulture

Arthropods / Ants (Taxonomic group)

Medium risk species (B) / All regions combined	
Species	**Pathway**
Lasius neglectus	Horticulture, Landscaping

Arthropods / Barnacles (Taxonomic group)

Medium risk species (B) / All regions combined	
Species	**Pathway**
Amphibalanus amphitrite	Hull fouling, Ballast water & sediments, Secondary introduction
Solidobalanus fallax	Hull fouling, Ballast water & sediments, Secondary introduction

Arthropods / Coleoptera (Taxonomic group)

Medium risk species (B) / All regions combined	
Species	**Pathway**
Agrilus anxius	Forestry
Epitrix tuberis	Horticulture

Arthropods / Diptera (Taxonomic groups)

Medium risk species (B) / All regions combined	
Species	**Pathway**
Aedes albopictus	Transport
Coenosia attenuata	
Drosophila suzukii	
Ochlerotatus japonicus	Transport
Rhagoletis cingulata	Horticulture

Athropods / Freshwater crayfish (Taxonomic group)

Medium risk species (B) / All regions combined	
Species	**Pathway**
Orconectes rusticus	Aquaculture, Aquaria with Secondary introduction
Procambarus clarkii	Aquaculture, aquaria, secondary introduction
Procambarus fallax f virginalis	Aquaria, Escapes

Athropods / Lepidoptera (Taxonomic group)

Medium risk species (B) / All regions combined	
Species	**Pathway**
Cacoecimorpha pronubana	Horticulture, Secondary introduction
Dendrolimus superans	Horticulture, Forestry
Hyphantria cunea	
Lymantria mathura	Horticulture, Forestry, Transport

Arthropods / Marine crab (Taxonomic group)

Medium risk species (B) / All regions combined	
Species	**Pathway**
Callinectes sapidus	Ballast water & sediments
Charybdis japonica	Ballast water & sediments, Secondary introduction

Arthropods / Marine prawn (Taxonomic group)

Medium risk species (B) / All regions combined	
Species	**Pathway**
Marsupenaeus japonicus	Aquaculture, Ballast water & sediments

Arthropods / Trips (Taxonomic group)

Medium risk species (B) / All regions combined	
Species	**Pathway**
Thrips palmi	Agriculture

Birds (Taxonomic group)

Medium risk species (B) / All regions combined	
Species	**Pathway**
Callonetta leucophrys	Escapes
Chrysolophus pictus	Hunting
Falco biarmicus	Escapes
Lophura nycthemera	Hunting
Nymphicus hollandicus	

Fish / Freshwater (Taxonomic group)

Medium risk species (B) / All regions combined	
Species	**Pathway**
Coregonus muksun	Aquaculture
Neogobius fluviatilis	Ballast water & sediments, Transport, Secondary introduction
Neogobius gymnotrachelus	Ballast water & sediments, Secondary introduction
Neogobius kessleri	Ballast water & sediments, Transport, Secondary introduction
Romanogobio belingi	

Fish / Marine (Taxonomic group)

Medium risk species (B) / All regions combined	
Species	**Pathway**
Anguilla rostrata	Fisheries, Aquaculture

Fungi (Taxonomic group)

Medium risk species (B) / All regions combined	
Species	**Pathway**
Gymnopus luxurians	Horticulture, Forestry
Panaeolus cyanescens	Horticulture, (Medicinal)
Psilocybe cubensis	Horticulture, (Medicinal)
Suillus placidus	Forestry, Horticulture, Secondary introduction

Fungus / Pathogen (Taxonomic group)

Medium risk species (B) / All regions combined	
Species	**Pathway**
Endocronartium harknessii	Forestry
Ophiostoma wageneri	Forestry

Mammal (Taxonomic group)

Medium risk species (B) / All regions combined	
Species	**Pathway**
Herpestes javanicus	Ornamental, Escapes
Mustela furo	Animal husbandry, Escapes

Mollusca / Marine mollusca (Taxonomic group)

Medium risk species (B) / All regions combined	
Species	**Pathway**
Musculista senhousia	Hull fouling, Secondary introduction

Mollusca / Marine snail (Taxonomic group)

Medium risk species (B) / All regions combined	
Species	**Pathway**
Rapana venosa	Aquaculture, Secondary introduction

Plant-parasitic nematode (Taxonomic group)

Medium risk species (B) / All regions combined	
Species	**Pathway**
Meloidogyne fallax	Horticulture

Parasitic Nematode (Taxonomic group)

Medium risk species (B) / All regions combined	
Species	**Pathway**
Ashworthius sidemi	Animal husbandry

Reptilia (Taxonomic group)

Medium risk species (B) / All regions combined	
Species	**Pathway**
Apalone spinifera	Ecapes
Boa constrictor imperator	Ecapes
Elaphe schrenckii	Escapes, Ornamental, Secondary introduction

Appendix 8: Species not assessed

Species not assessed / All regions combined	
Group	**Species**
Angiosperms	Verbena brasiliensis
Angiosperms	Sorghum x almum
Angiosperms	Cyperus esculentus
Angiosperms	Malus asiatica
Arthropods	Chelicorophium robustum
Arthropods	Crematogaster auberti
Arthropods	Crematogaster osakensis
Arthropods	Crematogaster rogenhoferi
Arthropods	Pheidole pallidula
Arthropods	Crematogaster auberti
Arthropods	Crematogaster osakensis
Arthropods	Crematogaster rogenhoferi
Arthropods	Pheidole pallidula
Arthropods	Anopheles quadrimaculatus
Arthropods	Aphidoletes abietis
Arthropods	Micropygus vagans
Arthropods	Tephritis praecox
Arthropods	Thoracochaeta johnsoni
Arthropods	Blepharipa schineri
Arthropods	Orconectes juvenilis
Arthropods	Ammothea hilgendorfi
Birds	Chloephaga picta
Bryozoan	Watersipora subtorquata
Bryozoan	Tricellaria inopinata
Bryozoan	Bugula stolonifera
Cnidarians	Garveia franciscana
Cnidarians	Blackfordia virginica
Fish/Marine	Platichthys stellatus
Fish/Marine	Sebastes schlegelii
Fish/Marine	Trinectes maculatus
Fish/Marine	Micropogonias undulatus
Fish/Marine	Paralichthys olivaceus
Macroalgae	Asperococcus scaber
Macroalgae	Botrytella pacifica
Macroalgae	Botrytella parva
Macroalgae	Caulerpa racemosa
Macroalgae	Codium fragile ssp. atlanticum
Macroalgae	Codium textile
Macroalgae	Corynophlaea verruculiformis
Macroalgae	Cryptonemia hibernica
Macroalgae	Goniotrichopsis sublittoralis
Macroalgae	Grateloupia subpectinata
Macroalgae	Myriactula areschougii
Macroalgae	Myriactula clandestina
Macroalgae	Polyopes lancifolius
Macroalgae	Polysiphonia atlantica
Macroalgae	Scytosiphon dotyi
Macroalgae	Solieria chordalis
Macroalgae	Ulva pertusa
Macroalgae	Asparagopsis armata
Macroalgae	Grateloupia doryphore (Syn. Grateloupia turuturu)

Species not assessed / All regions combined	
Group	**Species**
Mollusca	Rangia cuneata
Plant-parasitic nematode	Meloidogyne minor
Other Chordates	Corella eumyota
Other Chordates	Perophora japonica
Other Chordates	Didemnum vexillum
Other invertebrates	Celtodoryx ciocalyptoides
Sea urchins & starfish	Asterias amurensis

Appendix 9: High risk species for the Nordic region

Angiosperms (Taxonomic group)

High risk species (A) / Nordic region	
Species	**Pathway**
Gunnera tinctoria	Horticulture
Pueraria montana var. lobata (Syn. P. lobata)	Horticulture, Agriculture, Transport
Amorpha fructicosa	Horticulture, Landscaping

Arthropods / Prawn (Taxonomic group)

High risk species (A) / Nordic region	
Species	**Pathway**
Palaemon macrodactylus	Ballast water & sediments, Secondary introduction

Arthropods / Amphipods (Taxonomic group)

High risk species (A) / Nordic region	
Species	**Pathway**
Dikerogammarus villosus	Ballast water & sediments

Arthropods / Ants (Taxonomic group)

High risk species (A) / Nordic region	
Species	**Pathway**
Lasius neglectus	Horticulture, Landscaping

Arthropods / Coleoptera (Taxonomic group)

High risk species (A) / Nordic region	
Species	**Pathway**
Diabrotica virgifera	Agriculture, Transport, Secondary introduction
Agrilus planipennis	Forestry
Luperomorpha xanthodera	Horticulture
Otiorhynchus liguricus (Syn. O. salicicola)	Horticulture
Phloeosinus aubei	Horticulture
Phloeosinus rudis	Horticulture

Arthropods / Diptera (Taxonomic group)

High risk species (A) / Nordic region	
Species	**Pathway**
Aedes albopictus	Transport
Ochlerotatus japonicus	Transport
Coenosia attenuata	

Arthropods / Freshwater crayfish (Taxonomic group)

High risk species (A) / Nordic region	
Species	**Pathway**
Orconectes virilis	Aquaculture, Aquaria with Secondary introduction

Arthropods / Lepidoptera (Taxonomic group)

High risk species (A) / Nordic region	
Species	**Pathway**
Dendrolimus sibiricus	Horticulture, Forestry

Arthropods / Marine crab (Taxonomic group)

High risk species (A) / Nordic region	
Species	**Pathway**
Hemigrapsus penicillatus	Ballast water & sediments, Hull fouling, Secondary introduction
Hemigrapsus takanoi	Ballast water & sediments, Hull fouling, Secondary introduction
Hemigrapsus sanguineus	Ballast water & sediments, Hull fouling, Secondary introduction

Arthropods / Tanaidacea (Taxonomic groups)

High risk species (A) / Nordic region	
Species	**Pathway**
Sinelobus stanfordi	Ballast water & sediments, Hull fouling

Arthropods / Wasp (Taxonomic group)

High risk species (A) / Nordic region	
Species	**Pathway**
Sirex ermak	Forestry, Transport, Seconday introduction
Vespa velutina	Seconday introduction, Transport

Birds (Taxonomic group)

High risk species (A) / Nordic region	
Species	**Pathway**
Myiopsitta monachus	Escapes, Ornamental

Fish / Freshwater (Taxonomic group)

High risk species (A) / Nordic region	
Species	**Pathway**
Ameiurus melas	Angling/sport, Aquaculture, Fisheries

Fungus / Pathogen (Taxonomic group)

High risk species (A) / Nordic region	
Species	**Pathway**
Ceratocystis fagacearum	Forestry
Cryptostroma corticale	Forestry, Horticulture
Cryphonectria parasitica	Horticulture
Monilinia fructicola	Horticulture
Splanchnonema platani	Horticulture

Mammal (Taxonomic group)

High risk species (A) / Nordic region	
Species	**Pathway**
Muntiacus reevesi	Escapes
Callosciurus erythraeus	Secondary introduction, Escapes
Sciurus carolinensis	Ornamental, Escapes

Mollusca / Terrestrial gastropoda (Taxonomic group)

High risk species (A) / Nordic region	
Species	**Pathway**
Tandonia budapestensis	Horticulture, Transport

Plant-parasitic nematode (Taxonomic group)

High risk species (A) / Nordic region	
Species	**Pathway**
Meloidogyne chitwoodi	Horticulture
Meloidogyne fallax	Horticulture

Parasitic Nematode (Taxonomic group)

High risk species (A) / Nordic region	
Species	**Pathway**
Bursaphelenchus xylophilus	Forestry, Transport

Reptilia (Taxonomic group)

High risk species (A) / Nordic region	
Species	**Pathway**
Chelydra serpentina	Escapes
Chrysemys picta	Escapes
Graptemys pseudogeographica	Escapes
Macrochelys temminckii	Escapes

Appendix 10: Medium risk species for the Nordic region

Amphibial (Taxonomic group)

Medium risk species (B) / Nordic region	
Species	**Pathway**
Bufo marinus	Escapes
Xenopus laevis	Escapes

Angiosperms (Taxonomic group)

Medium risk species (B) / Nordic region	
Species	**Pathway**
Sicyos angulatus	Agriculture, Horticulture
Sagittaria graminea	Aquaria
Pistia stratiotes	Aquaria
Myriophyllum aquaticum	Aquaria
Lemna minuta	Aquaria
Lagarosiphon major	Aquaria
Hygrophila polysperma	Aquaria
Hydrocotyle ranunculoides	Aquaria
Gymnocoronis spilanthoides	Aquaria
Spathodea campanulata	Horticulture
Rosa bracteata	Horticulture
Pittosporum undulatum	Horticulture
Phormium tenax	Horticulture
Paulownia tomentosa	Horticulture
Morella faya	Horticulture
Ligustrum sinense	Horticulture
Ligustrum lucidum	Horticulture
Libertia chilensis (Syn Libertia Formosa)	Horticulture
Imperata cylindrica	Horticulture
Hedychium gardnerianum	Horticulture
Gaultheria mucronata (Syn. Pernettya mucronata)	Horticulture
Sasa palmata	Horticulture
Acacia melanoxylon	Horticulture
Akebia quinata	Horticulture
Allium triquetrum	Horticulture
Cortaderia selloana	Horticulture
Rhus radicans (Syn. Toxicodendron radicans)	Horticulture, Landscaping
Hakea sericea	Landscaping, Horticulture

Arthropods / Barnacles (Taxonomic group)

Medium risk species (B) / Nordic region	
Species	**Pathway**
Amphibalanus amphitrite	Hull fouling, Ballast water & sediments, Secondary introduction
Solidobalanus fallax	Hull fouling, Ballast water & sediments, Secondary introduction

Arthropods / Coleoptera (Taxonomic group)

Medium risk species (B) / Nordic region	
Species	**Pathway**
Agrilus anxius	Forestry
Epitrix tuberis	Horticulture

Arthropods / Coleoptera (Taxonomic group)

Medium risk species (B) / Nordic region	
Species	**Pathway**
Rhagoletis cingulata	Horticulture

Arthropods / Freshwater crayfish (Taxonomic group)

Medium risk species (B) / Nordic region	
Species	**Pathway**
Orconectes rusticus	Aquaculture, Aquaria with Secondary introduction
Procambarus clarkii	Aquaculture, aquaria, secondary introduction
Procambarus fallax f virginalis	Aquaria, Escapes

Arthropods / Lepidoptera (Taxonomic group)

Medium risk species (B) / Nordic region	
Species	**Pathway**
Dendrolimus superans	Horticulture, Forestry
Cacoecimorpha pronubana	Horticulture, Secondary introduction
Hyphantria cunea	

Arthropods / Marine crab (Taxonomic group)

Medium risk species (B) / Nordic region	
Species	**Pathway**
Charybdis japonica	Ballast water & sediments, Secondary introduction

Arthropods / Marine prawn (Taxonomic group)

Medium risk species (B) / Nordic region	
Species	**Pathway**
Marsupenaeus japonicus	Aquaculture, Ballast water & sediments

Arthropods / Trips (Taxonomic group)

Medium risk species (B) / Nordic region	
Species	**Pathway**
Thrips palmi	Agriculture

Birds (Taxonomic group)

Medium risk species (B) / Nordic region	
Species	**Pathway**
Callonetta leucophrys	Escapes
Falco biarmicus	Escapes
Chrysolophus pictus	Hunting
Lophura nycthemera	Hunting
Nymphicus hollandicus	

Fish / Freshwater (Taxonomic group)

Medium risk species (B) / Nordic region	
Species	**Pathway**
Coregonus muksun	Aquaculture
Neogobius kessleri	Ballast water & sediments, Transport, Secondary introduction

Fish / Marine (Taxonomic group)

Medium risk species (B) / Nordic region	
Species	**Pathway**
Anguilla rostrata	Fisheries, Aquaculture

Fungus (Taxonomic group)

Medium risk species (B) / Nordic region	
Species	**Pathway**
Suillus placidus	Forestry, Horticulture, Secondary introduction
Gymnopus luxurians	Horticulture, Forestry

Fungus / Pathogen (Taxonomic group)

Medium risk species (B) / Nordic region	
Species	**Pathway**
Endocronartium harknessii	Forestry
Ophiostoma wageneri	Forestry

Mammal (Taxonomic group)

Medium risk species (B) / Nordic region	
Species	**Pathway**
Mustela furo	Animal husbandry, Escapes
Herpestes javanicus	Ornamental, Escapes

Mollusca / Marine mollusca (Taxonomic group)

Medium risk species (B) / Nordic region	
Species	**Pathway**
Potamocorbula amurensis	Ballast water & sediments
Musculista senhousia	Hull fouling, Secondary introduction

Mollusca / Marine Snail (Taxonomic group)

Medium risk species (B) / Nordic region	
Species	**Pathway**
Rapana venosa	Aquaculture, Secondary introduction

Parasitic Nematode (Taxonomic group)

Medium risk species (B) / Nordic region	
Species	**Pathway**
Ashworthius sidemi	Animal husbandry

Reptilia (Taxonomic group)

Medium risk species (B) / Nordic region	
Species	**Pathway**
Apalone spinifera	Escapes
Boa constrictor imperator	Escapes
Elaphe schrenckii	Escapes, Ornamental, Secondary introduction

Appendix 11: High risk species for the Baltic region

Amphibia (Taxonomic group)

High risk species (A) / Baltic region	
Species	**Pathway**
Alytes obstetricans	Secondary introduction, Transport

Arthropods / Prawn (Taxonomic group)

High risk species (A) / Baltic region	
Species	**Pathway**
Palaemon macrodactylus	Ballast water & sediments, Secondary introduction

Arthropods / Amphipods (Taxonomic group)

High risk species (A) / Baltic region	
Species	**Pathway**
Dikerogammarus villosus	Ballast water & sediments

Arthropods / Coleoptera (Taxonomic group)

High risk species (A) / Baltic region	
Species	**Pathway**
Diabrotica virgifera	Agriculture, Transport, Secondary introduction
Agrilus planipennis	Forestry
Luperomorpha xanthodera	Horticulture
Otiorhynchus liguricus (Syn. O. salicicola)	Horticulture
Phloeosinus aubei	Horticulture
Phloeosinus rudis	Horticulture

Arthropods / Diptera (Taxonomic group)

High risk species (A) / Baltic region	
Species	**Pathway**
Aedes albopictus	Transport
Ochlerotatus japonicus	Transport
Coenosia attenuata	

Arthropods / Freshwater crayfish (Taxonomic group)

High risk species (A) / Baltic region	
Species	**Pathway**
Orconectes virilis	Aquaculture, Aquaria with Secondary introduction

Athropods / Lepidoptera (Taxonomic group)

High risk species (A) / Baltic region	
Species	**Pathway**
Dendrolimus sibiricus	Horticulture, Forestry

Arthropods / Wasp (Taxonomic group)

High risk species (A) / Baltic region	
Species	**Pathway**
Sirex ermak	Forestry, Transport, Seconday introduction
Vespa velutina	Seconday introduction, Transport

Fish / Freshwater (Taxonomic group)

High risk species (A) / Baltic region	
Species	**Pathway**
Ameiurus melas	Angling/sport, Aquaculture, Fisheries

Mammal (Taxonomic group)

High risk species (A) / Baltic region	
Species	**Pathway**
Sciurus carolinensis	Ornamental, Escapes

Mollusca / Terrestrial Gastropoda (Taxonomic group)

High risk species (A) / Baltic region	
Species	**Pathway**
Tandonia budapestensis	Horticulture, Transport

Plant-parasitic nematode (Taxonomic group)

High risk species (A) / Baltic region	
Species	**Pathway**
Meloidogyne chitwoodi	Horticulture

Parasitic Nematode (Taxonomic group)

High risk species (A) / Baltic region	
Species	**Pathway**
Ashworthius sidemi	Animal husbandry
Bursaphelenchus xylophilus	Forestry, Transport

Reptilia (Taxonomic group)

High risk species (A) / Baltic region	
Species	**Pathway**
Chelydra serpentina	Escapes
Macrochelys temminckii	Escapes
Chrysemys picta	Escapes
Graptemys pseudogeographica	Escapes

Appendix 12: Medium risk species for the Baltic region

Amphibia (Taxonomic group)

Medium risk species (B) / Baltic region	
Species	**Pathway**
Bufo marinus	Escapes
Xenopus laevis	Escapes

Angiosperms (Taxonomic group)

Medium risk species (B) / Baltic region	
Species	**Pathway**
Gymnocoronis spilanthoides	Aquaria
Gaultheria mucronata (Syn. Pernettya mucronata)	Horticulture
Cortaderia selloana	Horticulture
Amorpha fructicosa	Horticulture, Landscaping

Arthropods / Ants (Taxonomic group)

Medium risk species (B) / Baltic region	
Species	**Pathway**
Lasius neglectus	Horticulture, Landscaping

Athropods / Coleoptera (Taxonomic group)

Medium risk species (B) / Baltic region	
Species	**Pathway**
Epitrix tuberis	Horticulture

Arthropods / Diptera (Taxonomic group)

Medium risk species (B) / Baltic region	
Species	**Pathway**
Rhagoletis cingulata	Horticulture
Drosophila suzukii	
Coenosia attenuata	

Arthropods / Freshwater crayfish (Taxonomic group)

Medium risk species (B) / Baltic region	
Species	**Pathway**
Orconectes rusticus	Aquaculture, Aquaria with Secondary introduction
Procambarus clarkii	Aquaculture, aquaria, secondary introduction
Procambarus fallax f virginalis	Aquaria, Escapes

Arthropods / Lepidoptera (Taxonomic group)

Medium risk species (B) / Baltic region	
Species	**Pathway**
Dendrolimus superans	Horticulture, Forestry
Lymantria mathura	Horticulture, Forestry, Transport
Cacoecimorpha pronubana	Horticulture, Secondary introduction
Hyphantria cunea	

Arthropods / Trips (Taxonomic group)

Medium risk species (B) / Baltic region	
Species	**Pathway**
Thrips palmi	Agriculture

Birds (Taxonomic group)

Medium risk species (B) / Baltic region	
Species	**Pathway**
Chrysolophus pictus	Hunting
Nymphicus hollandicus	

Fish / Freshwater (Taxonomic group)

Medium risk species (B) / Baltic region	
Species	**Pathway**
Coregonus muksun	Aquaculture
Neogobius gymnotrachelus	Ballast water & sediments, Secondary introduction
Neogobius fluviatilis	Ballast water & sediments, Transport, Secondary introduction
Neogobius kessleri	Ballast water & sediments, Transport, Secondary introduction
Romanogobio belingi	

Fish / Marine (Taxonomic group)

Medium risk species (B) / Baltic region	
Species	**Pathway**
Anguilla rostrata	Fisheries, Aquaculture

Fungi (Taxonomic group)

Medium risk species (B) / Baltic region	
Species	**Pathway**
Panaeolus cyanescens	Horticulture, (Medicinal)
Psilocybe cubensis	Horticulture, (Medicinal)

Plant-parasitic nematode (Taxonomic group)

Medium risk species (B) / Baltic region	
Species	**Pathway**
Meloidogyne fallax	Horticulture

Reptilia (Taxonomic group)

Medium risk species (B) / Baltic region	
Species	**Pathway**
Boa constrictor imperator	Ecapes
Apalone spinifera	Ecapes
Elaphe schrenckii	Escapes, Ornamental, Secondary introduction

Appendix 13: High risk species for the Islands of the North Atlantic Ocean

Arthropods / Wasp (Taxonomic group)

High risk species (A) / Islands of the North Atlantic Ocean	
Species	**Pathway**
Vespa velutina	Seconday introduction, Transport

Mammal (Taxonomic group)

High risk species (A) / Islands of the North Atlantic Ocean	
Species	**Pathway**
Sciurus carolinensis	Ornamental, Escapes

Appendix 14: Medium risk species for the Islands of the North Atlantic Ocean

Angiosperms (Taxonomic group)

Medium risk species (B) / Islands of the North Atlantic Ocean	
Species	**Pathway**
Gaultheria mucronata (Syn. Pernettya mucronata)	Horticulture

Athropods / Barnacles (Taxonomic group)

Medium risk species (B) / Islands of the North Atlantic Ocean	
Species	**Pathway**
Solidobalanus fallax	Hull fouling, Ballast water & sediments, Secondary introduction

Arthropods / Diptera (Taxonomic group)

Medium risk species (B) / Islands of the North Atlantic Ocean	
Species	**Pathway**
Coenosia attenuata	
Aedes albopictus	Transport
Ochlerotatus japonicus	Transport
Drosophila suzukii	
Rhagoletis cingulata	Horticulture

Arthropods / Trips (Taxonomic group)

Medium risk species (B) / Islands of the North Atlantic Ocean	
Species	**Pathway**
Thrips palmi	Agriculture

Fish / Marine (Taxonomic group)

Medium risk species (B) / Islands of the North Atlantic Ocean	
Species	**Pathway**
Anguilla rostrata	Fisheries, Aquaculture

Appendix 15: Low risk species for the Nordic region

Amphibia (Taxonomic group)

Low risk species (C) / Nordic region	
Species	**Pathway**
Eleutherodactylus coqui	Transport
Osteopilus septentrionalis	Transport
Pelophylax bedriagae	Escapes

Angiosperms (Taxonomic group)

Low risk species (C) / Nordic region	
Species	**Pathway**
Zostera japonica	Transport
Ziziphus mauritiana	Horticulture, Agriculture
Vitex rotundifolia	Landscaping, Horticulture
Triadica sebifera	Horticulture
Solidago nemoralis	Horticulture, Landscaping
Sisyrinchium californicum	Horticulture
Sesbania punicea	Horticulture
Salvinia molesta	Aquaria
Psidium guajava	Agriculture
Prosopis glandulosa	Agriculture, Landscaping
Polygonum perfoliatum (Syn. Persicaria perfoliata)	Horticulture, Agriculture
Plantago serpentina	Agriculture
Paspalum distichum (Syn. Paspalum paspalodes)	Agriculture
Nassella trichotoma	Agriculture
Nassella neesiana	Horticulture
Myriophyllum heterophyllum	Aquaria
Mimosa pigra	Horticulture
Microstegium vimineum	Agriculture, Transport
Dolichandra unguis-cati (Syn. Macfadyena unguis-cati)	Horticulture
Ludwigia peploides	Aquaria
Ludwigia grandiflora	Aquaria
Juncus planifolius	
Ipomoea aquatica	Horticulture
Hydrocotyle ramiflora	
Hiptage benghalensis	Horticulture
Cyperus rotundus	Agriculture, Transport
Acacia dealbata	Horticulture
Acaena ovaliflolia	Horticulture
Alternanthera philoxeroides	Aquaria
Andropogon virginicus	Horticulture, Secondary introduction
Araujia sericifera	Horticulture
Ardisia elliptica	Horticulture
Artemisia tournefortiana	Agriculture, Forestry, Transport
Baccharis halimifolia	Horticulture, Secondary introduction
Calystegia inflate (Syn .C. sepium subsp. Americana)	Horticulture
Carpobrotus acinaciformis	Horticulture
Carpobrotus edulis	Horticulture
Cenchrus pauciflorus (Syn. Cenchrus pauciflorus, C. incertus)	Transport
Chromolaena odorata	
Clidemia hirta	Horticulture
Cuscuta tinei	Agriculture
Urtica cannabina	

Arthropods (Taxonomic group)

Low risk species (C) / Nordic region	
Species	**Pathway**
Crangonyx pseudogracilis	Ballast water & sediments
Linepithema humile	Horticulture, Landscaping
Wasmannia auropunctata	Horticulture, Landscaping
Balanus eburneus	Hull fouling, Secondary introduction
Balanus trigonus	Hull fouling, Ballast water & sediments, Secondary introduction
Balanus variegatus	Hull fouling, Secondary introduction
Megabalanus coccopoma	Hull fouling
Megabalanus tintinnabulum	Hull fouling
Megabalanus tulipiformis	Hull fouling
Dendroctonus ponderosae	Forestry
Enaphalodes rufulus	Forestry
Hesperophanes campestris	Forestry, Transport
Ips hauseri	Forestry
Ips pini	Forestry
Monochamus carolinensis	Forstry
Monochamus marmoratus	Forstry
Monochamus mutator	Forstry
Monochamus nitens	Forstry
Monochamus notatus	Forstry
Monochamus obtusus	Forstry
Monochamus scutellatus	Forstry
Oemona hirta	Forestry, Horticulture, Landscaping
Pissodes nemorensis	Forestry, Horticulture, Landscaping
Pissodes strobi	Forestry, Horticulture, Landscaping
Pissodes terminalis	Forestry, Horticulture, Landscaping
Popillia japonica	Horticulture
Saperda candida	Forestry, Horticulture, Landscaping
Scolytus moravitzi	Forestry
Tetropium gracilicorne	Forestry
Xylosandrus crassiusculus	Forestry, Horticulture, Landscaping
Braula schmitzi	
Rhagoletis fausta	Horticulture
Rhagoletis indifferens	Horticulture
Rhagoletis pomonella	Horticulture
Strobilomyia viaria	Transport
Potamon ibericum	Aquaculture, aquaria
Cherax destructor	Aquaculture, Aquaria with Secondary introduction
Cherax quadricarinatus	Aquaculture, Aquaria with Secondary introduction
Procambarus acutus	Aquaculture, aquaria, Angling/sport
Lymantria mathura	Horticulture, Forestry, Transport
Choristoneura fumiferana	Horticulture
Choristoneura occidentalis	Horticulture
Malacosoma americanum	Horticulture, Forestry
Malacosoma disstria	Horticulture, Forestry
Orgyia pseudotsugata	Horticulture, Forestry
Acleris gloverana	Horticulture, Landscaping
Acleris variana	Horticulture, Landscaping
Cydia prunivora	Horticulture, Landscaping
Spodoptera littoralis	Horticulture
Callinectes sapidus	Ballast water & sediments
Percnon gibbesi	Hull fouling, Ballast water & sediments, Secondary introduction
Portunus pelagicus	Hull fouling, Ballast water & sediments, Secondary introduction

Birds (Taxonomic group)

Low risk species (C) / Nordic region	
Species	**Pathway**
Psittacula eupatria	Escapes, Ornamental
Threskiornis aethiopicus	Escapes, Ornamental

Bryophytes (Taxonomic group)

Low risk species (C) / Nordic region	
Species	**Pathway**
Lophocolea semiteres	

Fish / Freshwater (Taxonomic group)

Low risk species (C) / Nordic region	
Species	**Pathway**
Neogobius fluviatilis	Ballast water & sediments, Transport, Secondary introduction
Neogobius gymnotrachelus	Ballast water & sediments, Secondary introduction
Romanogobio belingi	
Benthophilus durrelli	
Benthophilus nudus	
Catostomus commersonii	
Channa argus	Fisheries
Cichla ocellaris	
Clarias gariepinus	
Clupeonella tscharchalensis	
Cobitis bilineata	
Gambusia affinis	
Gambusia holbrooki	Biological control
Ictalurus punctatus	Aquaculture, Fisheries
Ictiobus niger	Aquaculture, Fisheries
Knipowitschia longecaudata	
Misgurnus anguillicaudatus	
Monopterus albus	
Neogobius gorlap	
Neogobius pallasi	
Parachondrostoma toxostoma	Angling/sport
Pimephales promelas	Angling/sport, Aquaria
Proterorhinus semilunaris	Ballast water & sediments, Transport, Secondary introduction
Pylodictis olivaris	

Fish / Marine (Taxonomic group)

Low risk species (C) / Nordic region	
Species	**Pathway**
Anguilla rostrata*	Fisheries, Aquaculture
Anguilla japonica	Fisheries, Aquaculture
Neogobius eurycephalus (Syn. Ponticola eurycephalus)	Ballast water & sediments
Siganus rivulatus	
Syngnathus nigrolineatus (Syn. Syngnathus abaster)	

Fungus (Taxonomic group)

Low risk species (C) / Nordic region	
Species	**Pathway**
Panaeolus cyanescens	Horticulture, (Medicinal)
Psilocybe cubensis	Horticulture, (Medicinal)
Clathrus ruber	Horticulture, Secondary introduction
Leucocoprinus straminellus	Horticulture
Suillus ochraceoroseus	Forestry, Horticulture, Secondary introduction

Fungus / Pathogen (Taxonomic group)

Low risk species (C) / Nordic region	
Species	**Pathway**
Atropellis pinicola	Forestry
Atropellis piniphila	Forestry
Chrysomyxa arctostaphyli	Forestry
Davidiella populorum	Forestry, Horticulture
Mycosphaerella laricis-leptolepidis	Forestry
Phellinus weirii	Forestry, Transport
Stegophora ulmea	Horticulture

Macroalgae (Taxonomic group)

Low risk species (C) / Nordic region	
Species	**Pathway**
Agardhiella subulata	
Grateloupia filicina	
Lomentaria hakodatensis	
Macrocystis pyrifera	
Undaria pinnatifida	Secondary introduction
Anotrichium furcellatum	
Antithamnion densum	
Antithamnionella spirographidis	
Antithamnionella ternifolia	
Caulacanthus ustulatus	
Colaconema dasyae	
Laurencia brongniartii	
Polysiphonia senticulosa	
Polysiphonia subtilissima	

Mammal (Taxonomic group)

Low risk species (C) / Nordic region	
Species	**Pathway**
Sus scrofa vittatus	Escapes, Hunting, Ornamental
Trichosurus vulpecula	Escapes
Tamias striatus	Ornamental
Sylvilagus floridanus	
Sciurus niger	
Sciurus anomalus	Ornamental, Escapes
Rusa timorensis	
Nasua nasua	Animal husbandry, Secondary introduction
Macropus rufogriseus	Escapes
Macaca fascicularis	Escapes
Callosciurus finlaysonii	Ornamental, Escapes
Axis axis	Ornamental, Escapes

Mollusca (Taxonomic group)

Low risk species (C) / Nordic region	
Species	**Pathway**
Brachidontes pharaonis	Hull fouling, Ballast water & sediments
Mercenaria mercenaria	Ballast water & sediments, Escapes
Ruditapes philippinarum	Aquaculture, Secondary introduction
Urosalpinx cinerea	Aquaculture, Secondary introduction
Corbicula fluminea	Ballast water & sediments, Aquaculture
Corbicula fluminalis	Hull fouling, Ballast water & sediments
Dreissena rostriformis bugensis	Ballast water & sediments, Secondary introduction
Crassostrea virginica	Mollusca
Ostrea chilensis	Aquaculture
Pinctada radiata	Aquaculture, Hull fouling
Euglandina rosea	
Chilostoma cingulatum gobanzi	Ornamental

Other Chordates (Taxonomic group)

Low risk species (C) / Nordic region	
Species	**Pathway**
Corella eumyota	Aquaculture, Hull fouling
Perophora japonica	Hull fouling

Reptilia (Taxonomic group)

Low risk species (C) / Nordic region	
Species	**Pathway**
Boiga irregularis	Escapes, Transport
Mauremys leprosa	Escapes, Ornamental

*Comment from expert: “the species spawns in the Sargasso Sea and will never become established in European waters”.

Appendix 16: Low risk species for the Baltic region

Amphibia (Taxonomic group)

Low risk species (C) / Baltic region	
Species	**Pathway**
Eleutherodactylus coqui	Transport
Osteopilus septentrionalis	Transport
Pelophylax bedriagae	Escapes

Angiosperms (Taxonomic group)

Low risk species (C) / Baltic region	
Species	**Pathway**
Zostera japonica	Transport
Ziziphus mauritiana	Horticulture, Agriculture
Vitex rotundifolia	Landscaping, Horticulture
Triadica sebifera	Horticulture
Spathodea campanulata	Horticulture
Solidago nemoralis	Horticulture, Landscaping
Sisyrinchium septentrionale	Horticulture
Sisyrinchium californicum	Horticulture
Sicyos angulatus	Agriculture, Horticulture
Sesbania punicea	Horticulture
Salvinia molesta	Aquaria
Sagittaria graminea	Aquaria
Rosa bracteata	Horticulture
Rhus radicans (Syn. Toxicodendron radicans)	Horticulture, Landscaping
Pueraria montana var. lobata (Syn. P. lobata)	Horticulture, Agriculture, Transport
Psidium guajava	Agriculture
Prosopis glandulosa	Agriculture, Landscaping
Polygonum perfoliatum (Syn. Persicaria perfoliata)	Horticulture, Agriculture
Plantago serpentina	Agriculture
Pittosporum undulatum	Horticulture
Pistia stratiotes	Aquaria
Phormium tenax	Horticulture
Paulownia tomentosa	Horticulture
Paspalum distichum (Syn. Paspalum paspalodes)	Agriculture
Nassella trichotoma	Agriculture
Nassella tenuissima	
Nassella neesiana	Horticulture
Myriophyllum heterophyllum	Aquaria
Myriophyllum aquaticum	Aquaria
Morella faya	Horticulture
Mimosa pigra	Horticulture
Microstegium vimineum	Agriculture, Transport
Dolichandra unguis-cati (Syn. Macfadyena unguis-cati)	Horticulture
Ludwigia peploides	Aquaria
Ludwigia grandiflora	Aquaria
Ligustrum sinense	Horticulture
Ligustrum lucidum	Horticulture
Libertia chilensis (Syn. Libertia Formosa)	Horticulture
Lemna minuta	Aquaria
Lagarosiphon major	Aquaria
Juncus planifolius	
Ipomoea aquatica	Horticulture
Imperata cylindrica	Horticulture
Hygrophila polysperma	Aquaria
Hydrocotyle ranunculoides	Aquaria
Hydrocotyle ramiflora	

Low risk species (C) / Baltic region	
Species	**Pathway**
Hiptage benghalensis	Horticulture
Hedychium gardnerianum	Horticulture
Hakea sericea	Landscaping, Horticulture
Gunnera tinctoria	Horticulture
Cyperus rotundus	Agriculture, Transport
Sasa palmata	Horticulture
Acacia dealbata	Horticulture
Acacia melanoxylon	Horticulture
Acaena ovaliflolia	Horticulture
Akebia quinata	Horticulture
Allium triquetrum	Horticulture
Alternanthera philoxeroides	Aquaria
Andropogon virginicus	Horticulture, Secondary introduction
Araujia sericifera	Horticulture
Ardisia elliptica	Horticulture
Artemisia tournefortiana	Agriculture, Forestry, Transport
Baccharis halimifolia	Horticulture, Secondary introduction
Calystegia inflate (Syn. C. sepium subsp. Americana)	Horticulture
Carpobrotus acinaciformis	Horticulture
Carpobrotus edulis	Horticulture
Cenchrus pauciflorus (Syn. Cenchrus pauciflorus, C. incertus)	Transport
Chromolaena odorata	
Clidemia hirta	Horticulture
Cuscuta tinei	Agriculture
Urtica cannabina	

Arthropods (Taxonomic group)

Low risk species (C) / Baltic region	
Species	**Pathway**
Crangonyx pseudogracilis	Ballast water & sediments
Linepithema humile	Horticulture, Landscaping
Wasmannia auropunctata	Horticulture, Landscaping
Amphibalanus amphitrite	Hull fouling, Ballast water & sediments, Secondary introduction
Balanus eburneus	Hull fouling, Secondary introduction
Balanus trigonus	Hull fouling, Ballast water & sediments; Secondary introduction
Balanus variegatus	Hull fouling, Secondary introduction
Megabalanus coccopoma	Hull fouling
Megabalanus tintinnabulum	Hull fouling
Megabalanus tulipiformis	Hull fouling
Solidobalanus fallax	Hull fouling, Ballast water & sediments, Secondary introduction
Agrilus anxius	Forestry
Dendroctonus ponderosae	Forestry
Enaphalodes rufulus	Forestry
Hesperophanes campestris	Forestry, Transport
Ips hauseri	Forestry
Ips pini	Forestry
Monochamus carolinensis	Forstry
Monochamus marmoratus	Forstry
Monochamus mutator	Forstry
Monochamus nitens	Forstry
Monochamus notatus	Forstry
Monochamus obtusus	Forstry
Monochamus scutellatus	Forstry
Oemona hirta	Forestry, Horticulture, Landscaping
Pissodes nemorensis	Forestry, Horticulture, Landscaping
Pissodes strobi	Forestry, Horticulture, Landscaping
Pissodes terminalis	Forestry, Horticulture, Landscaping
Popillia japonica	Horticulture

Low risk species (C) / Baltic region	
Species	**Pathway**
Saperda candida	Forestry, Horticulture, Landscaping
Scolytus moravitzi	Forestry
Tetropium gracilicorne	Forestry
Xylosandrus crassiusculus	Forestry, Horticulture, Landscaping
Braula schmitzi	
Rhagoletis fausta	Horticulture
Rhagoletis indifferens	Horticulture
Rhagoletis pomonella	Horticulture
Strobilomyia viaria	Transport
Potamon ibericum	Aquaculture, aquaria
Cherax destructor	Aquaculture, Aquaria with Secondary introduction
Cherax quadricarinatus	Aquaculture, Aquaria with Secondary introduction
Procambarus acutus	Aquaculture, aquaria, Angling/sport
Choristoneura fumiferana	Horticulture
Choristoneura occidentalis	Horticulture
Malacosoma americanum	Horticulture, Forestry
Malacosoma disstria	Horticulture, Forestry
Orgyia pseudotsugata	Horticulture, Forestry
Acleris gloverana	Horticulture, Landscaping
Acleris variana	Horticulture, Landscaping
Cydia prunivora	Horticulture, Landscaping
Spodoptera littoralis	Horticulture
Charybdis japonica	Ballast water & sediments, Secondary introduction
Hemigrapsus penicillatus	Ballast water & sediments, Hull fouling, Secondary introduction
Hemigrapsus takanoi	Ballast water & sediments, Hull fouling, Secondary introduction
Hemigrapsus sanguineus	Ballast water & sediments, Hull fouling, Secondary introduction
Percnon gibbesi	Hull fouling, Ballast water & sediments, Secondary introduction
Portunus pelagicus	Hull fouling, Ballast water & sediments, Secondary introduction
Marsupenaeus japonicus	Aquaculture, Ballast water & sediments
Sinelobus stanfordi	Ballast water & sediments, Hull fouling

Birds (Taxonomic group)

Low risk species (C) / Baltic region	
Species	**Pathway**
Callonetta leucophrys	Escapes
Lophura nycthemera	Hunting
Myiopsitta monachus	Escapes, Ornamental
Psittacula eupatria	Escapes, Ornamental
Threskiornis aethiopicus	Escapes, Ornamental

Bryophytes (Taxonomic group)

Low risk species (C) / Baltic region	
Species	**Pathway**
Lophocolea semiteres	

Fish / Freshwater (Taxonomic group)

Low risk species (C) / Baltic region	
Species	**Pathway**
Benthophilus durrelli	
Benthophilus nudus	
Catostomus commersonii	

Low risk species (C) / Baltic region	
Species	**Pathway**
Channa argus	Fisheries
Cichla ocellaris	
Clarias gariepinus	
Clupeonella tscharchalensis	
Cobitis bilineata	
Gambusia affinis	
Gambusia holbrooki	Biological control
Ictalurus punctatus	Aquaculture, Fisheries
Ictiobus niger	Aquaculture, Fisheries
Knipowitschia longecaudata	
Misgurnus anguillicaudatus	
Monopterus albus	
Neogobius gorlap	
Neogobius pallasi	
Parachondrostoma toxostoma	Angling/sport
Pimephales promelas	Angling/sport, Aquaria
Proterorhinus semilunaris	Ballast water & sediments, Transport, Secondary introduction
Pylodictis olivaris	

Fish / Marine (Taxonomic group)

Low risk species (C) / Baltic region	
Species	**Pathway**
Anguilla rostrata*	Fisheries, Aquaculture
Anguilla japonica	Fisheries, Aquaculture
Neogobius eurycephalus (Syn. Ponticola eurycephalus)	Ballast water & sediments
Siganus rivulatus	
Syngnathus nigrolineatus (Syn. Syngnathus abaster)	

Fungus (Taxonomic group)

Low risk species (C) / Baltic region	
Species	**Pathway**
Clathrus ruber	Horticulture, Secondary introduction
Gymnopus luxurians	Horticulture, Forestry
Leucocoprinus straminellus	Horticulture
Suillus ochraceoroseus	Forestry, Horticulture, Secondary introduction

Macroalgae (Taxonomic group)

Low risk species (C) / Baltic region	
Species	**Pathway**
Anotrichium furcellatum	
Antithamnion densum	
Antithamnionella spirographidis	
Antithamnionella ternifolia	
Caulacanthus ustulatus	
Colaconema dasyae	
Laurencia brongniartii	
Polysiphonia senticulosa	
Polysiphonia subtilissima	

Mammal (Taxonomic group)

Low risk species (C) / Baltic region	
Species	**Pathway**
Sus scrofa vittatus	Escapes, Hunting, Ornamental
Trichosurus vulpecula	Escapes
Tamias striatus	Ornamental
Sylvilagus floridanus	
Sciurus niger	
Sciurus anomalus	Ornamental, Escapes
Rusa timorensis	
Nasua nasua	Animal husbandry, Secondary introduction
Mustela furo	Animal husbandry, Escapes
Muntiacus reevesi	Escapes
Macropus rufogriseus	Escapes
Macaca fascicularis	Escapes
Herpestes javanicus	Ornamental, Escapes
Callosciurus finlaysonii	Ornamental, Escapes
Callosciurus erythraeus	Secondary introduction, Escapes
Axis axis	Ornamental, Escapes

Mollusca (Taxonomic group)

Low risk species (C) / Baltic region	
Species	**Pathway**
Mercenaria mercenaria	Ballast water & sediments, Escapes
Musculista senhousia	Hull fouling, Secondary introduction
Ruditapes philippinarum	Aquaculture, Secondary introduction
Rapana venosa	Aquaculture, Secondary introduction
Urosalpinx cinerea	Aquaculture, Secondary introduction
Dreissena rostriformis bugensis	Ballast water & sediments, Secondary introduction
Crassostrea virginica	
Ostrea chilensis	Aquaculture
Pinctada radiata	Aquaculture, Hull fouling
Euglandina rosea	
Chilostoma cingulatum gobanzi	Ornamental

Reptilia (Taxonomic group)

Low risk species (C) / Baltic region	
Species	**Pathway**
Boiga irregularis	Escapes, Transport
Mauremys leprosa	Escapes, Ornamental

*Comment from expert: “the species spawns in the Sargasso Sea and will never become established in European waters”.

Appendix 17: Low risk species for the Islands of the North Atlantic Ocean

Amphibia (Taxonomic group)

Low risk species (C) / Islands of the North Atlantic Ocean	
Species	**Pathway**
Alytes obstetricans	Secondary introduction, Transport
Bufo marinus	Escapes
Xenopus laevis	Escapes
Eleutherodactylus coqui	Transport
Osteopilus septentrionalis	Transport
Pelophylax bedriagae	Escapes

Angiosperms (Taxonomic group)

Low risk species (C) / Islands of the North Atlantic Ocean	
Species	**Pathway**
Gymnocoronis spilanthoides	Aquaria
Amorpha fructicosa	Horticulture, Landscaping
Cortaderia selloana	Horticulture
Zostera japonica	Transport
Ziziphus mauritiana	Horticulture, Agriculture
Vitex rotundifolia	Landscaping, Horticulture
Triadica sebifera	Horticulture
Spathodea campanulata	Horticulture
Solidago nemoralis	Horticulture, Landscaping
Sisyrinchium septentrionale	Horticulture
Sisyrinchium californicum	Horticulture
Sicyos angulatus	Agriculture, Horticulture
Sesbania punicea	Horticulture
Salvinia molesta	Aquaria
Sagittaria graminea	Aquaria
Rosa bracteata	Horticulture
Rhus radicans (Syn. Toxicodendron radicans)	Horticulture, Landscaping
Pueraria montana var. lobata (Syn. P. lobata)	Horticulture, Agriculture, Transport
Psidium guajava	Agriculture
Prosopis glandulosa	Agriculture, Landscaping
Polygonum perfoliatum (Syn. Persicaria perfoliata)	Horticulture, Agriculture
Plantago serpentina	Agriculture
Pittosporum undulatum	Horticulture
Pistia stratiotes	Aquaria
Phormium tenax	Horticulture
Paulownia tomentosa	Horticulture
Paspalum distichum (Syn. Paspalum paspalodes)	Agriculture
Nassella trichotoma	Agriculture
Nassella tenuissima	
Nassella neesiana	Horticulture
Myriophyllum heterophyllum	Aquaria
Myriophyllum aquaticum	Aquaria
Morella faya	Horticulture
Mimosa pigra	Horticulture
Microstegium vimineum	Agriculture, Transport
Dolichandra unguis-cati (Syn. Macfadyena unguis-cati)	Horticulture
Ludwigia peploides	Aquaria
Ludwigia grandiflora	Aquaria
Ligustrum sinense	Horticulture
Ligustrum lucidum	Horticulture
Libertia chilensis (Syn. Libertia formosa)	Horticulture

Low risk species (C) / Islands of the North Atlantic Ocean	
Species	**Pathway**
Lemna minuta	Aquaria
Lagarosiphon major	Aquaria
Juncus planifolius	
Ipomoea aquatica	Horticulture
Imperata cylindrica	Horticulture
Hygrophila polysperma	Aquaria
Hydrocotyle ranunculoides	Aquaria
Hydrocotyle ramiflora	
Hiptage benghalensis	Horticulture
Hedychium gardnerianum	Horticulture
Hakea sericea	Landscaping, Horticulture
Gunnera tinctoria	Horticulture
Cyperus rotundus	Agriculture, Transport
Sasa palmata	Horticulture
Acacia dealbata	Horticulture
Acacia melanoxylon	Horticulture
Acaena ovaliflolia	Horticulture
Akebia quinata	Horticulture
Allium triquetrum	Horticulture
Alternanthera philoxeroides	Aquaria
Andropogon virginicus	Horticulture, Secondary introduction
Araujia sericifera	Horticulture
Ardisia elliptica	Horticulture
Artemisia tournefortiana	Agriculture, Forestry, Transport
Baccharis halimifolia	Horticulture, Secondary introduction
Calystegia inflata (Syn.C. sepium subsp. Americana)	Horticulture
Carpobrotus acinaciformis	Horticulture
Carpobrotus edulis	Horticulture
Cenchrus pauciflorus (Syn. Cenchrus pauciflorus, C. incertus)	Transport
Chromolaena odorata	
Clidemia hirta	Horticulture
Cuscuta tinei	Agriculture
Urtica cannabina	

Arthropods (Taxonomic group)

Low risk species (C) / Islands of the North Atlantic Ocean	
Species	**Pathway**
Palaemon macrodactylus	Ballast water & sediments, Secondary introduction
Dikerogammarus villosus	Ballast water & sediments
Lasius neglectus	Horticulture, Landscaping
Linepithema humile	Horticulture, Landscaping
Wasmannia auropunctata	Horticulture, Landscaping
Amphibalanus amphitrite	Hull fouling, Ballast water & sediments, Secondary introduction
Balanus eburneus	Hull fouling, Secondary introduction
Balanus trigonus	Hull fouling, Ballast water & sediments; Secondary introduction
Balanus variegatus	Hull fouling, Secondary introduction
Megabalanus coccopoma	Hull fouling
Megabalanus tintinnabulum	Hull fouling
Megabalanus tulipiformis	Hull fouling
Agrilus planipennis	Forestry
Diabrotica virgifera	Agriculture, Transport, Secondary introduction
Luperomorpha xanthodera	Horticulture
Otiorhynchus liguricus (Syn. O. salicicola)	Horticulture
Phloeosinus aubei	Horticulture
Phloeosinus rudis	Horticulture
Epitrix tuberis	Horticulture
Agrilus anxius	Forestry
Dendroctonus ponderosae	Forestry

Low risk species (C) / Islands of the North Atlantic Ocean	
Species	**Pathway**
Enaphalodes rufulus	Forestry
Hesperophanes campestris	Forestry, Transport
Ips hauseri	Forestry
Ips pini	Forestry
Monochamus carolinensis	Forstry
Monochamus marmoratus	Forstry
Monochamus mutator	Forstry
Monochamus nitens	Forstry
Monochamus notatus	Forstry
Monochamus obtusus	Forstry
Monochamus scutellatus	Forstry
Oemona hirta	Forestry, Horticulture, Landscaping
Pissodes nemorensis	Forestry, Horticulture, Landscaping
Pissodes strobi	Forestry, Horticulture, Landscaping
Pissodes terminalis	Forestry, Horticulture, Landscaping
Popillia japonica	Horticulture
Saperda candida	Forestry, Horticulture, Landscaping
Scolytus moravitzi	Forestry
Tetropium gracilicorne	Forestry
Xylosandrus crassiusculus	Forestry, Horticulture, Landscaping
Braula schmitzi	
Rhagoletis fausta	Horticulture
Rhagoletis indifferens	Horticulture
Rhagoletis pomonella	Horticulture
Strobilomyia viaria	Transport
Potamon ibericum	Aquaculture, aquaria
Orconectes virilis	Aquaculture, Aquaria with Secondary introduction
Procambarus fallax f virginalis	Aquaria, Escapes
Procambarus clarkii	Aquaculture, aquaria, secondary introduction
Orconectes rusticus	Aquaculture, Aquaria with Secondary introduction
Cherax destructor	Aquaculture, Aquaria with Secondary introduction
Cherax quadricarinatus	Aquaculture, Aquaria with Secondary introduction
Procambarus acutus	Aquaculture, aquaria, Angling/sport
Dendrolimus sibiricus	Horticulture, Forestry
Hyphantria cunea	
Cacoecimorpha pronubana	Horticulture, Secondary introduction
Dendrolimus superans	Horticulture, Forestry
Lymantria mathura	Horticulture, Forestry, Transport
Choristoneura fumiferana	Horticulture
Choristoneura occidentalis	Horticulture
Malacosoma americanum	Horticulture, Forestry
Malacosoma disstria	Horticulture, Forestry
Orgyia pseudotsugata	Horticulture, Forestry
Acleris gloverana	Horticulture, Landscaping
Acleris variana	Horticulture, Landscaping
Cydia prunivora	Horticulture, Landscaping
Spodoptera littoralis	Horticulture
Callinectes sapidus	Ballast water & sediments
Charybdis japonica	Ballast water & sediments, Secondary introduction
Hemigrapsus penicillatus	Ballast water & sediments, Hull fouling, Secondary introduction
Hemigrapsus takanoi	Ballast water & sediments, Hull fouling, Secondary introduction
Hemigrapsus sanguineus	Ballast water & sediments, Hull fouling, Secondary introduction
Percnon gibbesi	Hull fouling, Ballast water & sediments, Secondary introduction
Portunus pelagicus	Hull fouling, Ballast water & sediments, Secondary introduction
Marsupenaeus japonicus	Aquaculture, Ballast water & sediments
Sinelobus stanfordi	Ballast water & sediments, Hull fouling
Sirex ermak	Forestry, Transport, Seconday introduction

Birds (Taxonomic group)

Low risk species (C) / Islands of the North Atlantic Ocean	
Species	**Pathway**
Chrysolophus pictus	Hunting
Nymphicus hollandicus	
Callonetta leucophrys	Escapes
Lophura nycthemera	Hunting
Myiopsitta monachus	Escapes, Ornamental
Psittacula eupatria	Escapes, Ornamental
Threskiornis aethiopicus	Escapes, Ornamental

Bryophytes (Taxonomic group)

Low risk species (C) / Islands of the North Atlantic Ocean	
Species	**Pathway**
Lophocolea semiteres	

Fish / Freshwater (Taxonomic group)

Low risk species (C) / Islands of the North Atlantic Ocean	
Species	**Pathway**
Ameiurus melas	Angling/sport, Aquaculture, Fisheries
Coregonus muksun	Aquaculture
Neogobius fluviatilis	Ballast water & sediments, Transport, Secondary introduction
Neogobius gymnotrachelus	Ballast water & sediments, Secondary introduction
Neogobius kessleri	Ballast water & sediments, Transport, Secondary introduction
Romanogobio belingi	
Benthophilus durrelli	
Benthophilus nudus	
Catostomus commersonii	
Channa argus	Fisheries
Cichla ocellaris	
Clarias gariepinus	
Clupeonella tscharchalensis	
Cobitis bilineata	
Gambusia affinis	
Gambusia holbrooki	Biological control
Ictalurus punctatus	Aquaculture, Fisheries
Ictiobus niger	Aquaculture, Fisheries
Knipowitschia longecaudata	
Misgurnus anguillicaudatus	
Monopterus albus	
Neogobius gorlap	
Neogobius pallasi	
Parachondrostoma toxostoma	Angling/sport
Pimephales promelas	Angling/sport, Aquaria
Proterorhinus semilunaris	Ballast water & sediments, Transport, Secondary introduction
Pylodictis olivaris	

Fish / Marine (Taxonomic group)

Low risk species (C) / Islands of the North Atlantic Ocean	
Species	**Pathway**
Anguilla rostrata*	Fisheries, Aquaculture
Anguilla japonica	Fisheries, Aquaculture
Neogobius eurycephalus (Syn. Ponticola eurycephalus)	Ballast water & sediments
Siganus rivulatus	
Syngnathus nigrolineatus (Syn. Syngnathus abaster)	

Macroalgae (Taxonomic group)

Low risk species (C) / Islands of the North Atlantic Ocean	
Species	**Pathway**
Agardhiella subulata	
Grateloupia filicina	
Macrocystis pyrifera	
Undaria pinnatifida	Secondary introduction
Anotrichium furcellatum	
Antithamnion densum	
Antithamnionella spirographidis	
Antithamnionella ternifolia	
Caulacanthus ustulatus	
Colaconema dasyae	
Laurencia brongniartii	
Polysiphonia senticulosa	
Polysiphonia subtilissima	

Mammal (Taxonomic group)

Low risk species (C) / Islands of the North Atlantic Ocean	
Species	**Pathway**
Sus scrofa vittatus	Escapes, Hunting, Ornamental
Trichosurus vulpecula	Escapes
Tamias striatus	Ornamental
Sylvilagus floridanus	
Sciurus niger	
Sciurus anomalus	Ornamental, Escapes
Rusa timorensis	
Nasua nasua	Animal husbandry, Secondary introduction
Mustela furo	Animal husbandry, Escapes
Muntiacus reevesi	Escapes
Macropus rufogriseus	Escapes
Macaca fascicularis	Escapes
Herpestes javanicus	Ornamental, Escapes
Callosciurus finlaysonii	Ornamental, Escapes
Callosciurus erythraeus	Secondary introduction, Escapes
Axis axis	Ornamental, Escapes

Mollusca (Taxonomic group)

Low risk species (C) / Islands of the North Atlantic Ocean	
Species	**Pathway**
Mercenaria mercenaria	Ballast water & sediments, Escapes
Musculista senhousia	Hull fouling, Secondary introduction
Ruditapes philippinarum	Aquaculture, Secondary introduction
Rapana venosa	Aquaculture, Secondary Introduction
Urosalpinx cinerea	Aquaculture, Secondary introduction
Dreissena rostriformis bugensis	Ballast water & sediments, Secondary introduction
Crassostrea virginica	Mollusca
Ostrea chilensis	Aquaculture
Pinctada radiata	Aquaculture, Hull fouling
Tandonia budapestensis	Horticulture, Transport
Euglandina rosea	
Chilostoma cingulatum gobanzi	Ornamental

Parasitic Nematode (Taxonomic group)

Low risk species (C) / Islands of the North Atlantic Ocean	
Species	**Pathway**
Ashworthius sidemi	Animal husbandry
Bursaphelenchus xylophilus	Forestry, Transport

Reptilia (Taxonomic group)

Low risk species (C) / Islands of the North Atlantic Ocean	
Species	**Pathway**
Chelydra serpentina	Escapes
Macrochelys temminckii	Escapes
Chrysemys picta	Escapes
Graptemys pseudogeographica	Escapes
Boa constrictor imperator	Ecapes
Apalone spinifera	Ecapes
Elaphe schrenckii	Escapes, Ornamental, Secondary introduction
Boiga irregularis	Escapes, Transport
Mauremys leprosa	Escapes, Ornamental

*Comment from expert: “the species spawns in the Sargasso Sea and will never become established in European waters”.

Appendix 18: List of potential door knocker species

Amphibian (Taxonomic group)

Potential door knocker species / Horizon scanning		
Species name	**Family name**	**Order**
Alytes obstetricans	Discoglossidae	-
Bufo marinus	Bufonidae	-
Eleutherodactylus coqui	Leptodactylidae	-
Osteopilus septentrionalis	Hylidae	-
Pelophylax bedriagae	Ranidae	-
Xenopus laevis	Pipidae	-

Angiosperms (Taxonomic group)

Potential door knocker species / Horizon scanning		
Species name	**Family name**	**Order**
Acacia dealbata	Fabaceae	-
Acacia melanoxylon	Fabaceae	-
Acaena ovaliflolia	Rosaceae	-
Akebia quinata	Lardizabalaceae	-
Allium triquetrum	Alliaceae	-
Alternanthera philoxeroides	Amaranthaceae	-
Amorpha fructicosa*	Fabaceae	-
Andropogon virginicus	Poaceae	-
Araujia sericifera	Apocynaceae	-
Ardisia elliptica	Myrsinaceae	-
Artemisia tournefortiana*	Asteraceae	-
Baccharis halimifolia	Asteraceae	-
Calystegia inflata	Convolvulaceae	-
Carpobrotus acinaciformis	Aizoaceae	-
Carpobrotus edulis*	Aizoaceae	-
Cenchrus pauciflorus	Poaceae	-
Chromolaena odorata	Asteraceae	-
Clidemia hirta	Melastromataceae	-
Cortaderia selloana	Poaceae	-
Crepis aurea	Asteraceae	-
Cuscuta tinei	Cuscutaceae	-
Cyperus esculentus	Cyperaceae	-
Cyperus rotundus	Cyperaceae	-
Gaultheria mucronata	Ericacea	-
Gunnera tinctoria	Gunneraceae	-
Gymnocoronis spilanthoides	Asteraceae	-
Hakea sericea	Proteaceae	-
Hedychium gardnerianum	Asteraceae	-
Hiptage benghalensis	Malpighiaceae	-
Hydrocotyle ramiflora	Apiaceae	-
Hydrocotyle ranunculoides	Apiaceae	-
Hygrophila polysperma	Acanthaceae	-
Imperata cylindrica	Poaceae	-
Ipomoea aquatica	Convolvulaceae	-
Juncus planifolius	Juncacea	-
Lagarosiphon major	Hydrocharitaceae	-
Lemna minuta*	Lemnaceae	-
Libertia formosa	Iridacea	-
Ligustrum lucidum	Oleaceae	-
Ligustrum sinense	Oleaceae	-
Ludwigia grandiflora	Onagraceae	-
Ludwigia peploides	Onagraceae	-
Macfadyena unguis-cati	Bignoniaceae	-

Potential door knocker species / Horizon scanning		
Species name	**Family name**	**Order**
Malus asiatica	Rosaceae	-
Microstegium vimineum	Poaceae	-
Mimosa pigra	Fabaceae	-
Morella faya	Myricaceae	-
Myriophyllum aquaticum	Haloragaceae	-
Myriophyllum heterophyllum	Haloragaceae	-
Nassella neesiana	Poaceae	-
Nassella tenuissima	Poaceae	-
Nassella trichotoma	Poaceae	-
Paspalum paspalodes	Poaceae	-
Paulownia tomentosa	Scruphulariaceae	-
Phormium tenax	Xanthorrhoeaceae	-
Pistia stratiotes*	Araceae	-
Pittosporum undulatum	Pittosporaceae	-
Plantago serpentina	Plantaginaceae	-
Polygonum perfoliatum	Polygonaceae	-
Prosopis glandulosa	Fabaceae	-
Psidium guajava	Myrtaceae	-
Pueraria lobata	Fabaceae	-
Rhus radicans	Anacardiaceae	-
Rosa bracteata	Rosacea	-
Sagittaria graminea	Alismataceae	-
Salvinia molesta	Salviniaceae	-
Sasa palmata	Poaceae	-
Sesbania punicea	Fabaceae	-
Sicyos angulatus*	Cucurbitaleae	-
Sisyrinchium californicum	Iridacea	-
Sisyrinchium septentrionale	Iridaceae	-
Solidago nemoralis	Asteraceae	-
Sorghum x almum	Poaceae	-
Spathodea campanulata	Bignoniaceae	-
Triadica sebifera	Euphorbiaceae	-
Urtica cannabina	Urticaceae	-
Verbena brasiliensis	Verbenaceae	-
Vitex rotundifolia	Lamiaceae	-
Ziziphus mauritiana	Rhamnaceae	-
Zostera japonica	Zosteraceae	-

Annelids (Taxonomic group)

Potential door knocker species / Horizon scanning		
Species name	**Family name**	**Order**
Hydroides dianthus	Serpulidae	-
Hydroides elegans	Serpulidae	-
Hydroides ezoensis	Serpulidae	-
Sabella spallanzanii	Sabellidae	-

Arthropods (Taxonomic group)

Potential door knocker species / Horizon scanning		
Species name	**Family name**	**Order**
Crematogaster auberti	Formicidae	Hymenoptera
Crematogaster osakensis	Formicidae	Hymenoptera
Crematogaster rogenhoferi	Formicidae	Hymenoptera
Lasius neglectus	Formicidae	Hymenoptera
Linepithema humile	Formicidea	Hymenoptera

Potential door knocker species / Horizon scanning		
Species name	**Family name**	**Order**
Pheidole pallidula	Formicidae	Hymenoptera
Wasmannia auropunctata	Formicidae	Hymenoptera
Vespa velutina	Vespidae	Hymenoptera
Sirex ermak	Siricidae	Hymenoptera
Agrilus anxius	Buprestidae	Coleoptera
Agrilus planipennis	Buprestidae	Coleoptera
Conotrachelus nenuphar	Curculionidae	Coleoptera
Cryptophilus integer	Languriidae	Coleoptera
Dendroctonus ponderosae	Curculionidae	Coleoptera
Diabrotica virgifera	Chrysomelidae	Coleoptera
Enaphalodes rufulus	Cerambycidae	Coleoptera
Epitrix tuberis	Chrysomelidae	Coleoptera
Glischrochilus quadrisignatus*	Nitidulidae	Coleoptera
Hesperophanes campestris	Cerambycidae	Coleoptera
Ips hauseri	Curculionidae	Coleoptera
Ips pini	Curculionidae	Coleoptera
Lissorhoptrus oryzophilus	Curculionidae	Coleoptera
Luperomorpha xanthodera	Chrysomelidae	Coleoptera
Monochamus carolinensis	Cerambycidae	Coleoptera
Monochamus marmorator	Cerambycidae	Coleoptera
Monochamus mutator	Cerambycidae	Coleoptera
Monochamus nitens	Cerambycidae	Coleoptera
Monochamus notatus	Cerambycidae	Coleoptera
Monochamus obtusus	Cerambycidae	Coleoptera
Monochamus scutellatus	Cerambycidae	Coleoptera
Oemona hirta	Cerambycidae	Coleoptera
Otiorhynchus liguricus	Curculionidae	Coleoptera
Phloeosinus aubei	Scolytidae	Coleoptera
Phloeosinus rudis	Scolytidae	Coleoptera
Pissodes nemorensis	Curculionidae	Coleoptera
Pissodes strobi	Curculionidae	Coleoptera
Pissodes terminalis	Curculionidae	Coleoptera
Popillia japonica	Scarabaeidae	Coleoptera
Saperda candida	Cerambycidae	Coleoptera
Scolytus morawitzi	Scolytidae	Coleoptera
Sefrania bleusei	Dermesteidae	Coleoptera
Tetropium gracilicorne	Cerambycidae	Coleoptera
Xylosandrus crassiusculus	Scolytidae	Coleoptera
Aedes albopictus	Culicidae	Diptera
Anopheles quadrimaculatus	Culicidae	Diptera
Aphidoletes abietis	Cecidomyiidae	Diptera
Blepharipa schineri	Tachinidae	Diptera
Braula schmitzi	Braulidae	Diptera
Coenosia attenuata	Muscidae	Diptera
Drosophila suzukii	Drosophilidae	Diptera
Liriomyza huidobrensis	Agromyzidae	Diptera
Micropygus vagans	Dolichopodidae	Diptera
Ochlerotatus japonicus	Culicidae	Diptera
Rhagoletis cingulata	Tephritidae	Diptera
Rhagoletis fausta	Tephritidae	Diptera
Rhagoletis indifferens	Tephritidae	Diptera
Rhagoletis pomonella	Tephritidae	Diptera
Strobilomyia viaria	Anthomyiidae	Diptera
Tephritis praecox	Tephritidae	Diptera
Thoracochaeta johnsoni	Sphaeroceridae	Diptera
Diaphorina citri	Psyllidae	Hemiptera
Homalodisca vitripennis	Cicadellidae	Hemiptera
Metcalfa pruinosa	Flatidae	Hemiptera
Scaphoideus titanus	Cicadellidae	Hemiptera
Adelges tsugae	Adelgidae	Hemiptera
Halyomorpha halys	Pentatomidae	Hemiptera

Potential door knocker species / Horizon scanning		
Species name	**Family name**	**Order**
Lepidosaphes ussuriensis	Diaspididae	Hemiptera
Margarodes vitis	Margarodidae	Hemiptera
Nysius huttoni	Lygaeidae	Hemiptera
Orius laevigatus	Anthocoridae	Hemiptera
Oxycarenus lavaterae	Lygaeidae	Hemiptera
Stephanitis takeyai	Tingidae	Hemiptera
Stictocephala bubalis	Membracidae	Hemiptera
Arocatus longiceps	Lygaeidae	Hemiptera
Corythucha arcuata	Tingidae	Hemiptera
Corythucha ciliata	Tingidae	Hemiptera
Acleris gloverana	Tortricidae	Lepidoptera
Acleris variana	Tortricidae	Lepidoptera
Cydia prunivora	Tortricidae	Lepidoptera
Hyphantria cunea*	Arctiidae	Lepidoptera
Lymantria mathura	Lymantriidae	Lepidoptera
Malacosoma americanum	Lasiocampidae	Lepidoptera
Malacosoma disstria	Lasiocampidae	Lepidoptera
Orgyia pseudotsugata	Lymantriidae	Lepidoptera
Spodoptera littoralis	Noctuidae	Lepidoptera
Cacoecimorpha pronubana*	Tortricidae	Lepidoptera
Choristoneura fumiferana	Tortricidae	Lepidoptera
Choristoneura occidentalis	Tortricidae	Lepidoptera
Dendrolimus sibiricus	Lasiocampidae	Lepidoptera
Dendrolimus superans	Lasiocampidae	Lepidoptera
Opilio ruzickai	Phalangiidae	Opiliones
Ammothea hilgendorfi	Ammotheidae	Pantopoda
Frankliniella occidentalis	Tripidae	Thysanoptera
Thrips palmi	Thripinae	Thysanoptera
Obesogammarus obessus	Gammaridae	Amphipoda
Dikerogammarus villosus	Gammaridae	Amphipoda
Chelicorophium robustum	Corophiidae	Amphipoda
Crangonyx pseudogracilis	Crangonyctidae	Amphipoda
Amphibalanus amphitrite	Balanidae	Sessilia
Balanus eburneus	Balanidae	Sessilia
Balanus trigonus	Balanidae	Sessilia
Balanus variegatus	Balanidae	Sessilia
Megabalanus coccopoma	Balanidae	Sessilia
Megabalanus tintinnabulum	Balanidae	Sessilia
Megabalanus tulipiformis	Balanidae	Sessilia
Solidobalanus fallax	Archaeobalanidae	Sessilia
Acartia omori	Acartiidae	Calanoida
Eurytemora americana	Temoridae	Calanoida
Eurytemora pacifica	Temoridae	Calanoida
Myicola ostrea	Myicolidae	Poecilostomatoida
Pseudomyicola spinosus	Myicolidae	Poecilostomatoida
Daphnia lumholtzi	Daphniidae	Cladocera
Daphnia parvula	Anomopoda	Cladocera
Callinectes sapidus*	Portunidae	Decapoda
Charybdis japonica	Portunidae	Decapoda
Hemigrapsus penicillatus	Varunidae	Decapoda
Hemigrapsus takanoi*	Varunidae	Decapoda
Hemigrapsus sanguineus*	Varunidae	Decapoda
Percnon gibbesi	Plagusiidae	Decapoda
Portunus pelagicus	Portunidae	Decapoda
Potamon ibericum	Potamidae	Decapoda
Procambarus fallax f virginalis*	Cambaridae	Decapoda
Procambarus clarkii	Cambaridae	Decapoda
Cherax destructor	Parastacidae	Decapoda
Cherax quadricarinatus	Parastacidae	Decapoda
Orconectes juvenilis	Cambaridae	Decapoda
Orconectes rusticus	Cambaridae	Decapoda

Potential door knocker species / Horizon scanning		
Species name	**Family name**	**Order**
Orconectes virilis	Cambaridae	Decapoda
Procambarus acutus	Cambaridae	Decapoda
Cordioniscus stebbingi	Styloniscidae	Isopoda
Porcellio dilatatus	Porcellionidae	Isopoda
Trichorhina tomentosa	Platyarthridae	Isopoda
Marsupenaeus japonicus	Penaeidae	Decapoda
Palaemon macrodactylus	Palaemonidae	Decapoda
Sinelobus stanfordi	Tanaidae	Tanaidacea

Birds (Taxonomic group)

Potential door knocker species / Horizon scanning		
Species name	**Family name**	**Order**
Callonetta leucophrys	Anatidae	-
Chloephaga picta	Anatidae	-
Chrysolophus pictus*	Phasianidae	-
Falco biarmicus*	Falconidae	-
Lophura nycthemera	Phasianidae	-
Myiopsitta monachus	Psittacidae	-
Nymphicus hollandicus	Cacatuidae	-
Psittacula eupatria	Psittacidae	-
Threskiornis aethiopicus	Threskiornithida	-

Bryophytes (Taxonomic group)

Potential door knocker species / Horizon scanning		
Species name	**Family name**	**Order**
Lophocolea semiteres	Geocalycaceae	-

Bryozoan (Taxonomic group)

Potential door knocker species / Horizon scanning		
Species name	**Family name**	**Order**
Watersipora subtorquata	Watersiporidae	-
Bugula stolonifera	Bugulidae	-
Tricellaria inopinata	Scrupocellariidae	-

Cnidarians (Taxonomic group)

Potential door knocker species / Horizon scanning		
Species name	**Family name**	**Order**
Blackfordia virginica	Blackfordiidae	-
Garveia franciscana	Bougainvilliidae	-
Rhopilema nomadica	Rhizostomae	-

Sea urchins & starfish (Taxonomic group)

Potential door knocker species / Horizon scanning		
Species name	**Family name**	**Order**
Asterias amurensis	Asteriidae	-

Fish (Taxonomic group)

Potential door knocker species / Horizon scanning		
Species name	**Family name**	**Order**
Ameiurus melas*	Ictaluridae	-
Benthophilus durrelli	Gobiidae	-
Benthophilus nudus	Gobiidae	-
Catostomus commersonii	Catostomidae	-
Channa argus	Channidae	-
Cichla ocellaris	Cichlidae	-
Clarias gariepinus	Clariidae	-
Clupeonella tscharchalensis	Clupeidae	-
Cobitis bilineata	Cobitidae	-
Coregonus muksun*	Coregonidae	-
Gambusia affinis	Poeciliidae	-
Gambusia holbrooki	Poeciliidae	-
Ictalurus punctatus*	Ictaluridae	-
Ictiobus niger*	Catastomidae	-
Knipowitschia longecaudata	Gobiidae	-
Misgurnus anguillicaudatus	Cabitidae	-
Monopterus albus	Synbranchidae	-
Neogobius fluviatilis	Gobiidae	-
Neogobius gorlap	Gobiidae	-
Neogobius gymnotrachelus	Gobiidae	-
Neogobius kessleri	Gobiidae	-
Neogobius pallasi	Gobiidae	-
Pimephales promelas	Cyprinidae	-
Proterorhinus semilunaris	Gobiidae	-
Pylodictis olivaris	Ictaluridae	-
Romanogobio belingi	Cyprinidae	-
Parachondrostoma toxostoma	Cyprinidae	-
Anguilla japonica	Anguillidae	-
Anguilla rostrata	Anguillidae	-
Micropogonias undulatus	Sciaenidae	-
Paralichthys olivaceus	Paralichthyidae	-
Platichthys stellatus	Pleuronectidae	-
Sebastes schlegelii	Sebastidae	-
Siganus rivulatus	Sigaridae	-
Syngnathus nigrolineatus/ Syngnathus abaster	Syngnathidae	-
Trinectes maculatus	Achiridae	-
Neogobius eurycephalus	Gobiidae	-

Flatworms (Taxonomic group)

Potential door knocker species / Horizon scanning		
Species name	**Family name**	**Order**
Bothriocephalus acheilognathi	Bothriocephalidae	-
Dactylogyrus lamellatus	Dactylogyridae	-
Dendrocoelum romanodanubiale	Dendrocoelidae	-
Fascioloides magna	Fasciolidae	-
Platydemus manokwari	Geoplanidae	-

Not pathogenic fungi (Taxonomic group)

Potential door knocker species / Horizon scanning		
Species name	**Family name**	**Order**
Clathrus ruber	Phallaceae	-
Gymnopus luxurians*	Tricholomatacea	-
Leucocoprinus straminellus	Agaricaceae	-
Panaeolus cyanescens	Bolbitiaceae	-
Psilocybe cubensis	Hymenogastraceae	-
Suillus ochraceoroseus	Suillaceae	-
Suillus placidus*	Suillaceae	-

Pathogenic fungi (Taxonomic group)

Potential door knocker species / Horizon scanning		
Species name	**Family name**	**Order**
Atropellis pinicola	Dermateaceae	-
Atropellis piniphila	Dermateaceae	-
Ceratocystis fagacearum	Ceratocystidaceae	-
Chrysomyxa arctostaphyli	Coleosporiaceae	-
Cryphonectria parasitica	Valsaceae	-
Cryptostroma corticale	Not assigned	-
Davidiella populorum	Davidiellaceae	-
Endocronartium harknessii	Cronartiaceae	-
Monilinia fructicola	Sclerotiniaceae	-
Mycosphaerella laricis-leptolepidis	Mycosphaerellaceae	-
Ophiostoma wageneri	Ophiostomataceae	-
Phellinus weirii	Hymenochaetaceae	-
splanchnonema platani	Pleomassariaceae	-
Stegophora ulmea	Gnomoniaceae	-

Macroalgae (Taxonomic group)

Potential door knocker species / Horizon scanning		
Species name	**Family name**	**Order**
Agardhiella subulata	Areschougiaceae	-
Anotrichium furcellatum	Ceramiaceae	-
Antithamnion densum	Ceramiaceae	-
Antithamnionella spirographidis	Ceramiaceae	-
Antithamnionella ternifolia	Ceramiaceae	-
Asparagopsis armata	Bonnemaisoniaceae	-
Asperococcus scaber	Chordariaceae	-
Botrytella pacifica	Chordariaceae	-
Botrytella parva	Chordariaceae	-
Caulacanthus ustulatus	Caulacanthaceae	-
Caulerpa racemosa	Caulerpacea	-
Codium fragile ssp. atlanticum	Codiaceae	-
Codium textile	Codiaceae	-
Colaconema dasyae	Colaconemataceae	-
Corynophlaea verruculiformis	Chordariaceae	-
Cryptonemia hibernica	Halymeniaceae	-
Goniotrichopsis sublittoralis	Stylonemataceae	-
Grateloupia filicina	Halymeniaceae	-
Grateloupia subpectinata	Halymeniaceae	-
Grateloupia turuturu	Halymeniaceae	-
Laurencia brongniartii	Rhodomelaceae	-
Lomentaria hakodatensis	Lomentariaceae	-
Macrocystis pyrifera	Laminariaceae	-
Myriactula areschougii	Chordariaceae	-

Potential door knocker species / Horizon scanning		
Species name	**Family name**	**Order**
Myriactula clandestina	Chordariaceae	-
Polyopes lancifolius	Halymeniaceae	-
Polysiphonia atlantica	Rhodomelaceae	-
Polysiphonia senticulosa	Rhodomelaceae	-
Polysiphonia subtilissima	Rhodomelaceae	-
Scytosiphon dotyi	Scytosiphonaceae	-
Solieria chordalis	Solieriaceae	-
Ulva pertusa	Ulvaceae	-
Undaria pinnatifida	Alariaceae	-

Mammal (Taxonomic group)

Potential door knocker species / Horizon scanning		
Species name	**Family name**	**Order**
Axis axis	Cervidae	-
Callosciurus erythraeus	Sciuridae	-
Callosciurus finlaysonii	Sciuridae	-
Herpestes javanicus	Herpestidae	-
Macaca fascicularis	Cercopithecideae	-
Macropus rufogriseus	Macropodidae	-
Muntiacus reevesi	Cervidae	-
Mustela furo	Mustelidae	-
Nasua nasua	Procyonidae	-
Rusa timorensis	Cervidae	-
Sciurus anomalus	Sciuridae	-
Sciurus carolinensis	Sciuridae	-
Sciurus niger	Sciuridae	-
Sylvilagus floridanus	Leporidae	-
Tamias striatus	Sciuridae	-
Trichosurus vulpecula	Phalangeridae	-
Sus scrofa bittatus	Suidae	-

Microorganisms (Taxonomic group)

Potential door knocker species / Horizon scanning		
Species name	**Family name**	**Order**
Clavibacter michiganensis ssp. insidiosus	Microbacteriaceae	-
Clavibacter michiganensis ssp. michiganensis	Microbacteriaceae	-
Leptosphaeria maculans	Phaeosphaeriaceae	-
Rabbit haemorrhagic disease virus	Caliciviridae	-
Tobacco ringspot nepovirus	Secoviridae	-
Phytophthora kernoviae	Pythiaceae	-
Erwinia amylovora	Enterobacteriaceae	-
Pepino mosaic virus	Flexiviridae	-
Ph. cambivora x Ph. fragariae	Phytophthoraceae	-

Mollusca (Taxonomic group)

Potential door knocker species / Horizon scanning		
Species name	**Family name**	**Order**
Brachidontes pharaonis	Mytilidae	-
Chilostoma cingulatum gobanzi	Helicidae	-
Corbicula fluminalis	Corbiculidae	-
Corbicula fluminea	Corbiculidae	-

Potential door knocker species / Horizon scanning		
Species name	**Family name**	**Order**
Crassostrea virginica*	Ostreidae	-
Dreissena bugensis	Dreissenidae	-
Euglandina rosea	Spiraxidae	-
Mercenaria mercenaria	Veneridae	-
Musculista senhousia	Mytilidae	-
Ostrea chilensis	Ostreidae	-
Pinctada radiata	Pteriidae	-
Potamocorbula amurensis	Cardiidae	-
Rangia cuneata	Mactridae	-
Rapana venosa	Muricidae	-
Ruditapes philippinarum	Veneridae	-
Tandonia budapestensis	Milacidae	-
Urosalpinx cinerea	Muricidae	-

Plant-parasitic nematode (Taxonomic group)

Potential door knocker species / Horizon scanning		
Species name	**Family name**	**Order**
Meloidogyne chitwoodi	Meloidogynidae	-
Meloidogyne fallax	Meloidogynidae	-
Meloidogyne minor	Meloidogynidae	-
Angiostrongylus vasorum	Metastrongylidae	-

Paracitic nematode (Taxonomic group)

Potential door knocker species / Horizon scanning		
Species name	**Family name**	**Order**
Ashworthius sidemi	Trichostrongylidae	-
Bursaphelenchus xylophilus	Parasitaphelenchidae	-

Other chordates (Taxonomic group)

Potential door knocker species / Horizon scanning		
Species name	**Family name**	**Order**
Didemnum vexillum	Didemnidae	-
Perophora japonica	Perophoridae	-
Corella eumyota	Corellidae	-

Other invertebrates (Taxonomic group)

Potential door knocker species / Horizon scanning		
Species name	**Family name**	**Order**
Celtodoryx ciocalyptoides	Coelosphaeridae	-
Botrylloides violaceus	Botryllidae	-

Phytoplankton (Taxonomic group)

Potential door knocker species / Horizon scanning		
Species name	**Family name**	**Order**
Alexandrium catenella	Gonyaulacaceae	-
Alexandrium leei	Goniodomataceae	-
Alexandrium taylorii	Goniodomataceae	-
Asteromphalus sarcophagus	Asterolampraceae	-
Chaetoceros peruvianus	Chaetocerotaceae	-
Chaetoceros rostratus	Chaetocerotaceae	-
Eucampia cornuta	Hemiaulaceae	-
Isochrysis glabana	Isochrysidaceae	-
Isochrysis litoralis	Isochrysidaceae	-
Neoceratium candelabrum	Ceratiaceae	-
Olisthodiscus luteus	Chattonellaceae	-
Pleurosigma planctonicum	Pleurosigmataceae	-

Protist (Taxonomic group)

Potential door knocker species / Horizon scanning		
Species name	**Family name**	**Order**
Plasmodium relictum	Plasmodiidae	-

Reptile (Taxonomic group)

Potential door knocker species / Horizon scanning		
Species name	**Family name**	**Order**
Apalone spinifera	Trionychidae	-
Boa constrictor imperator	Boidea	-
Boiga irregularis	Colubridae	-
Chelydra serpentina	Chelydridae	-
Chrysemys picta	Emydidae	-
Elaphe schrenckii	Colubridae	-
Graptemys pseudogeographica	Emydidae	-
Macrochelys temminckii	Chelydridae	-
Mauremys leprosa	Geoemydidae	-

*Species observed but not established in one or more of the participating countries and territories.

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Invasive Alien Species

Invasive alien species are one of the main drivers of biodiversity loss, due to their ability to disperse and cause negative effects on native species and the environment. To reduce the introduction of invasive alien species in the future, preventive measures need to be implemented, and knowledge about pathways of introduction of new and potentially invasive alien species can facilitate tailor-made measures.

The aim of this project is to contribute to the fulfilment of obligations in the CBD Aichi target 9 and the EU Biodiversity Strategy 2020 target 5, by identifying and prioritising the most significant pathways of introduction for invasive alien species by conducting a pathway analysis and horizon scanning. This identification and prioritisation is done for 10 participating countries and territories part of the NOBANIS network to assist them in minimising and preventing further introductions and establishment of invasive alien species.

Based on the results from the pathway analysis and horizon scanning, this report presents a prioritised list of pathways of interest, general recommendations on measures to control pathways of interest, and advice on development of an early warning system for invasive alien species.

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