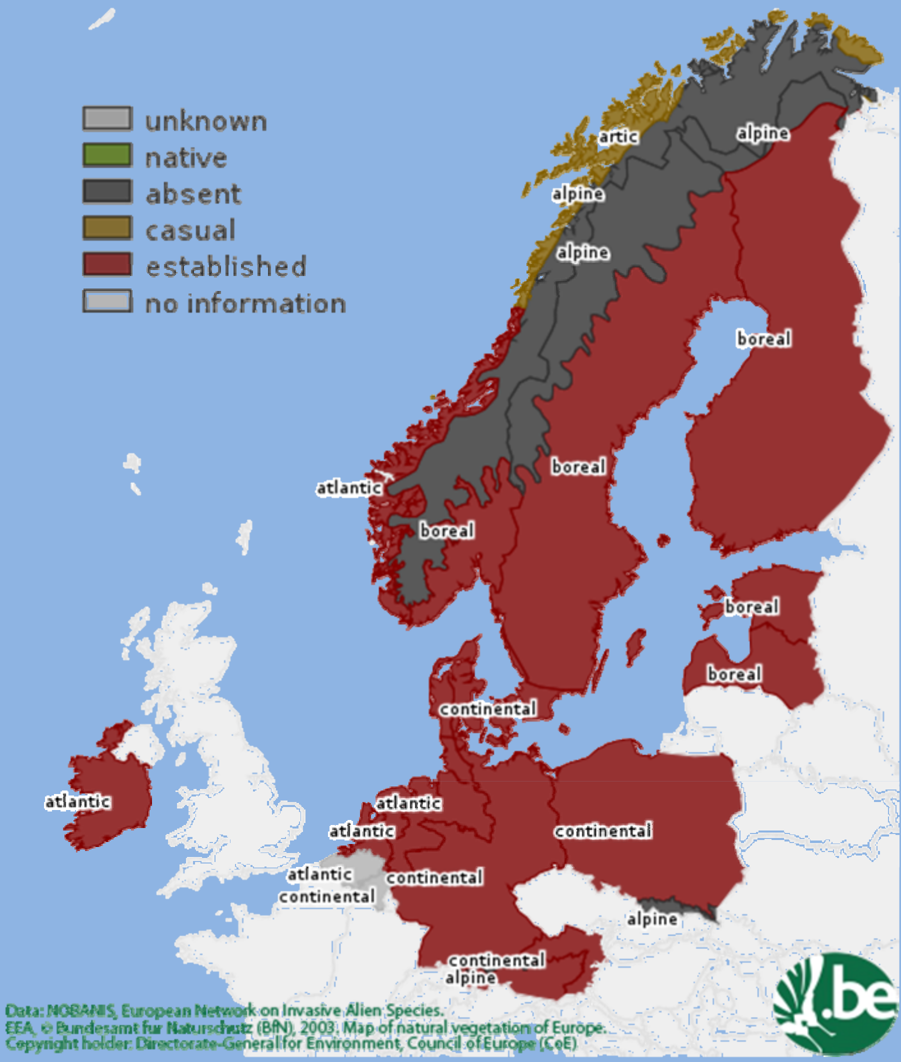
RISK-MAPPING FOR 100 NON-NATIVE SPECIES IN EUROPE



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NOBANIS
European Network on Invasive Alien Species
Gateway to information on Invasive Alien species in North and Central Europe

Risk-mapping for 100 non-native species in Europe is freely available online: www.nobanis.org/Risk-mapping.

Risk-mapping for 100 non-native species in Europe has been conducted with financial support from The Nordic Council of Ministers.

Citation:
Secretariat of NOBANIS (2012): *Risk-mapping for 100 non-native species in Europe.* Copenhagen.

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Index

Summary

Increasing globalisation has through human activities facilitated the introduction of animals, plants and other living organisms to areas outside their natural dispersal range. Some of these introduced species will be able to establish a viable population in areas to which they are introduced. An even smaller number of these alien species, which have established reproducing populations, will become *invasive*. Invasive alien species are recognised as one of the largest threats to world's biodiversity and may have profound impacts on the environment. Once an introduced species has established in an area, it is difficult and often even impossible to eliminate. In order to protect biodiversity and to minimize the financial costs of damage from IAS it is therefore far more effective to adopt a precautionary approach and first and foremost to take measures to prevent the introduction of IAS.

The present report aims at providing NOBANIS countries and other European countries with a useful tool for prioritizing their measures to prevent the introduction of IAS. Few species are able to colonise the full range of climatic conditions in Europe, which pleads for the use of a biogeographic approach when dealing with early warning, rapid response issues. The project further develops the use of biogeographic regions as a tool for warning European countries when a new, potentially invasive species is under establishment. By mapping the current distribution of alien species whose distribution range is expectedly still expanding, risk profiles are created and hence the countries will be able to make national alarm lists for these species. The target group of the project is managers in both the cooperating NOBANIS countries and other European countries.

Additionally the objective of the project is to further investigate the use of 2 types of biogeographical regions in Europe as defined by the European Environmental Agency and Metzger et al.; and describe limitations and strengths in the methods.

100 species, introduced to European countries, were selected for mapping risk profiles. The species were selected among terrestrial, freshwater and brackish water species and based on the criteria that they suspiciously are invasive or potentially invasive and that available distribution data exist. The 100 species were divided into three categories:

1. 10 species with a detailed distribution map available. The species form the basis for comparing the EEA method to the Metzger et al method.
2. Species with no detailed distribution map available. Species are still believed to expand their introduced range. Risk profiles of category 2 species will be useful for countries to create their alarm list.
3. Species with isolated local populations. Species may be present in captivity all over the region, but they are not yet widely established in the wild. Risk profiles of category 3 species will be useful for countries to create their alarm list.

Twelve NOBANIS countries participated: Austria, Belgium, Denmark, Estonia, Finland, Germany, Ireland, Latvia, The Netherlands, Norway, Poland and Sweden.

Information was collected by the NOBANIS focal points based on a questionnaire, requiring the use of a fixed set of vocabularies, designed by the NOBANIS secretariat. Information on each species' status in the bioclimatic zones, year of establishment, frequency and invasiveness was requested for. The

national focal points completed the questionnaire with data from the NOBANIS database as well as additional available scientific literature and registered observations.

The data was collected for all countries and sent to the Invasive Species Unit in the Natural Resources and Environment in Belgium where the maps were designed. Maps were generated by a (CherryPy) Python application, which use Mapserver and SLD stylesheets in background. Layers were stored in a PostgreSQL database thanks to the PostGIS extensions.

The results of the report basically consist of the risk maps. From these maps countries can make their national alarm lists.

The report concludes that the method of risk mapping, based on occurrence of an invasive alien species in biogeographic zones is a valuable, easily accessible tool for Early Warning and Rapid Response. Risk mapping can be used for rapidly identifying risks and invasion "hot spots" and it is invaluable in prioritizing and coordinating measures to meet these risks nationally as well as regionally. If it is too late in the invasion process for prevention, the method is also useful for coordinating eradication or control measures.

However, some methodological difficulties with risk mapping became clear during the course of the project and remain to be solved. These include:

- Lack of information on distribution and impacts – in particular for IAS recently arrived in Europe.
- When lack of a report of an IAS in a region occur it is difficult to interpret if the species cannot establish there or if it has only not yet done so.
- It was a major challenge for the participating countries to obtain distribution data at the necessary level of detail, which is considered one of the greatest obstacles at the moment for using this method.
- Scale of the biogeographic zones and mapping. The zone classifications as used in this project for both the EEA and Metzger Methods are too general to be of great value for planning more local measures on the national level for large countries.

This Risk mapping project compared the two different climatic stratifications of Europe; EEA biogeographical stratification and the Metzger environmental stratification with the aim was to see if the use of Metzger's stratification offered a more accurate result than the EEA biogeographical zones. Although Metzger's environmental stratification provides more detailed information on biogeographical zones it is not possible for this study to state that distribution depicted on Metzger maps provide a better foundation to predict possible new areas of distribution.

Overall, sources of information for risk mapping need to be improved in order to fully realize the potential of the method. It is recommended that monitoring of IAS in Europe is greatly improved in order to have the data to include in primary data sources like NOBANIS. Overlays with monitoring programs and citizen science reporting schemes with the risk maps would give the potential to greatly improve the accuracy of the risk maps.

It is however, clear from the results of the project that the biogeographic method of presenting data would be of great value for NOBANIS and this approach should be strived after in future development of the NOBANIS gateway.

Introduction

Increasing globalisation has through human activities facilitated the introduction of animals, plants and other living organisms to areas outside their natural dispersal range. The rate of introduction of IAS is still steadily increasing in all environments and is expected to be further exacerbated by increasing transports of humans and goods as well as the effects of climate change. A small number of these *introduced* species, also called alien, non-native or exotic species, will be able to establish a viable population in areas to which they are introduced. An even smaller number of these alien species, which have established reproducing populations, will become *invasive*.

Invasive alien species (IAS) are alien species whose introduction by human activities to an area outside their natural distribution area threatens biological diversity (CBD 2001, IUCN 2000). An alien species may in many cases also be considered invasive if it threatens human health, plant health, animal health and/or socio-economic values. For a species to become invasive, it must successfully survive its introduction into a new environment and reproduce, increase its population density, spread in its new environment, and finally threaten native species, habitats and/or ecosystems in its introduced range. To summarise, for an alien species to become invasive, it must arrive, survive and thrive [www.CBD.int, 1].

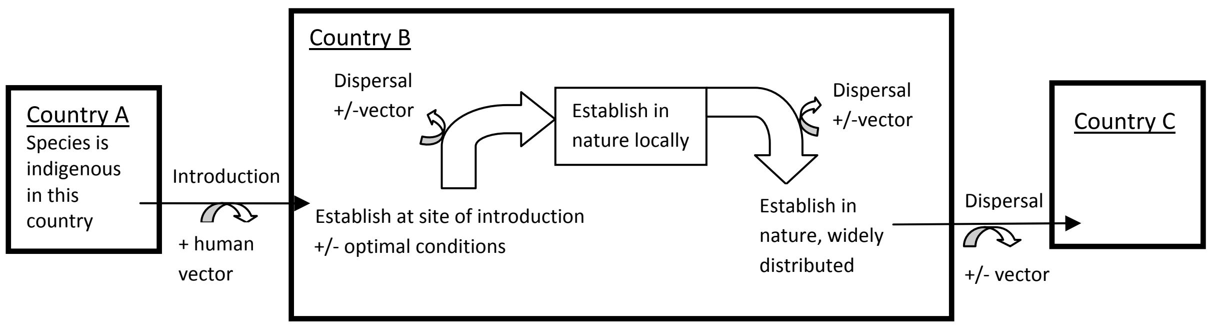


Figure 1: Example of how species can be transported by humans/human activities from its area of origin (A) to other countries (B) and from here by secondary dispersal be introduced to other countries (C).

Invasive alien species are recognised as one of the largest threats to world's biodiversity and may have profound impacts on the environment, especially on islands and in freshwater environments (CBD 2001, Council of Europe 2004, Millenium Ecosystem Assessment 2005, EEA 2007, Sec. CBD 2010,) In order to deal with this threat to biodiversity the Convention on Biological Diversity's Strategic Plan for Biodiversity 2011-2020 includes the Aichi Biodiversity Target 9 which states as follows:
By 2020, invasive alien species and pathways are identified and prioritized, priority species are controlled or eradicated, and measures are in place to manage pathways to prevent their introduction and establishment [www.CBD.int,2]. The European Union has also realized the importance of protecting biodiversity from the effects of invasive alien species and has included the Aichi Target on IAS as one of the six EU targets to halt the loss of biodiversity loss and degradation of ecosystem services in the EU Biodiversity Strategy (COM 2011). Thus, dealing with the issues concerning IAS is highly prioritised globally, regionally and nationally. This prioritisation is not just from a biodiversity perspective. There

is also a significant financial aspect to IAS since estimates of the yearly cost of damage caused by invasive alien species within Europe alone are €12 billion [Kettunen et al. 2009, Shine et al. 2010].

Once an introduced species has established in an area, it is difficult and often even impossible to eliminate. In order to protect biodiversity and to minimize the financial costs of damage from IAS it is therefore far more effective to adopt a precautionary approach and first and foremost to take measures to prevent the introduction of IAS. If prevention is not possible, eradication should be considered. If eradication is not feasible, the control of the spread of the IAS and management of its impacts would be targeted. With the increasing challenge of introductions of alien species, actions and measures against them need to be prioritized and focused on the IAS, which have the greatest risk of becoming invasive and for which measures have the greatest chance of being effective.

Risk assessments and risk profiles

Creating risk profiles for IAS is a very useful predictive tool for implementing the precautionary approach, since it is much more efficient and cheaper to do preventive work against invasive species, rather than try to control them once they are established. In a risk profile, one identifies invasive alien species for which there is a risk that they are introduced, established and may cause harm to biodiversity, human, plant and animal health and socio-economic values. Risk profiles can be used by individual countries to make alarm lists. In these alarm lists one may define appropriate responses, including prevention of introduction, monitoring, research and measures to eradicate or control an IAS should it be detected. Alarm lists focus especially on species that occur invasively within the same bioclimatic region and therefore will possibly act invasively if it makes its way to other countries or regions within the same zone.

Predicting what introduced species will have the potential to become invasive in a certain environment or habitat is however difficult. The factors, which determine if an alien species may become invasive and what impacts it may have on the receiving environment, are complex and poorly understood. The success of an alien species in acclimatizing to a new environment, spreading and causing negative effects may depend on a number of factors such as the biology of the species, the propagule pressure and conditions in the introduction area such as presence of suitable food items and habitat, escape from enemies and pathogens, fortuitous climatic conditions at the time of introduction disruptions in the receiving ecosystem which allow establishment without competition etc. Considerable efforts have been made during the past 20 years in developing methods for assessing the risks that introduced species may have in order to take steps to prevent harm by IAS before it occurs.

Many of the screening tools for rapidly assessing the risks that an alien species may become invasive are based on climate matching. Climate matching compares the climatic and environmental conditions where a species has its natural range and invaded ranges, with the new area of possible introduction. This comparison gives an indication of the likelihood that the IAS will become established and invasive. However, climate matching although useful has its limitations in predicting invasion success.

The certain biotic and abiotic conditions a specific species needs in order to be capable of establishing in an area can be met in one country without necessarily being met in the neighbour country or even in all parts of a country. Why an introduced species may become highly invasive in one country and remain benign in a neighbouring country is not fully understood. An example is *Dreissena polymorpha* the zebra mussel, which is considered highly invasive in most countries of Europe, but does relatively little harm in Sweden, possibly because of differences in the aquatic biochemistry of cation ratios, which may limit shell growth. Hence a species, which poses a threat to biodiversity in one country, may not necessarily be a threat in the neighbouring country. That an introduced species becomes invasive is a neighbouring country or region is however, regarded as a major warning signal that risks of the species should be assessed and preventative measures be considered.

NOBANIS and Early Warning

In Europe countries participating in the NOBANIS network have established a simple early warning system. When a participating country becomes aware that a new alien species has been found in their country, a warning is send to the other participating countries and posted on the NOBANIS website. This early warning enables countries to be alerted that a new species has been observed in the region. This system does not however, circulate information about the newly introduced species' ability to become established and hence if it may be potentially invasive and what the risks to biodiversity may be in the countries where it is not yet present. This is information that is necessary in order to assess the risks that an introduced species may have, what measures are possible to take and thus respond to the coming "invasion" in an effective and feasible way.

The ability to rapidly respond to encroachments of IAS is totally reliant on access to information about the presence of the species and its potential to cause harm. As possibilities to halt IAS at national boundaries continually decrease because of changing geopolitical conditions and radically increased volumes and patterns of global trade, regional and international cooperation has become increasingly more important to ensure effective responses to the threat of IAS. It is essential to prioritize preventative and eradication measures at not only national levels, but also regionally and internationally. For this, information is crucial.

The NOBANIS network contains a wealth of information on invasive alien species already present in the region that could be used to improve early warning capacities and countries´ possibilities to respond with appropriate preventative and management measures. This information on alien species in NOBANIS includes; the distribution, frequency, reported impacts, habitats affected and pathways and vectors of introduction and spread. It is important to further examine how this information could be used to improve our capacity for early warning and rapid response. To do this we must improve our ability to predict if an alien species may become established and invasive in a new environment, what the negative impacts can be and what preventative or management measures may be effective.

The NOBANIS data on alien species is however, based on a national level, which limits the usefulness of the data in early warning and for identifying what regions, habitats and species that may be at risk from IAS. Identifying invasion "hot spots" where the first incursions may occur and where measures for eradication would be most effective also requires a more refined level of information than the national level. This is particularly a problem for geographically large countries. A biogeographic approach is very much needed. Based on this, the present report will contribute to meeting this challenge by testing the use of biogeographic zones to better define the area of potential risk for the establishment of alien species and ensuing invasiveness. This would provide countries with a useful tool for assessing which invasive alien species they, from a conservational and financial perspective, could benefit from focussing their efforts on.

Background

This report is based on a pilot project from 2010 made by NOBANIS: *Risk mapping for non-native species in Europe* (Branquart et al. 2010).

The focus of the pilot project was to identify areas endangered by the establishment and spread of invasive alien species and the risk areas where they have not yet been reported, but are likely to establish in the near future (i.e. existing gaps within biogeographical regions). The study also examined if the limits of distribution of certain invasive alien species in Europe matched those of the biogeographical regions suggested by the European Environmental Agency. The objective was thus to assess how biogeographical regions can be used in the future to target the early warning-rapid response alert to countries in a potential risk zone.

The method was tested on 18 species selected from the lists of worst invasive alien species in Europe by comparing their known distribution with their presence in the biogeographic zones to see if a match was found. It was concluded that generally speaking there was a good match and hence that the method can be useful for countries to make alarm lists of alien species with the potential to invade certain countries (Branquart et al. 2010). However, the method does not allow prediction of establishment and invasion risk outside of specific biogeographical areas. Another weakness of the method is that it is based on the establishment potential of an organism rather than on its local abundance or ability to cause harm on a local basis. It is not possible to use this method to understand why an IAS may cause harm in one place, but be benign in another. For this, information needs to be gathered on impacts rather than only establishment, which is much more difficult and resource demanding.

Objectives

The objectives of this project are

1. to produce risk maps showing the current distribution of 100 non-native species in Northern, Western and Central Europe (in the NOBANIS countries);
2. to further investigate the use of 2 types of biogeographical regions in Europe as defined by the European Environmental Agency and Metzger et al.; and describe limitations and strengths in the methods;
3. to map the risk of non-native species establishment on that basis and to identify risk areas where they are not yet reported but are likely to establish in the near future (i.e. existing gaps within biogeographical regions);
4. to use the risk maps to build alarm lists on a country basis (warning tool for future establishment of detrimental species).

This project further develops the use of biogeographic regions as a tool for warning European countries when a new, potentially invasive species is under establishment. By mapping the current distribution of alien species whose distribution range is expectedly still expanding, risk profiles are created and hence the countries will be able to make national alarm lists for these species. The target group of the project is managers in both the cooperating NOBANIS countries and other European countries.

Additionally it is the aim of this project to follow up on the pilot project's recommendations to further investigate if a more accurate result is obtained by using another stratification of biogeographic zones than the EEA stratification. This will be explored by comparing results between the EEA stratification and Metzger et al.'s environmental stratification (see Box 1). The Metzger method classifies European climatic regions into different and more zones than the EEA approach does and hence could provide a more nuanced result. An additional objective was to compare the results to determine which of the stratification methods would be most useful when adopting a biogeographic approach in future developments of NOBANIS. It was also considered important to test how much data is already available and accessible in the NOBANIS Gateway and how it could be improved to add value for Early Warning.

Method

100 species, introduced to European countries, were selected for mapping risk profiles. Risk profiles for the 100 species were created by gathering information about their presence in the bio-geographic regions (according to the definitions from the European Environment Agency) in the countries participating in this project. Additionally, risk profiles based on Metzger's environmental zones were made for ten of the 100 species.

Twenty countries participated in the NOBANIS network at the time of the project and they were all invited to join this project. However, it was not possible to gather data with the necessary level of detail for some countries, hence twelve European countries participate in the project. These countries are: Austria, Belgium, Denmark, Estonia, Finland, Germany, Ireland, Latvia, The Netherlands, Norway, Poland and Sweden.

Selection of species

The 100 introduced species in this project were selected on the basis of the following criteria.

First, the species were selected on the suspicion that they are invasive or potentially invasive, using critera that; *the species is alien*[1] *to the country or at least one of the bioclimatic regions in the country. The species has established self-reproducing populations in the wild and may threaten biodiversity.*

The existence of available distribution data or at least an indication of available data was an important criterion for a species to be selected. The indication of available data could for instance be met if the species is listed as an alert species in the report *Horizon scanning for new invasive non-native animal species in England or if there are fact sheets within NOBANIS http://www.nobanis.org/Factsheets.asp or DAISIE http://www.europe-aliens.org/speciesTheWorst.do*.

[1] A species, subspecies or lower taxon, introduced outside its natural past or present distribution; includes any part, gametes, seeds, eggs, or propagules of such species that might survive and subsequently reproduce. (CBD 2001).

The 100 species were selected among terrestrial, freshwater and brakish water species. In general it was an aim to achieve maximum diversity within taxa, environment, establishment dates and biogeographic affinities among the selected species.

Furthermore the species were selected in order to fall into one of following three categories:

1) Species with a detailed distribution map available. Species are established as non-native in at least one country in the NOBANIS region. In the report Category 1 species are used to compare the risk profiles of EEA biogeographic zones to risk profiles based on Metzger's environmental zones.
2) Species with no detailed distribution map available. Species are established in the NOBANIS region either recently or has been for a longer period of time but are still expanding their introduced range. Risk profiles of category 2 species will be useful for countries to create their alarm list.
3) Species with isolated local populations. Species may be present in captivity all over the region, but they are not yet widely established in the wild. These include pet species, terrarium, and aquarium species. Prior to the mapping of the species, knowledge of the species' distribution range in the project area was not necessarily well known; hence some maps can turn out to be without data. Risk profiles of category 3 species will be useful for countries to create their alarm list.

Appendix I list the 100 species including common names, habitat and group. Appendix II alphabetically list the species divided into categories.

Data collection and validation

Few species are able to colonise the full range of climatic conditions in Europe, which pleads for the use of a biogeographic approach when dealing with early warning issues. Thus data about species establishment was collected for 12 European countries (Austria, Belgium, Denmark, Estonia, Finland, Germany, Ireland, Latvia, Netherlands, Norway, Poland, and Sweden) and included in the 5 biogeographical regions (sensu EEA) found within the NOBANIS area, i.e. Alpine, Arctic, Atlantic, Boreal and Continental regions. Countries may be classified as having 1 to 4 different biogeographical regions (see appendix III).

Information was collected by the NOBANIS focal points (country representatives, see http://www.nobanis.org/Contact.asp). A questionnaire was designed by the NOBANIS secretariat requesting information on each species status in the bioclimatic zones, year of establishment, frequency and invasiveness. The questionnaire was completed with a fixed set of vocabularies and hence definitions of all the terms used were also included in order to make sure that all countries performed the assessments based on the same criteria. The national focal points completed the questionnaire with data from the NOBANIS database as well as additional available scientific literature and registered observations.

Data on establishment status was gathered for all 100 IAS according to the biogeographic regions as defined by the EEA Stratification System and for 10 IAS also according to the Metzger Stratification System. The species were divided into following categories in each environmental zone in each country:

1. **Unknown**: No data available
2. **Native:** The species is native to the bioclimatic area in the country
3. **Absent:** The species is alien and has never been reported from the country bioclimatic area
4. **Casual**: The species is alien to the country bioclimatic area. It has been observed in the wild, but without forming self-reproducing populations (also called incidental)
5. **Established**: The species is alien to the country bioclimatic area. It makes self-reproducing populations in the wild
6. **No information:** Countries marked with **no information** refers exclusively to countries outside the project area

The data was collected for all countries and sent to the Invasive Species Unit in the Natural Resources and Environment in Belgium where the maps were designed. Maps were generated by a (CherryPy) Python application, which use Mapserver and SLD stylesheets in background. Layers were stored in a PostgreSQL database thanks to the PostGIS extensions.

During the exercise, some important discrepancies were observed on a first version of the maps, resulting in considerable concerns from partners. This event is an important result in itself as the maps were built with the data sent by the participating countries. The data validation step is thus crucial for the accuracy of such a risk mapping exercise, even when considering a larger number of species.

EEA Biogeographical zones

The Indicative Map of European Biogeographical Regions (Figure 2) was developed with the purpose of defining in practice the biogeographical regions mentioned in the Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and wild fauna and flora (Habitats Directive). It refers to the biogeographical regions as the geographical framework for the establishment of a draft list of sites of Community importance with a view of setting up the Natura2000 ecological network (Special Areas of Conservation – SACs) (ETC/BD 2006). The map has been extended to the Pan-European geographical area for the implementation of the Emerald Network. The mapping procedure is based on an interpretation of the digital version of the 'Map of Natural Vegetation of the member countries of the European Community and of the Council of Europe' (Noirfalise, 1987).

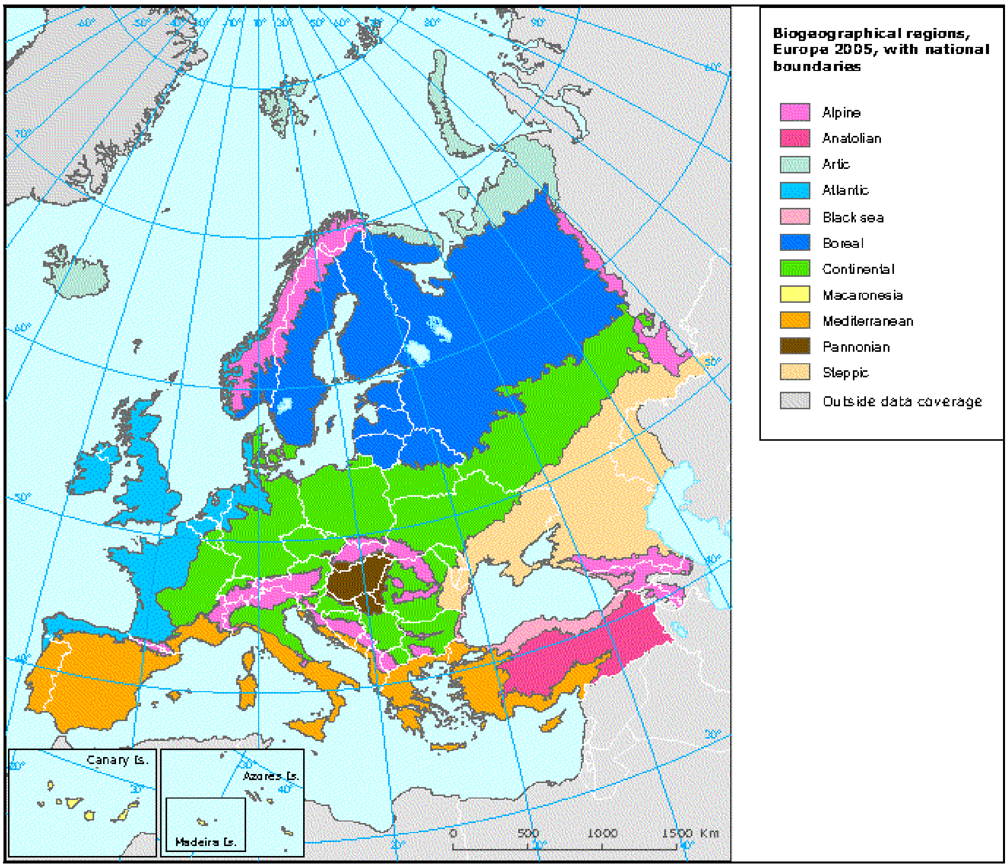


Figure 2: EEA stratification

Box 1

Metzger's Environmental Stratification of Europe

Metzger et al. (2005) has developed the Environmental Stratification of Europe (EnS) which is a climatic stratification based on a statistical foundation. The aim was to develop a stratification that as far as possible was free from personal bias. Twenty of the most relevant available environmental variables were selected based on experience from previous studies and subjected to statistical clustering (Metzger et al, 2005). It has resulted in a total number of 13 environmental zones, of which eight are represented in the focus area of this report. The eight zones are Alpine North, Boreal, Nemoral, Atlantic North, Alpine South, Continental, Atlantic Central and Pannonian.

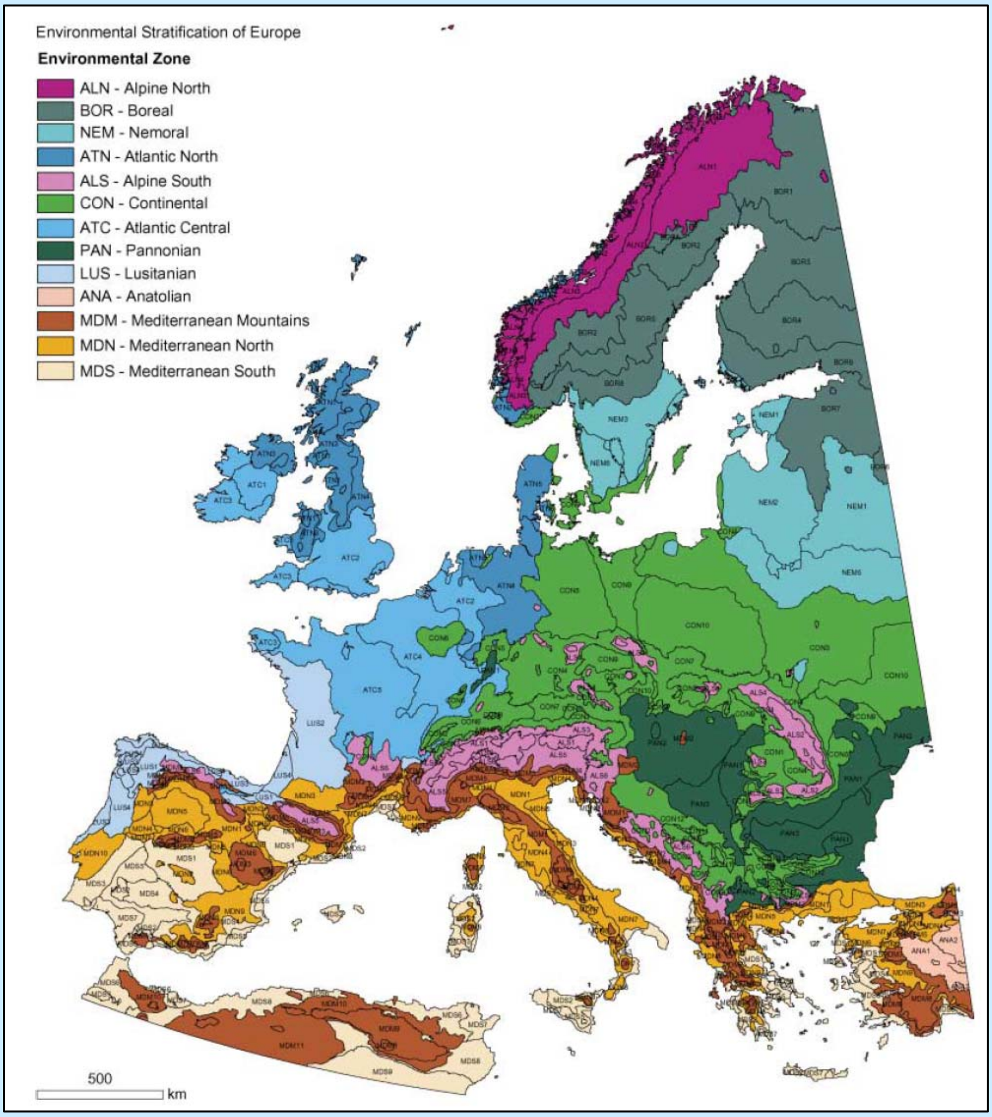


Figure 3: Metzger et al stratification

Results

The results of this report basically consist of the risk maps. The maps are constructed based on the criteria mentioned in the chapter: Method.

In the following a review of how the maps are presented is given.

The total distributions for 100 species are presented on risk maps. The results contain 108 maps; 20 categories 1-maps divided into 10 Metzger-maps and 10 EEA-maps, 33 category 2-maps including 35 species (*Elodea Canadensis* and *Elodea nuttallii* are displayed in one joint map as are *Ludwigia peploides* and *Ludwigia grandiflora* (= *L. uruguayensis*)), and 55 category 3-maps (for species lists see appendix I and II). The two species displayed on one joint map are in both cases closely related to each other and their distribution range in the area of introduction is identical.

The risk maps in this report illustrate presence and absence of the species in the biogeographical zones of the countries in the region.

To support the countries' elaboration of alarm lists, each map is provided with a figure text specifying what zones the species has established in and/or is casual. It is up to each individual country to elaborate their list. An example of how this could be done is given in the section: National alarm lists

Additionally, where information was available, category 2 and 3-maps are provided with data on which country and year the first report of the species was given. This information is taken from the NOBANIS database. For most species an estimate for the dispersal rate is also given.

Secondary dispersal rates of the IAS

Regarding the secondary dispersal rate, (the rate at which the species once introduced to an area, spreads without the help of humans) the indication on rate is based on the project area scale. Within a local area the species may be capable of spreading at a higher or lower rate. This is an indication of dispersal rate being relative.

For most species an assessment of their secondary dispersal rate is also given according to the definitions in the table below (Table 1). Note that a species' secondary dispersal rate can be slower than the dispersal rate, which can be interpreted from the risk maps. This is due to the fact that dispersal rates are often enhanced by human vectors.

Secondary dispersal rate	Organisms
Low	Trees and larger bushes, reptiles, vingless insects and insects known to fly short distances, terrestrial molluscs
Medium	Larger mammals, freshwater fish
High	Flying insects, birds, marine and some freshwater species with pelagic dispersal of eggs and/or larvae, seeds with pappus, plants with vegetative reproduction

Table 1. Assessed secondary dispersal rates for selected organisms

Examples of species, which in this report have been assessed as having high secondary dispersal rates, are the species *Elodea canadensis* and *Elodea nuttallii* in **Figure 34**. Dispersal of *E. canadensis* and *E.nuttallii* is very fast and effective because of their ability to reproduce vegetatively. Plant fragments and winter dormant buds are transported downstream in a water system by wind and wave action that then root in the sediment. In addition to this, water birds, mainly geese and swans, can facilitate transport over land. Apart from this efficient secondary dispersal rate, human influence is also known to be a central dispersal factor, for instance when small recreational boats are moved from one lake to the other (Josefsson 2011).

An example of a species designated as having a low secondary dispersal rate in this report, is the New Zealand flatworm *Arthurdendyus* triangulatus in **Figure 63**. Its egg capsules and the flatworms themselves are spread passively by commercial and non-commercial transport of plant and soil material. Hence the primary expansion of distribution range is caused by human action. Locally the New Zealand flatworms move around through naturally occurring crevices in the soil or by utilising passages that earthworms have made (Weidema, 2006). They are not capable of spreading over long distances on their own.

Due to human facilitation of the spreading of species, some species may not have the potential themselves to spread over larger areas within a shorter period of time. But facilitated by humans, they may be capable of spreading over vast distances within a relatively short time scale. An example of a species with a slow secondary dispersal rate but with a risk map indicating that the species has managed to spread at a great pace is the black cherry, *Prunus* serotina in Figure 47. Seeds from *P. serotina* are spread by generalist frugivorous birds and mammals. In Germany natural dispersal distances appear to be limited to less than 1 km in 40 years indicating that secondary dispersal is slow (Starfinger *et al.* 2003). Hence the main driving force for the large range extension has been planting rather than dispersal by natural means (Starfinger, 2010).

From a policy point of view, it is important to know the species' abilities to spread. If a species has a low secondary dispersal capacity this can be an advantage for reducing spread. In that case strict control on inhibiting human aided dispersal can have a great positive effect on preventing further spread of the species and regulations should be made in regard to this. On the contrary, if a species is known to have a high secondary dispersal capacity, additional measures must be taken in order to confine the distribution of the species.

Interpretation of the map for Salmo salar

Figure 104 shows the risk map for the Atlantic salmon (*Salmo salar*). As can be seen on the map *S. salar* is native to a number of countries in the project area. However, the map does not offer the full story of *Salmo salar*. Apart from the native stock of Atlantic salmon, some of the countries in the region also have stocks of escaped farmed Atlantic salmon sharing habitats with the wild population and even causing hybridization between them. The farmed salmon have distinctive genetic compositions, which varies considerable from the native local races of Salmon and can cause behavioural and genetic problems for offspring between farmed and wild salmon. According to the NOBANIS factsheet for *Salmo salar* this is particularly the case for Norway where farming of salmon dates back to 1969 and where escaped specimens are considered very common. Additionally it is also the case for Denmark, Poland, Ireland, Sweden and occasionally for Finland in rivers on the border to Norway but in these countries the escaped salmons are only found in a few sites (Fiske, 2006).

It is known that the escaped salmons have an impact on the wild populations of *Salmo salar* since they may be affected by competition (Lura and Sægrov, 1991; Fleming et al., 1996), by gene flow from farmed individuals to wild stock (McGinnity et al., 1997; Fleming et al., 2000; McGinnity et al., 2004) and through the spreading of deceases and parasites such as salmon lice (Heuch and Moe, 2001; Bjørn and Finstad, 2002).

How to depict the Atlantic salmon on the risk map is a matter of choosing if the distribution of the wild or the farmed salmon should be shown on the maps since the maps do not at present offer the possibility to show both at the same time.

National alarm lists

The maps in this report illustrate the presence and absence of species in countries in the region and thus act as a simple early warning system between countries in the northern part of Europe. From the maps, each country can get an overview of which of the 100 alien species selected for this project that are present – and to what extent they are present – in neighbouring countries. Additionally the maps indicate in which biogeographical regions the species have been capable of establishing viable populations. The country then knows that if the species has established in another country in a biogeographical zone identical to a zone they have in their country then, should the species arrive, it may possibly be able to establish in their country as well. This overview can provide countries with a foundation to prioritise appropriate actions against the IAS. With a targeted and rapid response towards newly arrived alien species the possibilities of controlling them are much better.

The procedure of making an alarm list for a country would simply include going through the Category 2 and 3 maps, registering if the species are present in one or more of the EEA-zones identical to the one/ones the country is covering.

In the following, an example will be given of how to assess if a species should be added to a country alarm list, using Norway as example;

Dreissena polymorpha, zebra mussel, is a freshwater mussel native to the drainage basins of the Black, Caspian and Aral Seas. The map in **Figure 33** shows that it is established in alpine, continental, Atlantic and boreal zones in Ireland, Austria, Germany, Poland, Belgium, The Netherlands, Latvia, Lithuania, Finland and Sweden. According to the map it is not present in Norway. Since *Dreissena polymorpha* has shown that it can establish viable populations in the above-mentioned zones, Norway has reason to believe that the mussel has the ability to spread and establish on Norwegian territory. Hence Norway can add the mussel to their alarm list for all of the country's zones apart perhaps from the arctic zone where is has not yet proven to be able to establish. In this case the reason for this can be that it has not yet had the opportunity to invade an arctic zone and this must be taken into consideration. Certainly, this knowledge gives an indication that Norway would be well advised to assess the risks that *Dreissena sp*. may have and take measures thereafter.

For *Linepithema humile*, the Argentine ant, the map in **Figure 85** shows that it is established in the continental zone and casual in the Atlantic zone. For Norway this means that they primarily will have to be precautionary if the species is found in their Atlantic zone since it has proven to be capable of establishing in that climatic zone. Hence *Linepithema humile* will be added to the Norwegian alarm list. If the species is found in a different zone than the Atlantic, naturally a precautionary approach should be taken, since knowledge of establishing possibilities for that zone could be unknown so far.

Risk maps

Category 1 maps

The following 20 maps from **Figure 4** to **Figure 23** (both included) are Category 1-maps.

Common for the Category 1-maps is that these species have a detailed distribution map available. Species are established as non-native in at least one country in the NOBANIS region.

Risk profiles of Category 1 species will be used in the report to compare the risk profiles of EEA biogeographic zones to risk profiles based on Metzger's environmental zones.

The distributions of the species are hence displayed on maps with EEA-biogeographical partitions as well as on maps with Metzger partitions.

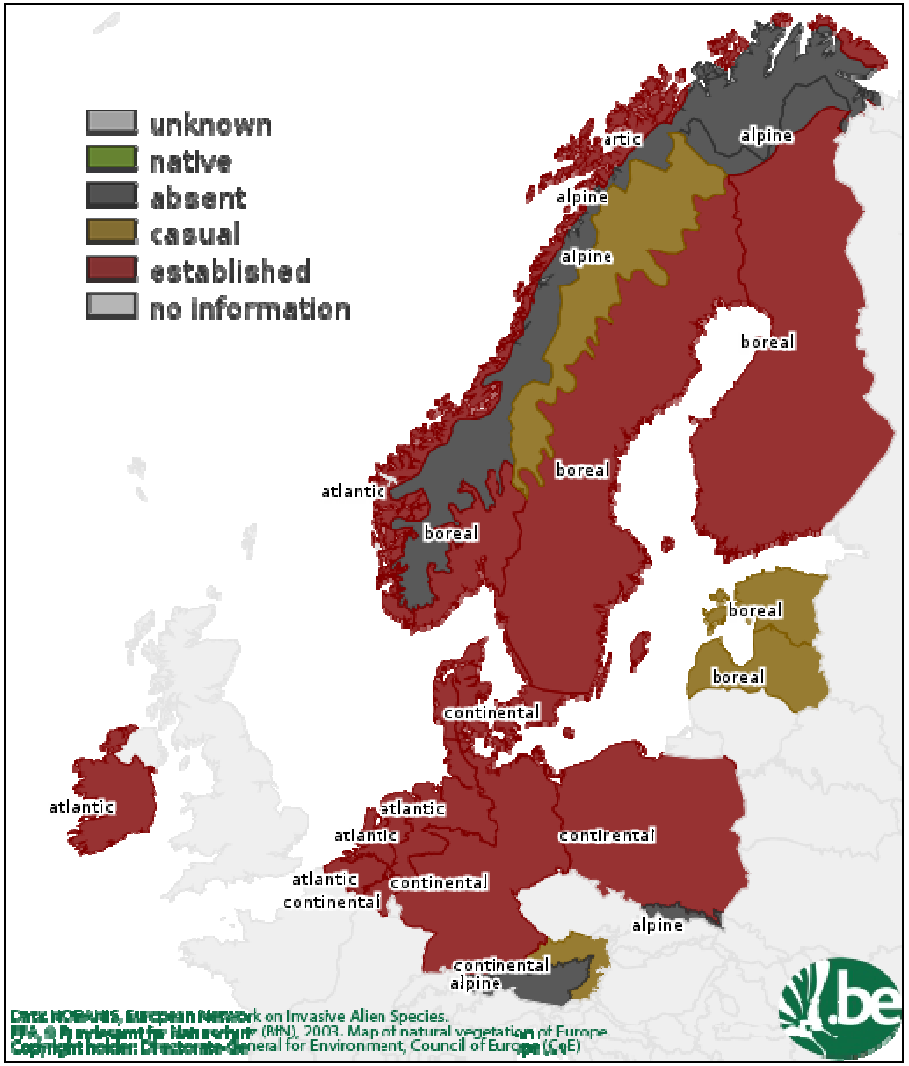


Figure 4: *Branta canadensis* – EEA. *Branta canadensis* is established in continental, atlantic, boreal and arctic zones. It is casual in the alpine zone.

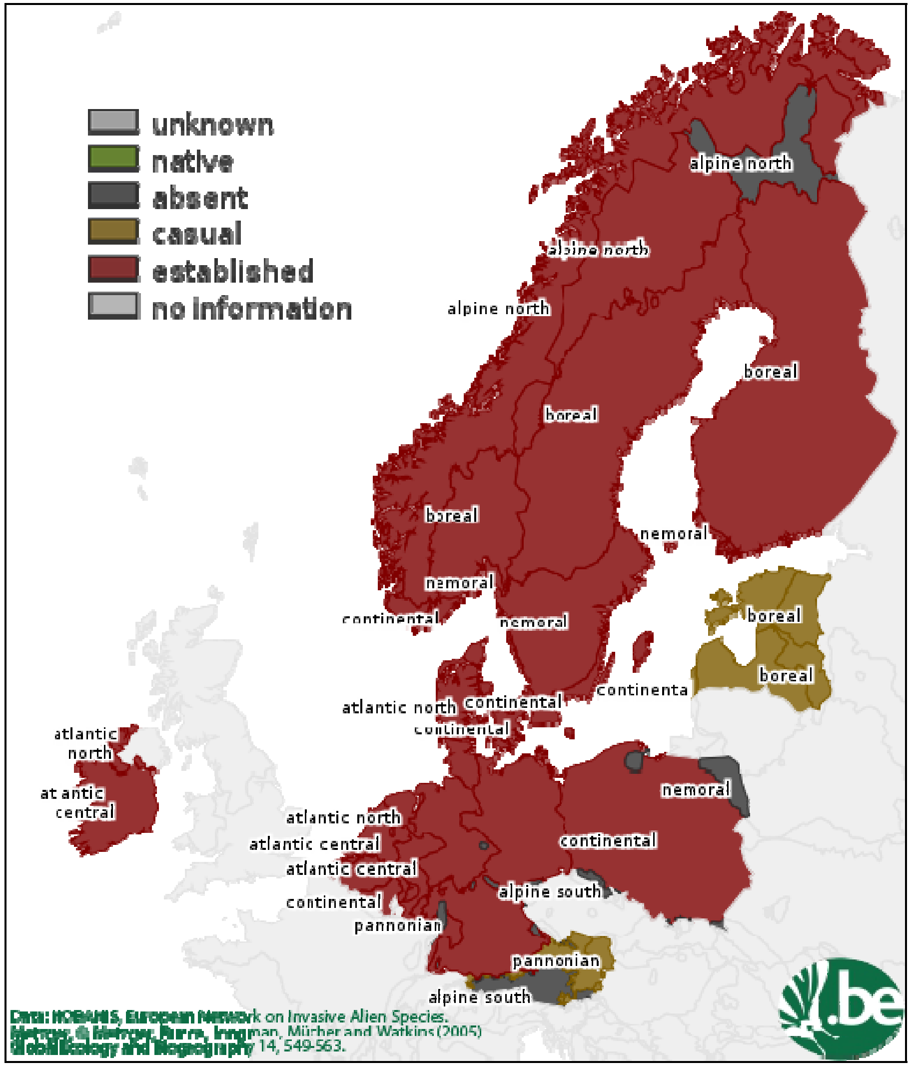


Figure 5: *Branta canadensis* – Metzger. *Branta canadensis* is established in continental, atlantic central and north, nemoral, boreal and alpine north zones. It is casual in the pannonian zone.

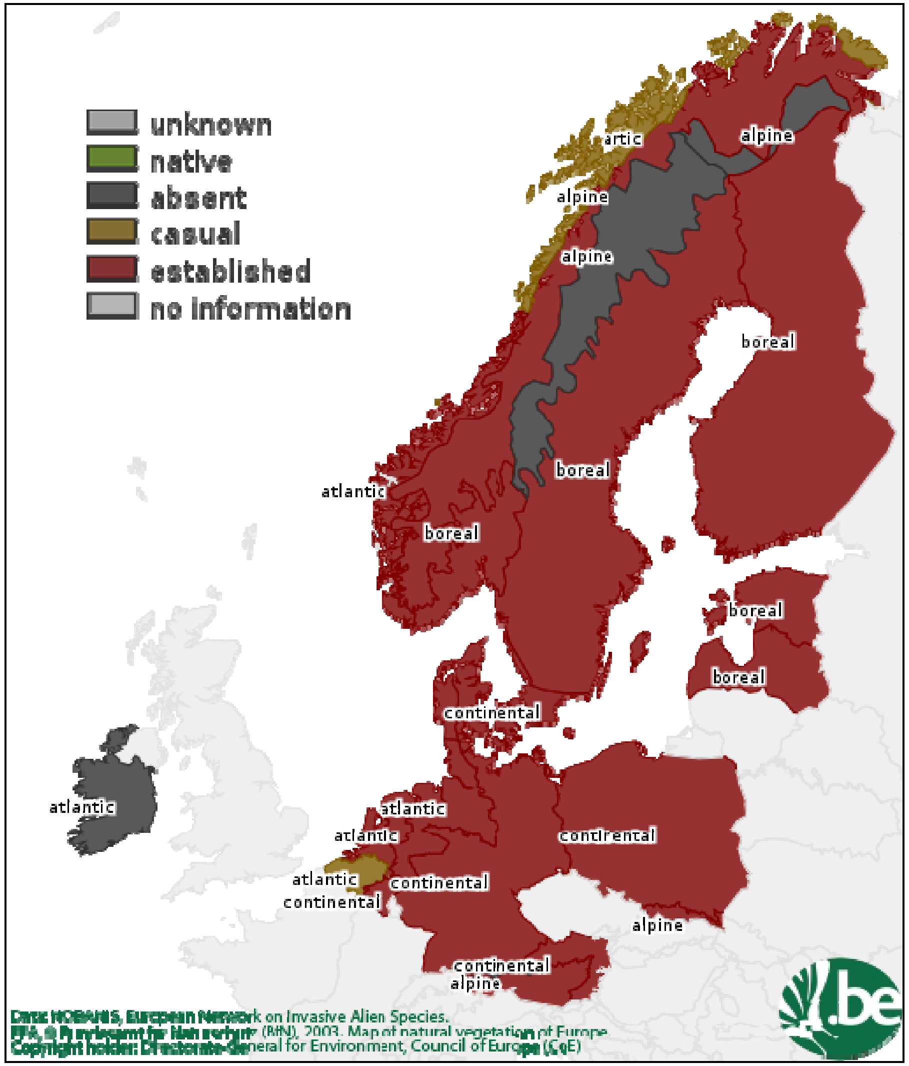


Figure 6: ***Bunias orientalis* – EEA.** *Bunias orientalis* is established in alpine, continental, atlantic and boreal zones. It is casual in the arctic zone.

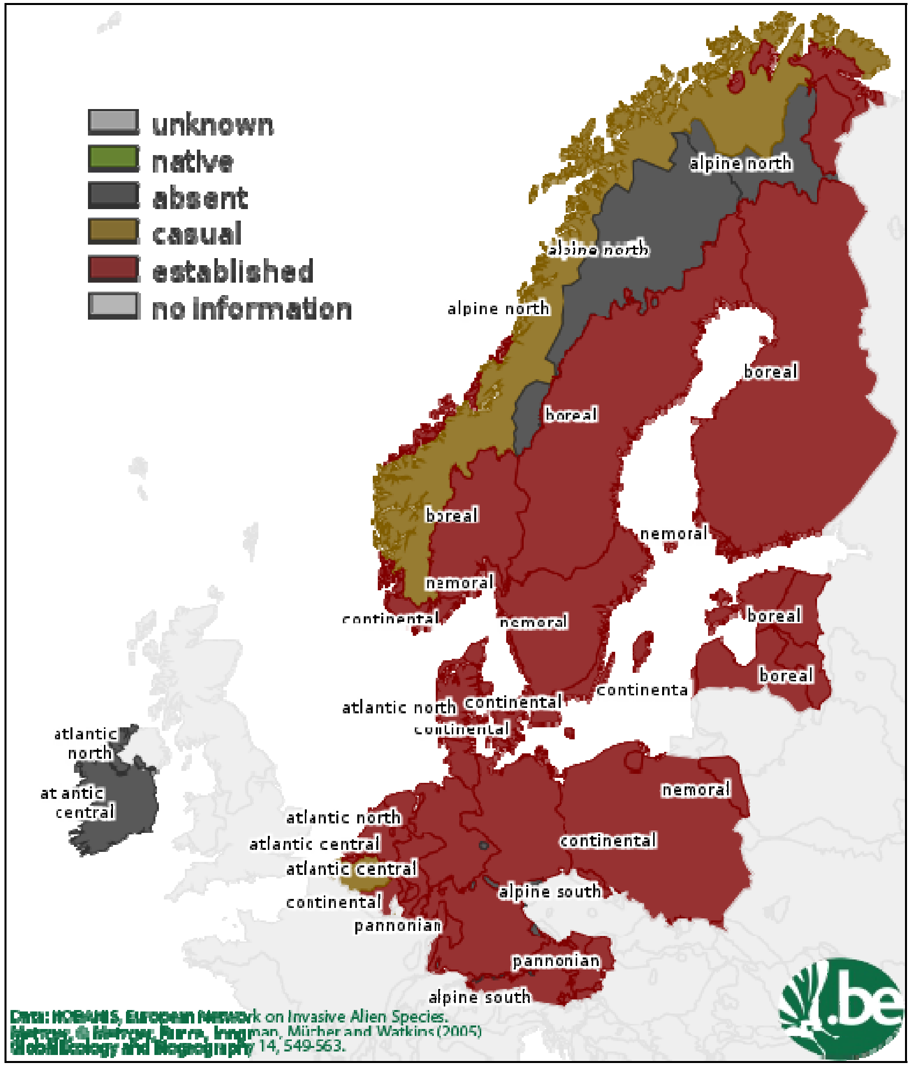


Figure 7: ***Bunias orientalis* – Metzger.** *Bunias orientalis* is established in alpine south, pannonian, continental, atlantic central and north, nemoral and boreal. It is casual in the alpine north zone.

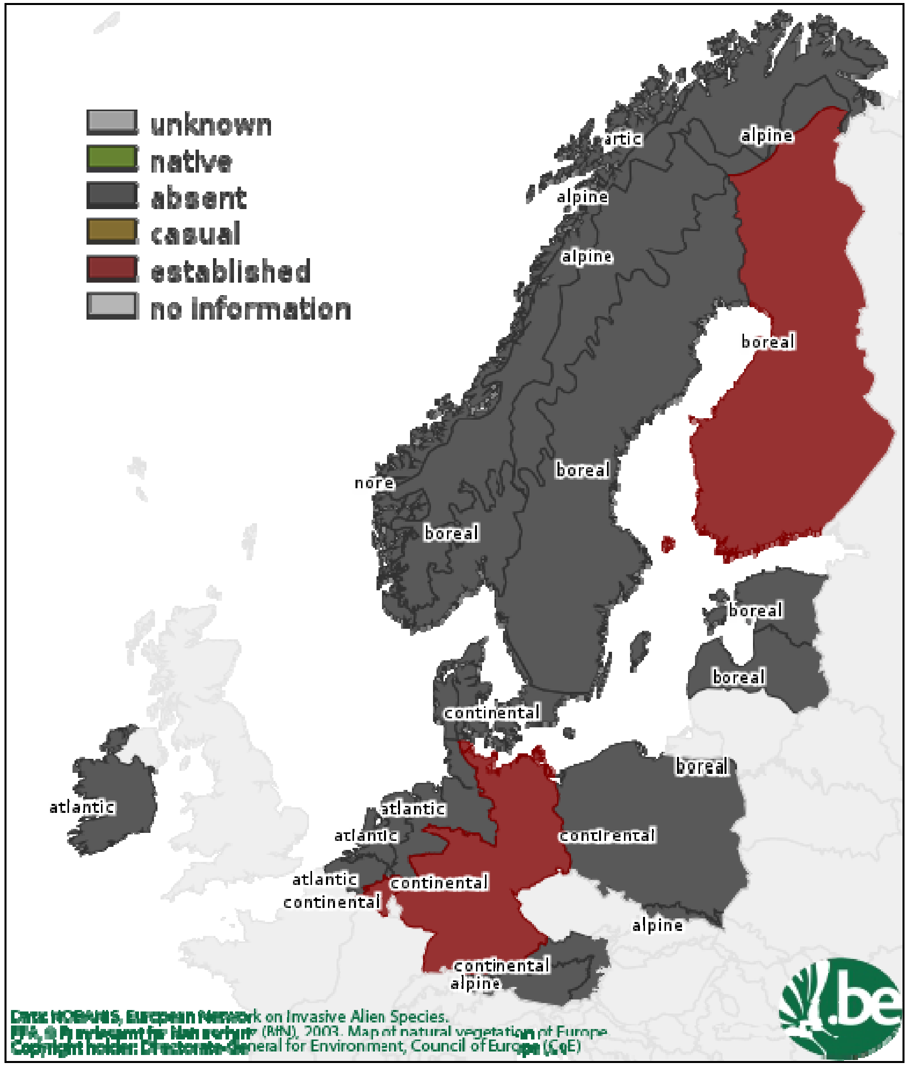


Figure 8: ***Castor canadensis*** **– EEA.** *Castor canadensis* is established in continental and boreal zones.

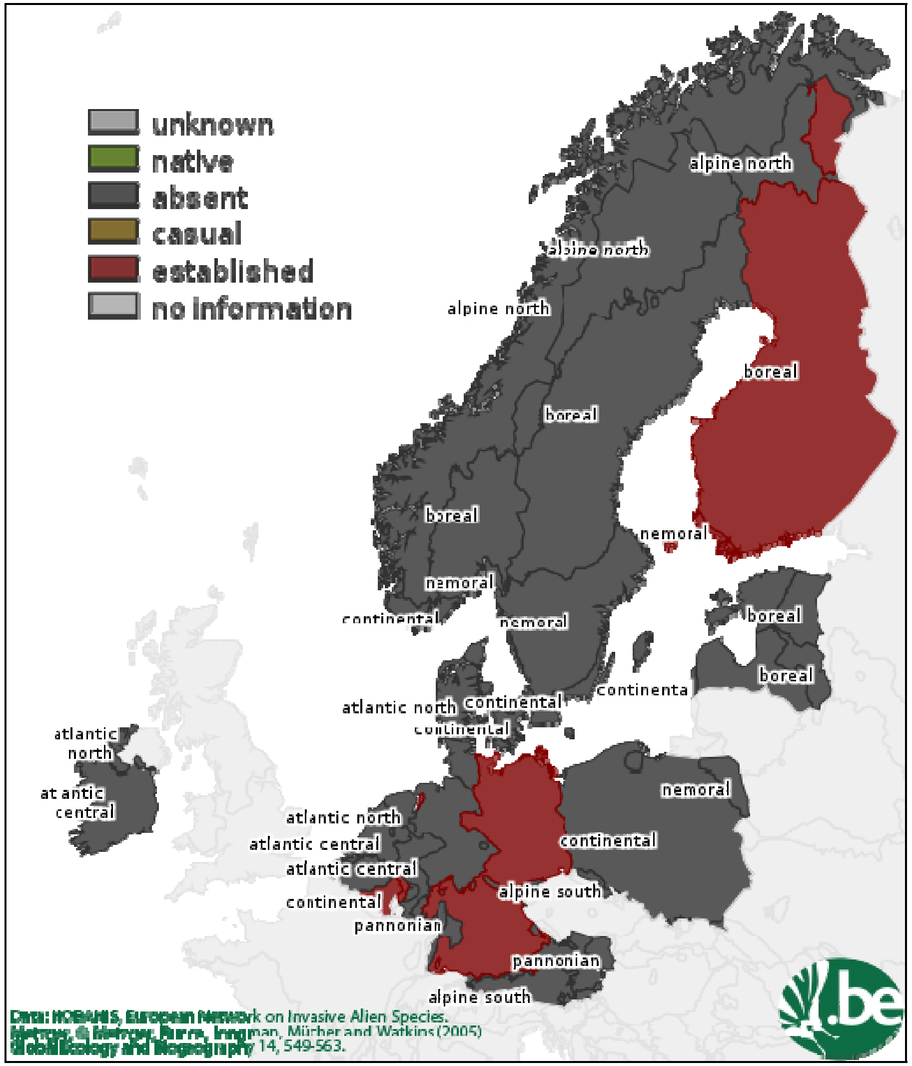


Figure 9: ***Castor canadensis*** **– Metzger.** *Castor canadensis* is established in alpine south, continental and boreal zones.

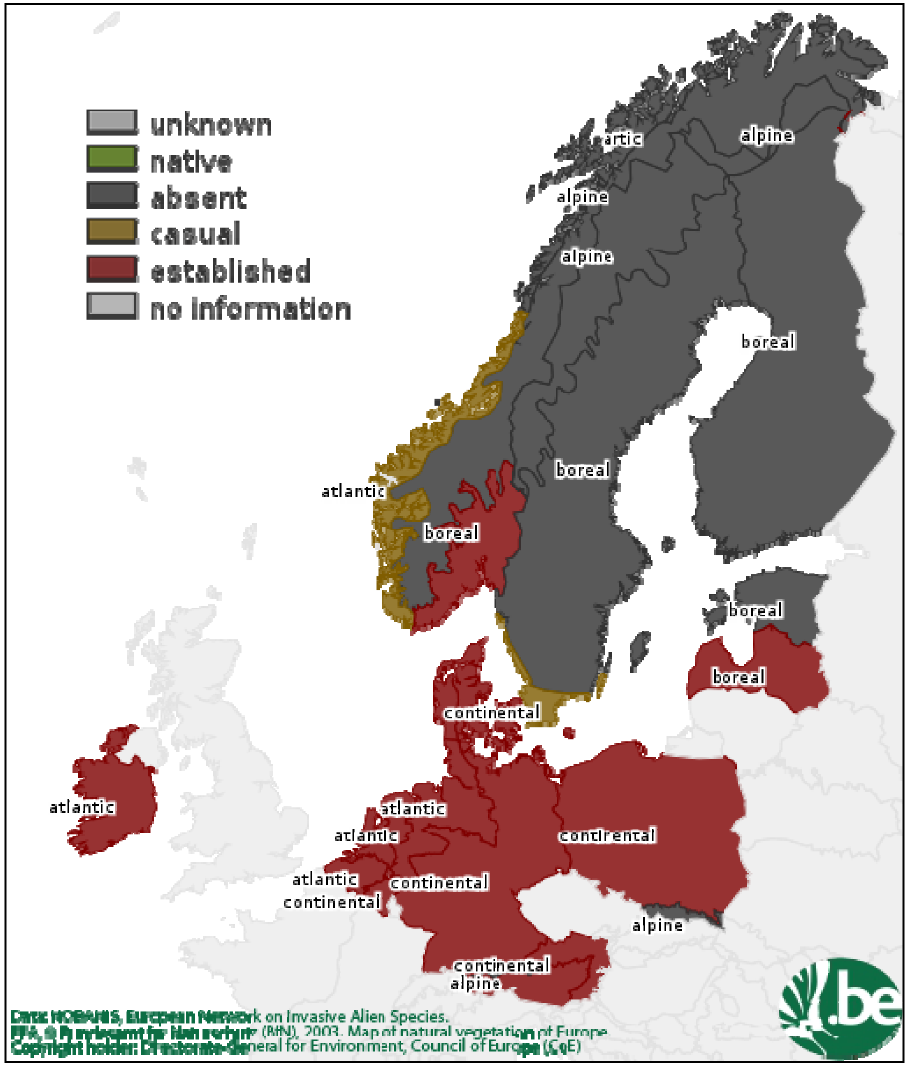


Figure 10: *Harmonia axyridis* – EEA. *Harmonia axyridis* is established in alpine, continental, atlantic and boreal zones.

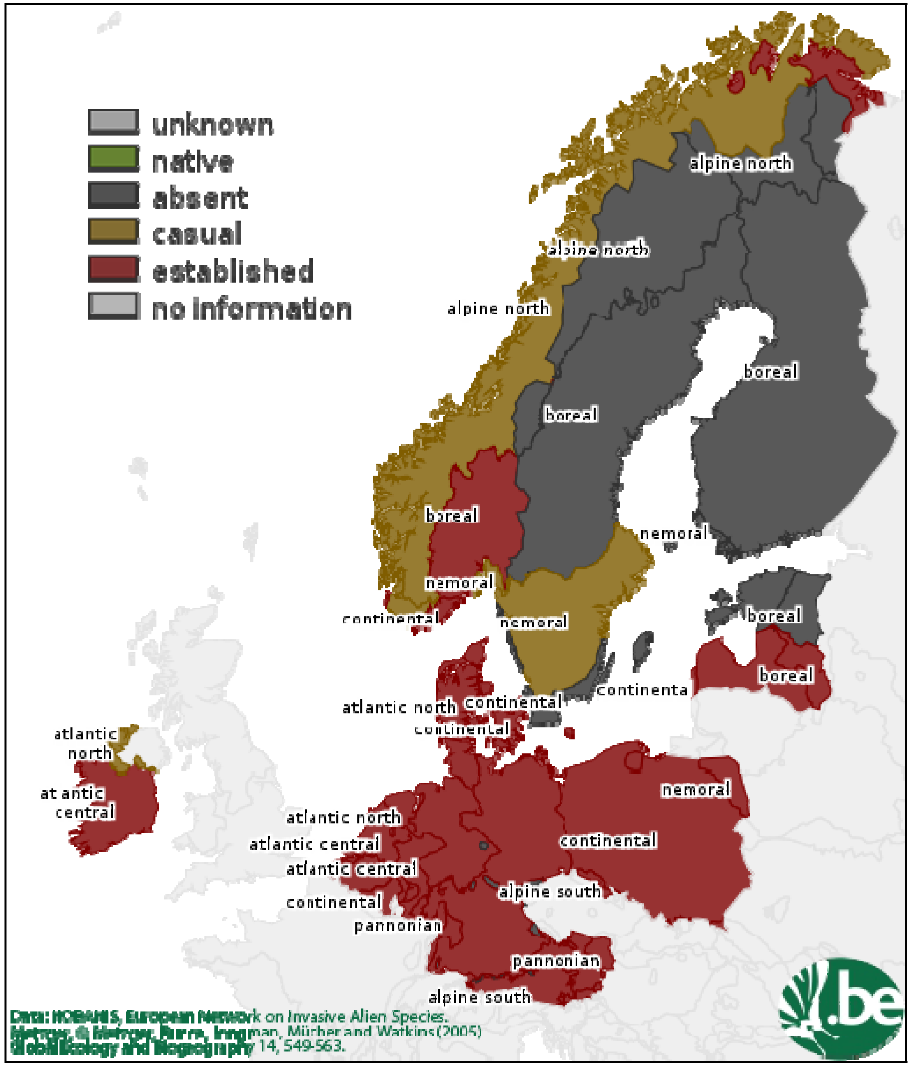


Figure 11: *Harmonia axyridis* – Metzger. *Harmonia axyridis* is established in alpine south, pannonian, continental, atlantic central and north, nemoral and boreal. It is casual in alpine north.

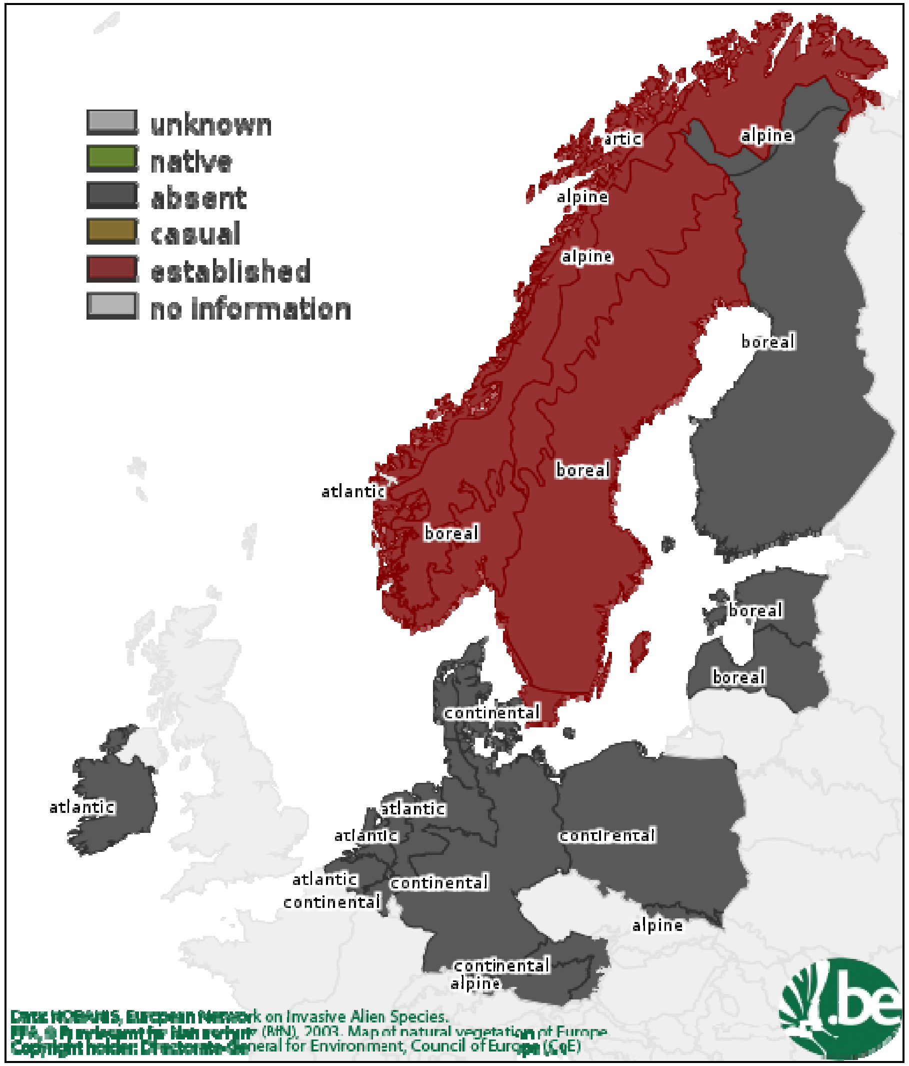


Figure 12: *Lupinus nootkatensis* – EEA. *Lupinus nootkatensis* is established in atlantic, boreal, alpine and arctic zones.

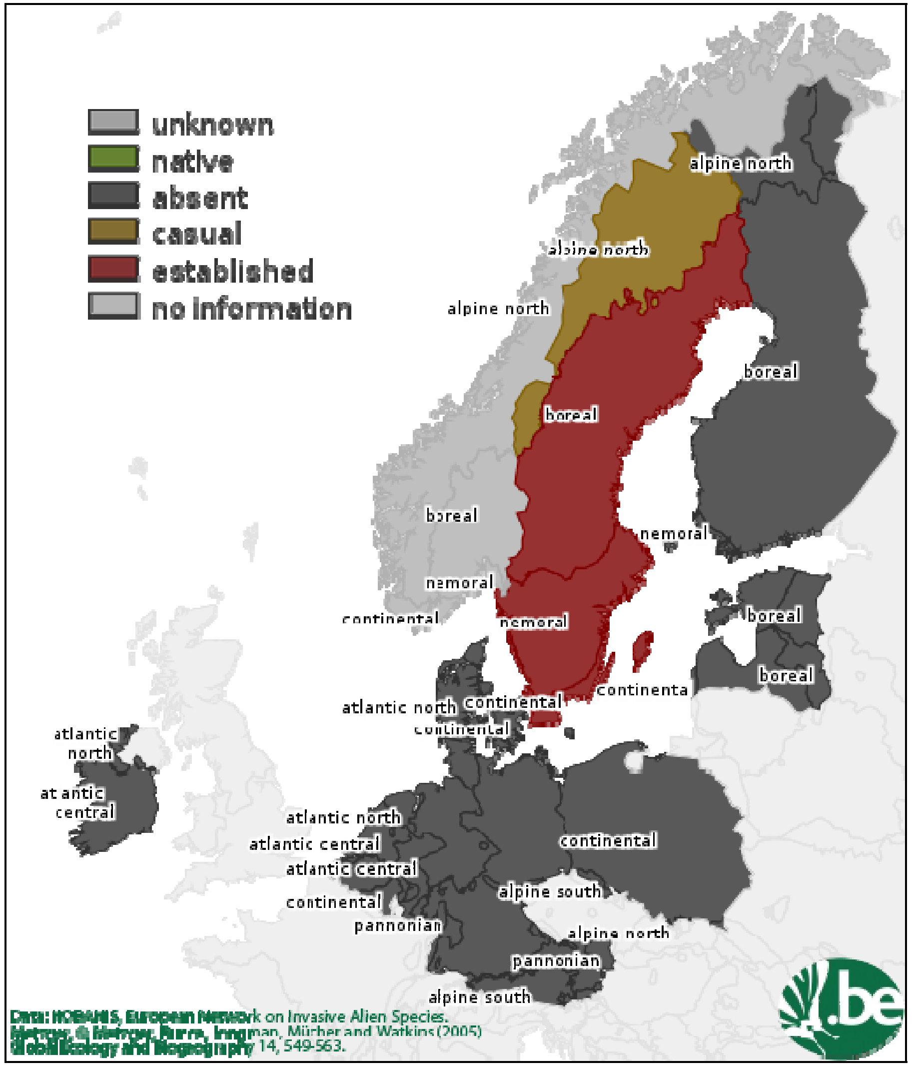


Figure 13: *Lupinus nootkatensis* – Metzger. *Lupinus nootkatensis* is established in continental, nemoral and boreal zones. It is casual in alpine north.

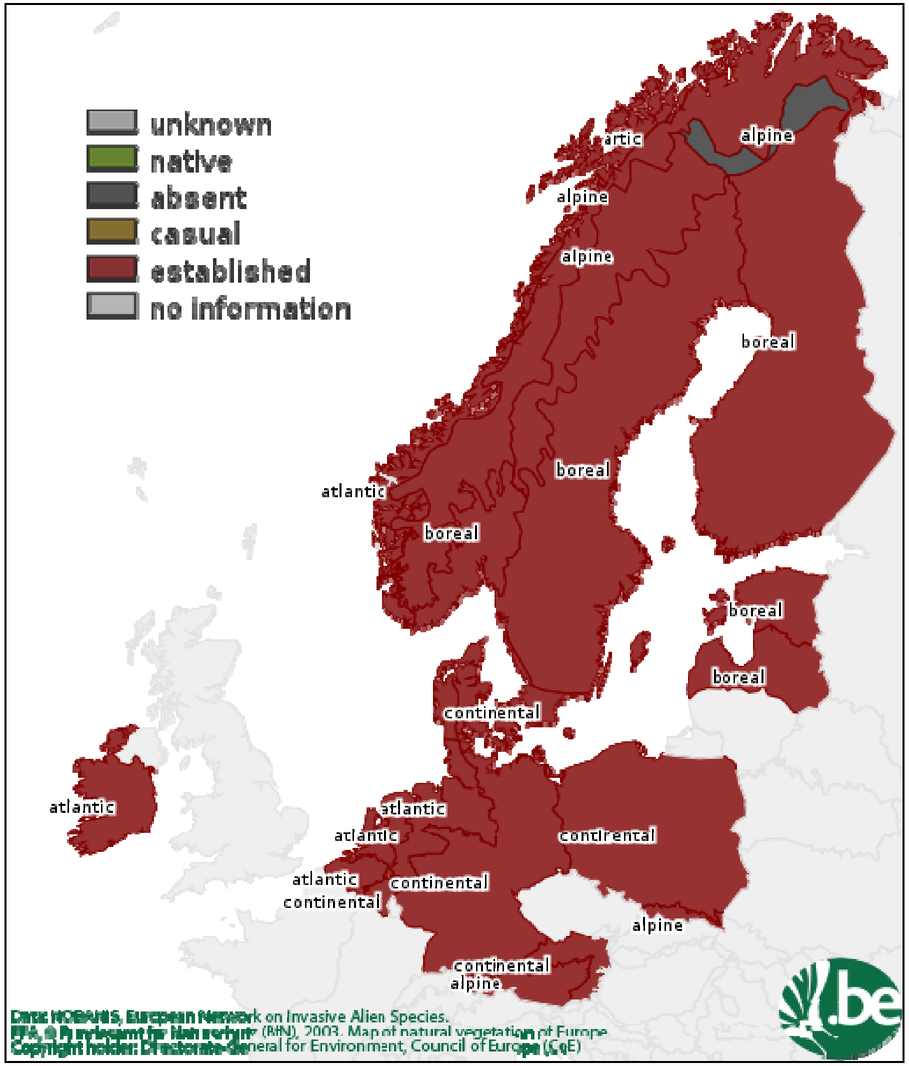


Figure 14: ***Lupinus polyphyllus* – EEA.** *Lupinus polyphyllus* is established in alpine, continental, atlantic, boreal and arctic zones.

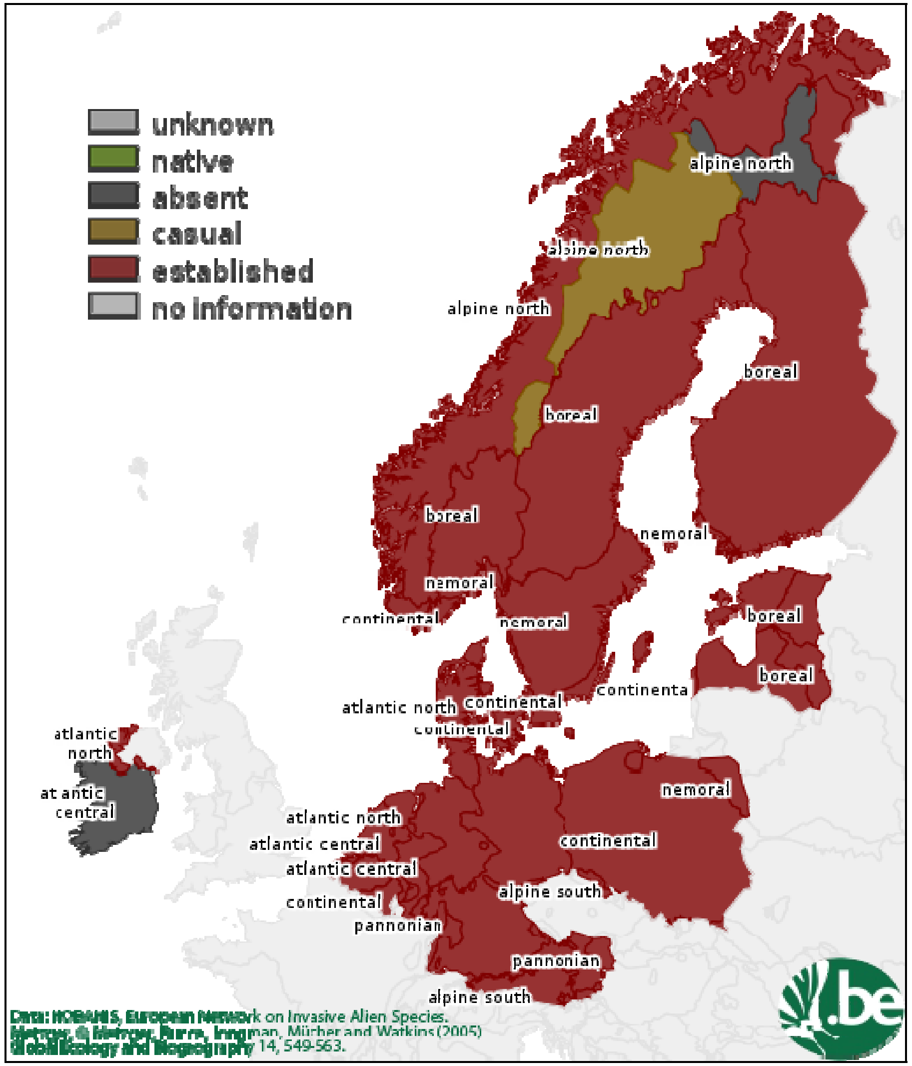


Figure 15: ***Lupinus polyphyllus* – Metzger.** *Lupinus polyphyllus* is established in alpine south and north, pannonian, continental, atlantic central and north, nemoral and boreal.

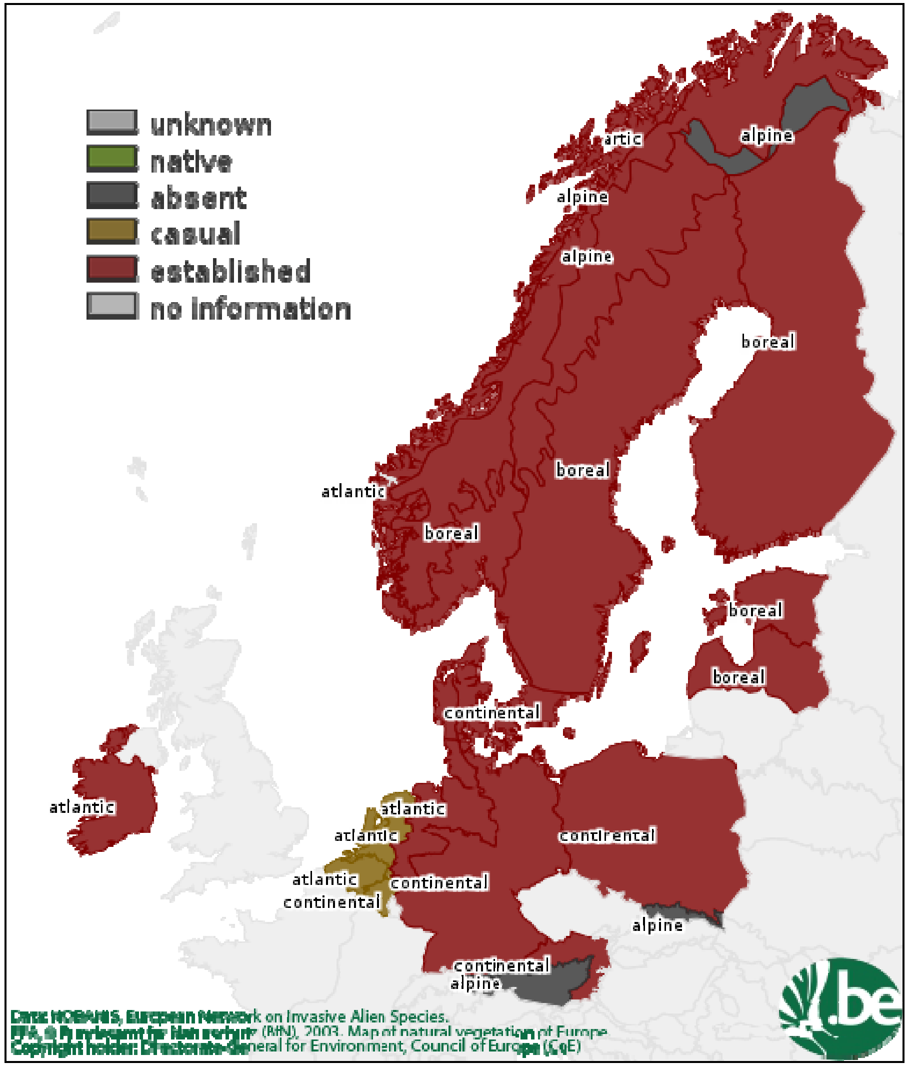


Figure 16: *Mustela vison* – EEA. Mustela vison is established in alpine, continental, atlantic , boreal and arctic zones.

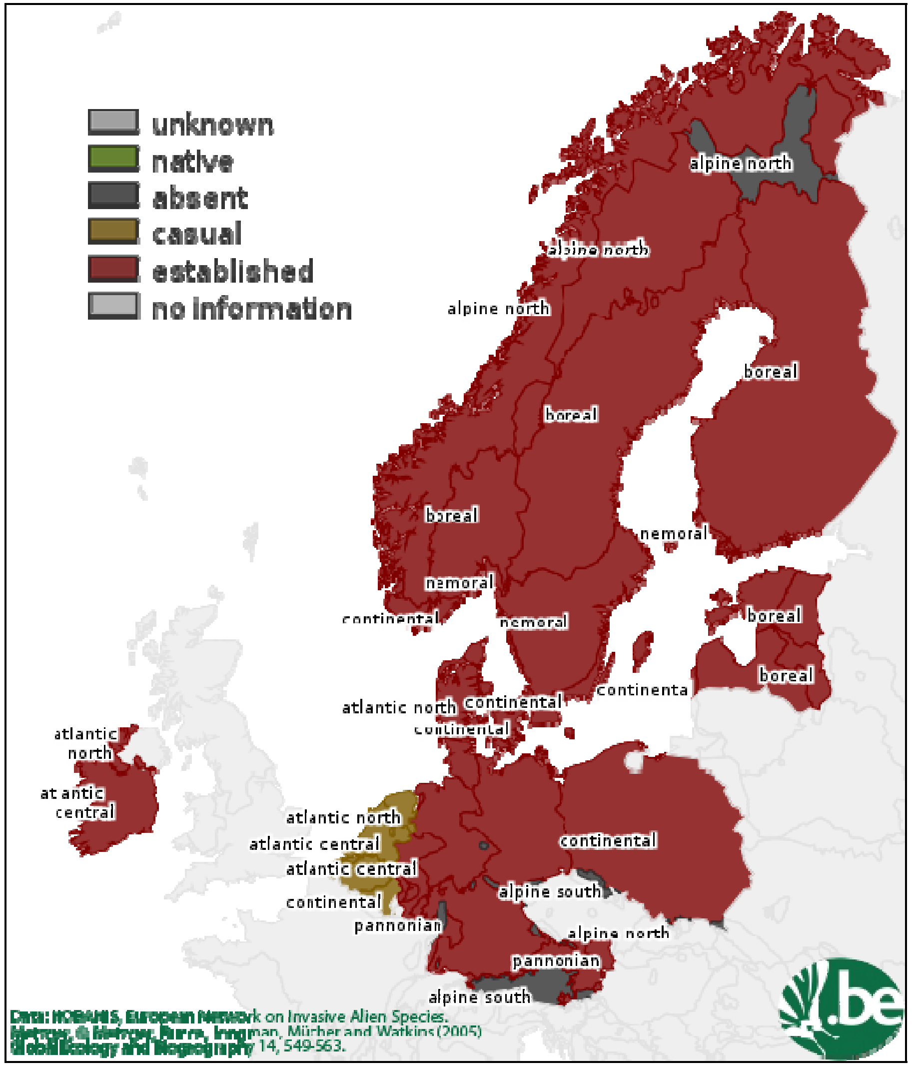


Figure 17: *Mustela vison* – Metzger. *Mustela vison* is established in pannonian, continental, atlantic central and north, nemoral, boreal and alpine north zones.

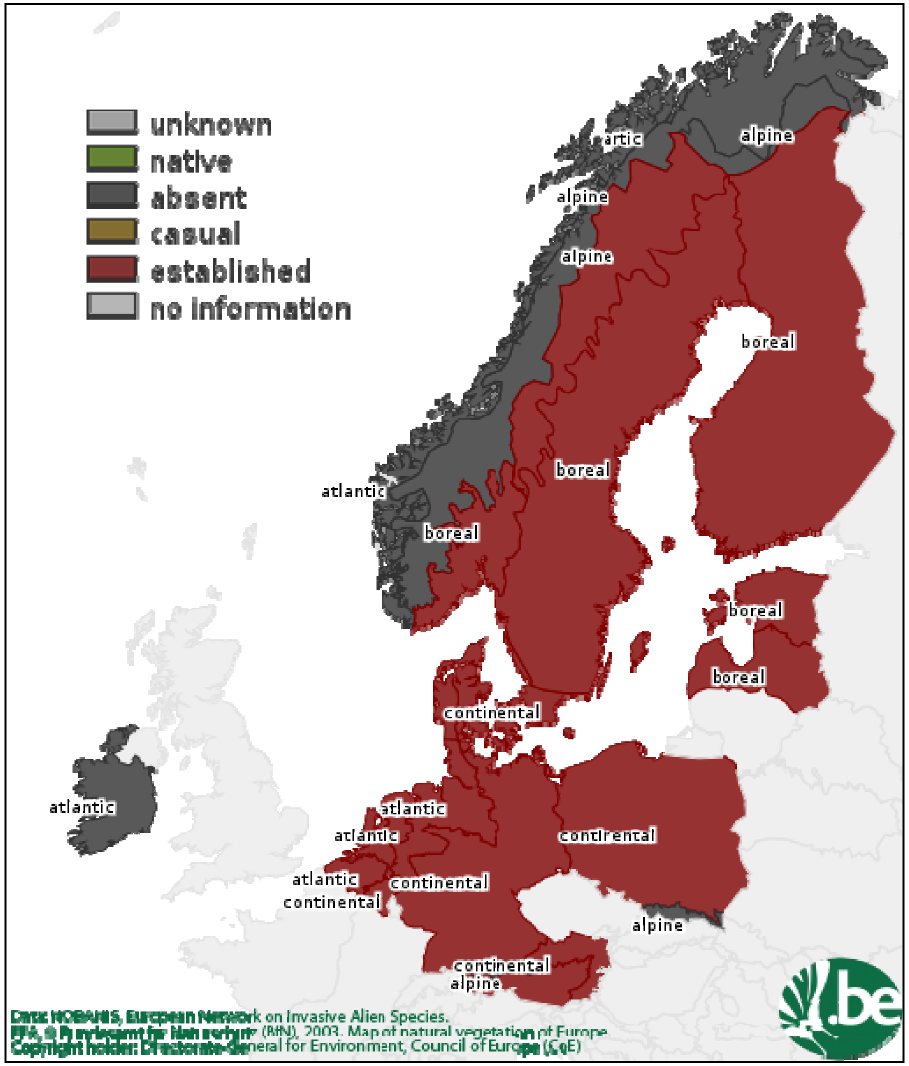


Figure 18: *Pacifastacus leniusculus* – EEA. *Pacifastacus leniusculus* is established in alpine, continental, atlantic and boreal zones.

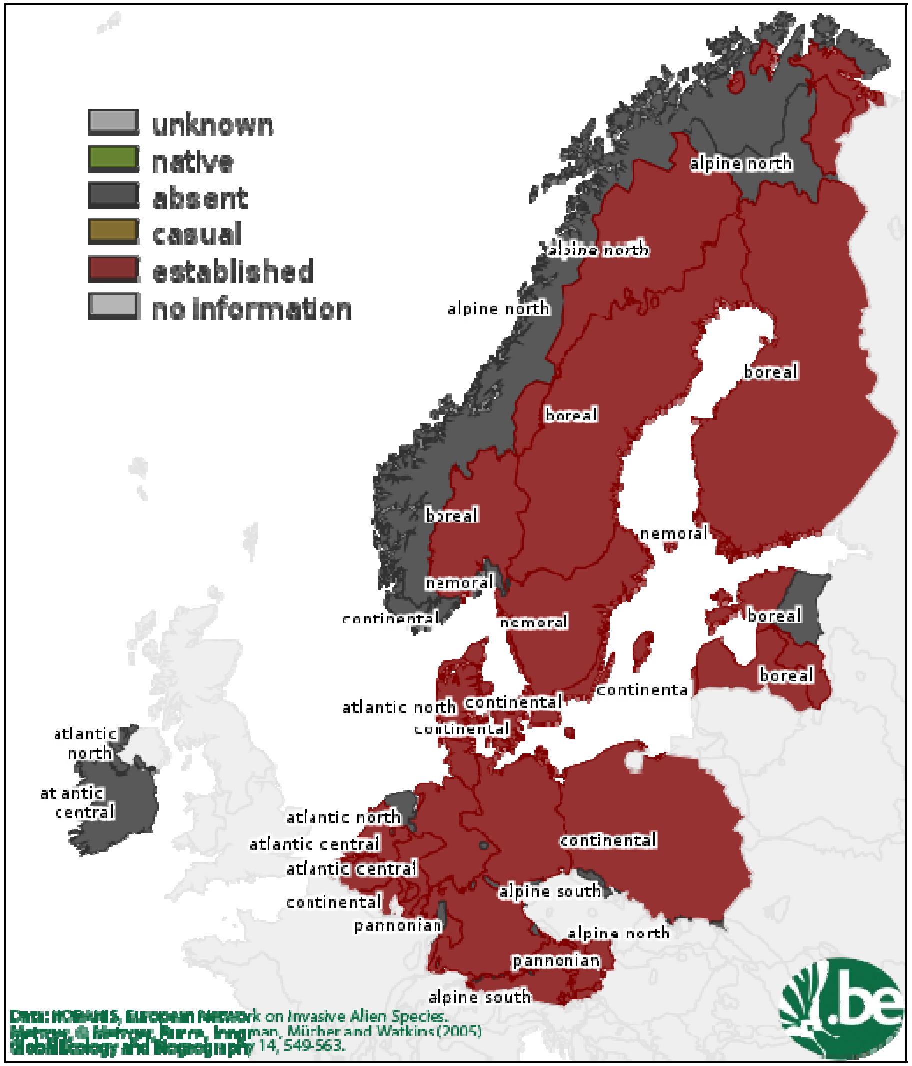


Figure 19: *Pacifastacus leniusculus* – Metzger. *Pacifastacus leniusculus* is established in alpine south and north, pannonian, continental, atlantic central and north, nemoral and boreal zones.

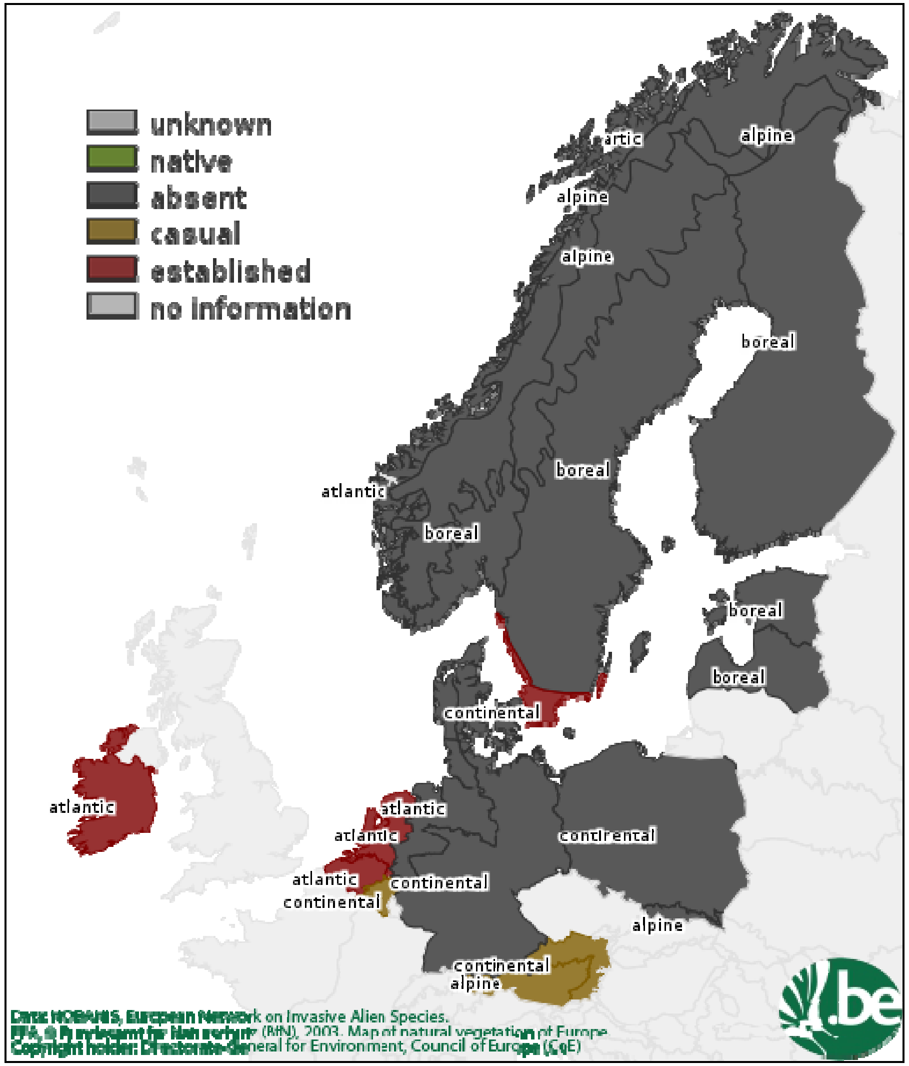


Figure 20: *Rhododendron ponticum* – EEA. *Rhododendron ponticum* is established in continental and atlantic zones. It is casual in the alpine zone.

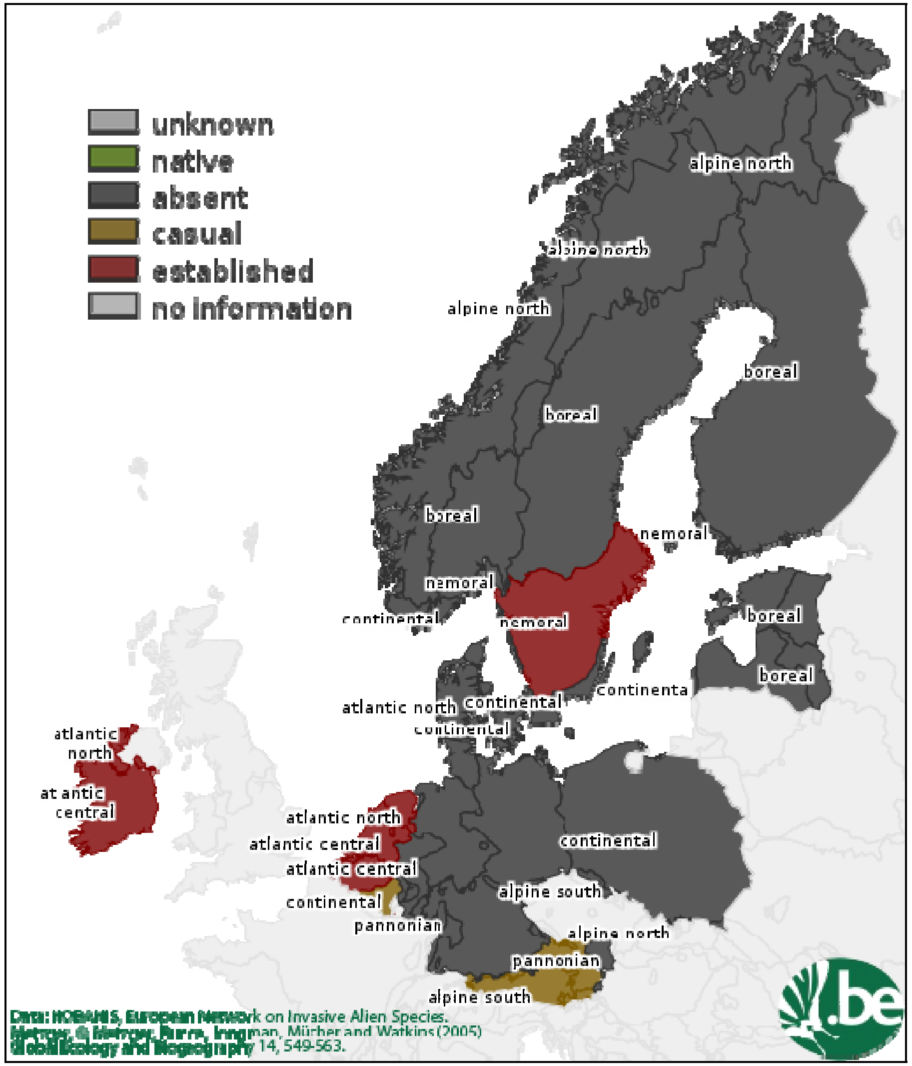


Figure 21: *Rhododendron ponticum* – Metzger. *Rhododendron ponticum* is established in atlantic central and north, and the nemoral zones. It is casual in the pannonian and continental zone.

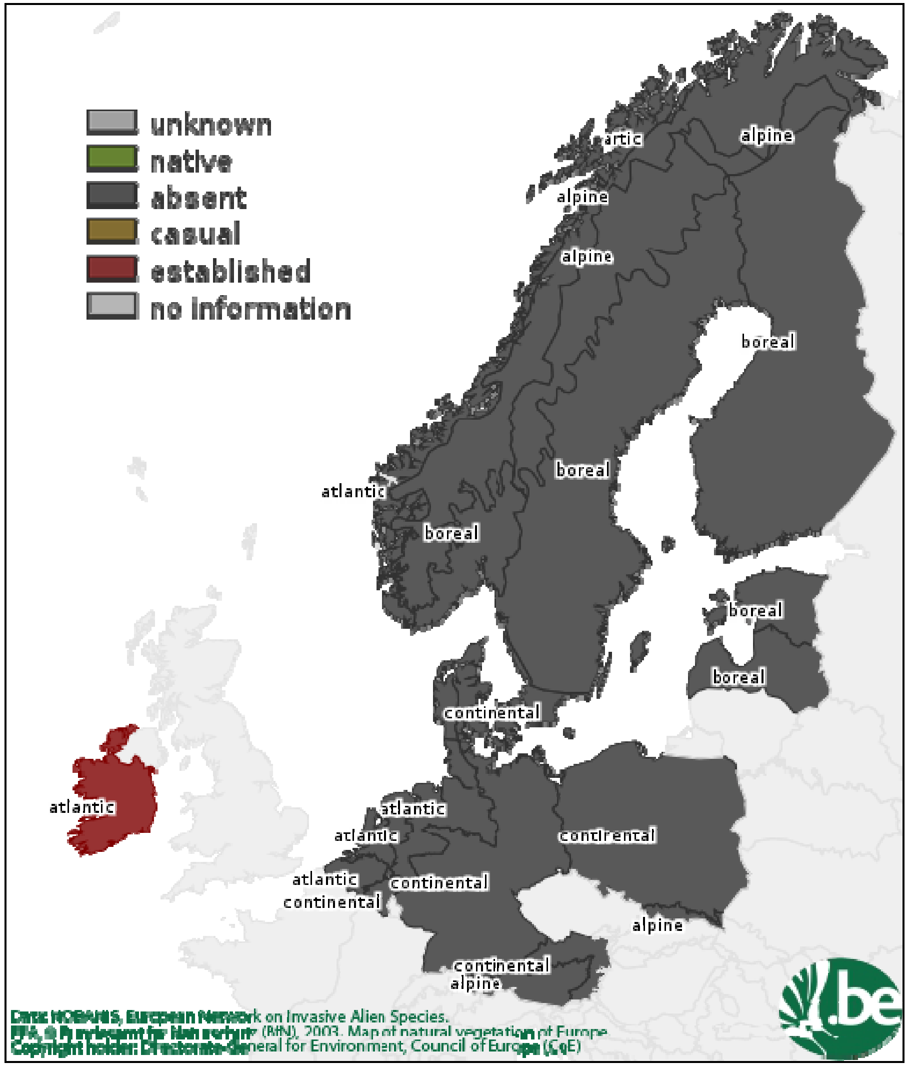


Figure 22: *Sciurus carolinensis* – EEA. *Sciurus carolinensis* is established in the atlantic zone.

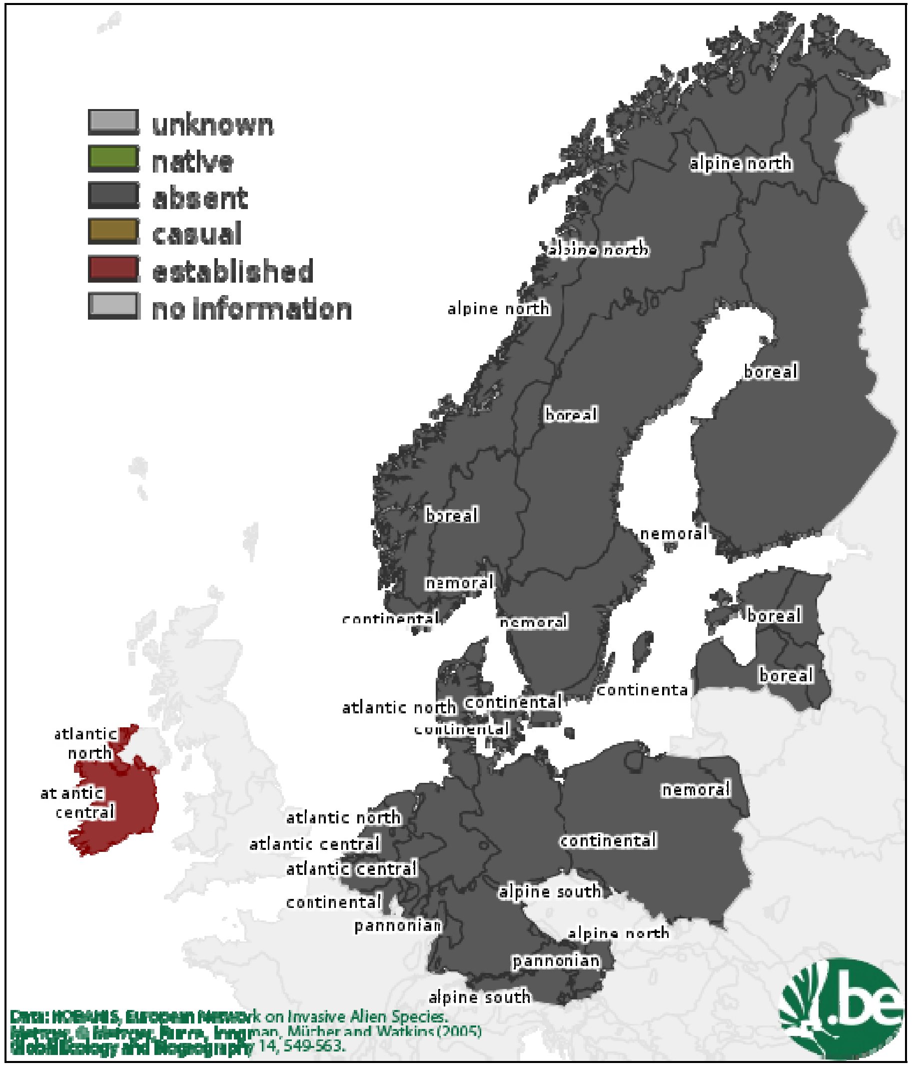


Figure 23: *Sciurus carolinensis* – Metzger. *Sciurus carolinensis* is established in atlantic central and north.

Category 2 maps

The following 33 maps from **Figure 24** to **Figure 56** (both included) are Category 2-maps.

Common for the Category 2-maps is that they are species with no detailed distribution map available. The species are established in the NOBANIS region either recently or has been for a longer period of time but are still expanding their introduced range.

Risk profiles of Category 2 species will be useful for countries to create their alarm list.

The distributions of the species are displayed on maps with EEA-biogeographical partitions.

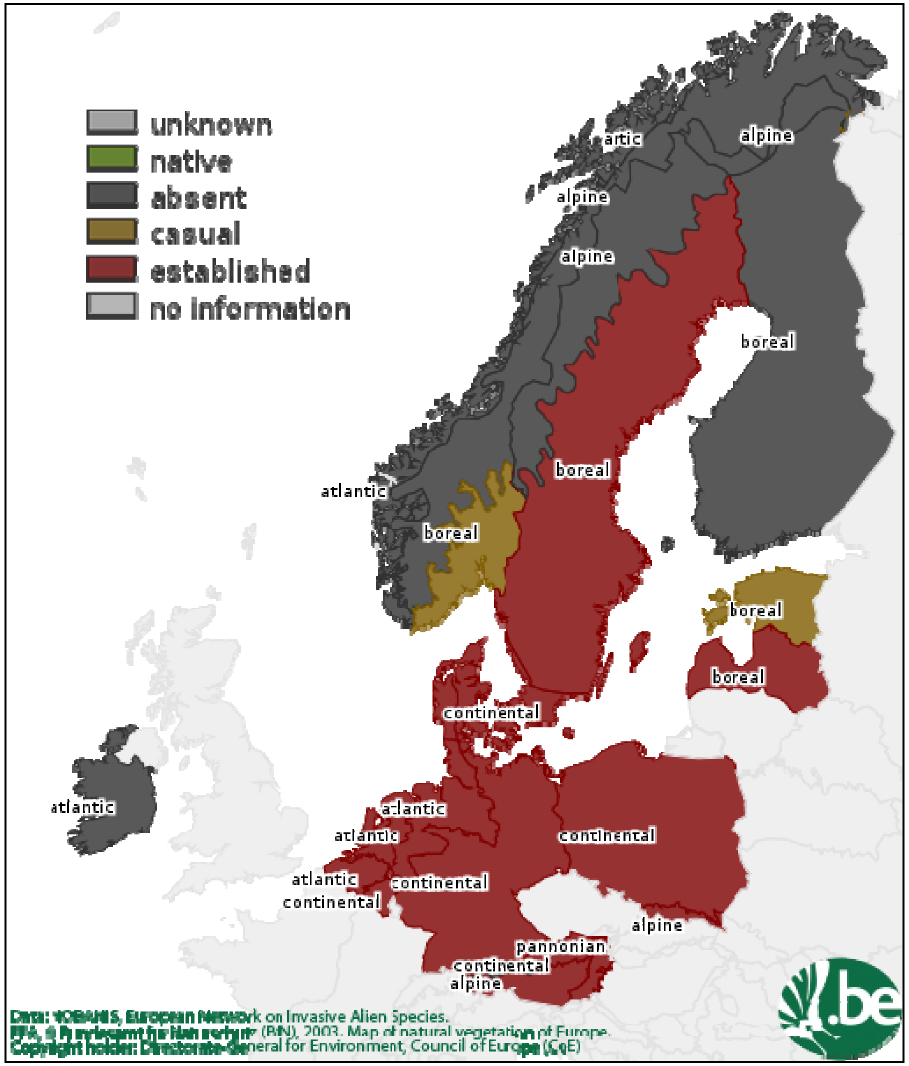


Figure 24: ***Acer negundo*** **– EEA.** *Acer negundo* is established in alpine, continental, atlantic and boreal zones. First record 1800 in AT. Dispersal rate fairly slow.

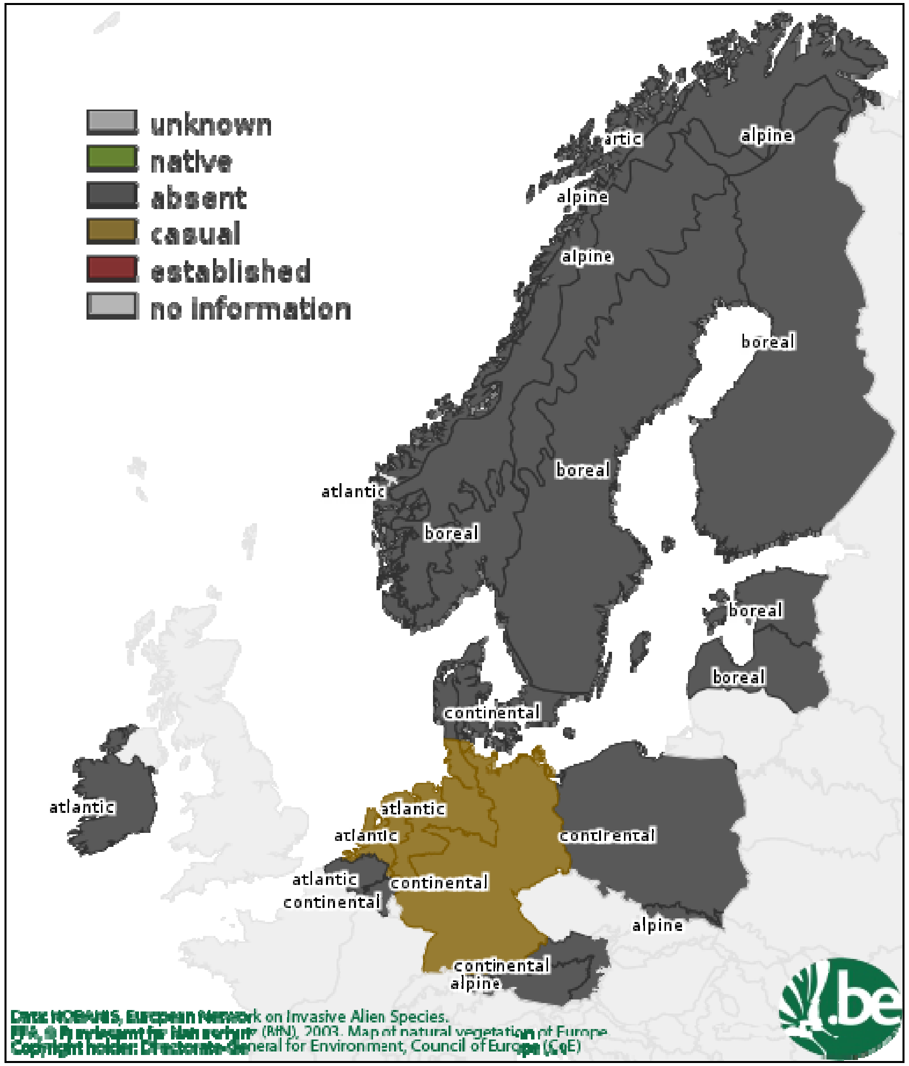


Figure 25: ***Acridotheres tristis* – EEA.** *Acridotheres tristis* has not established in any zones. It is casual in continental and atlantic zones. First record 1905 in DE. Dispersal rate fairly high.

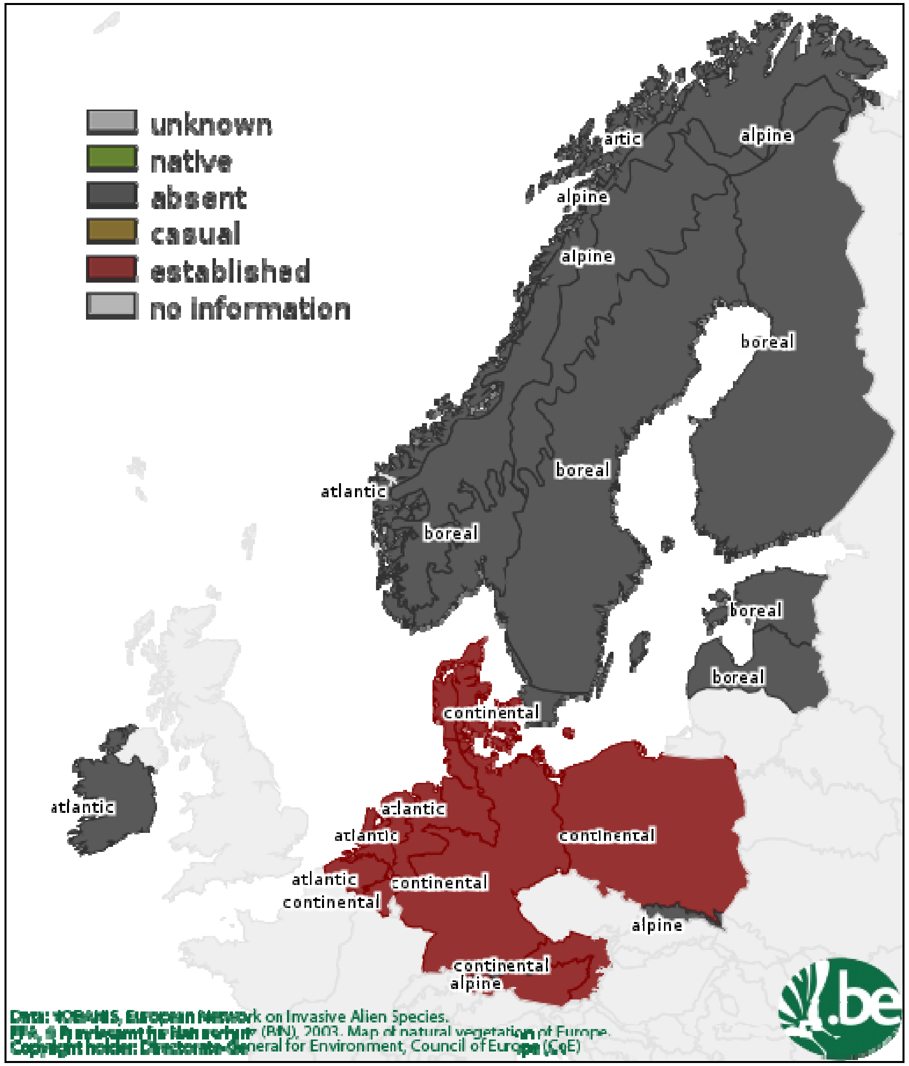


Figure 26: ***Ailanthus altissima* – EEA.** *Ailanthus altissima* is established in alpine, continental and atlantic zones. First record 1800 in DK. Dispersal rate fairly slow.

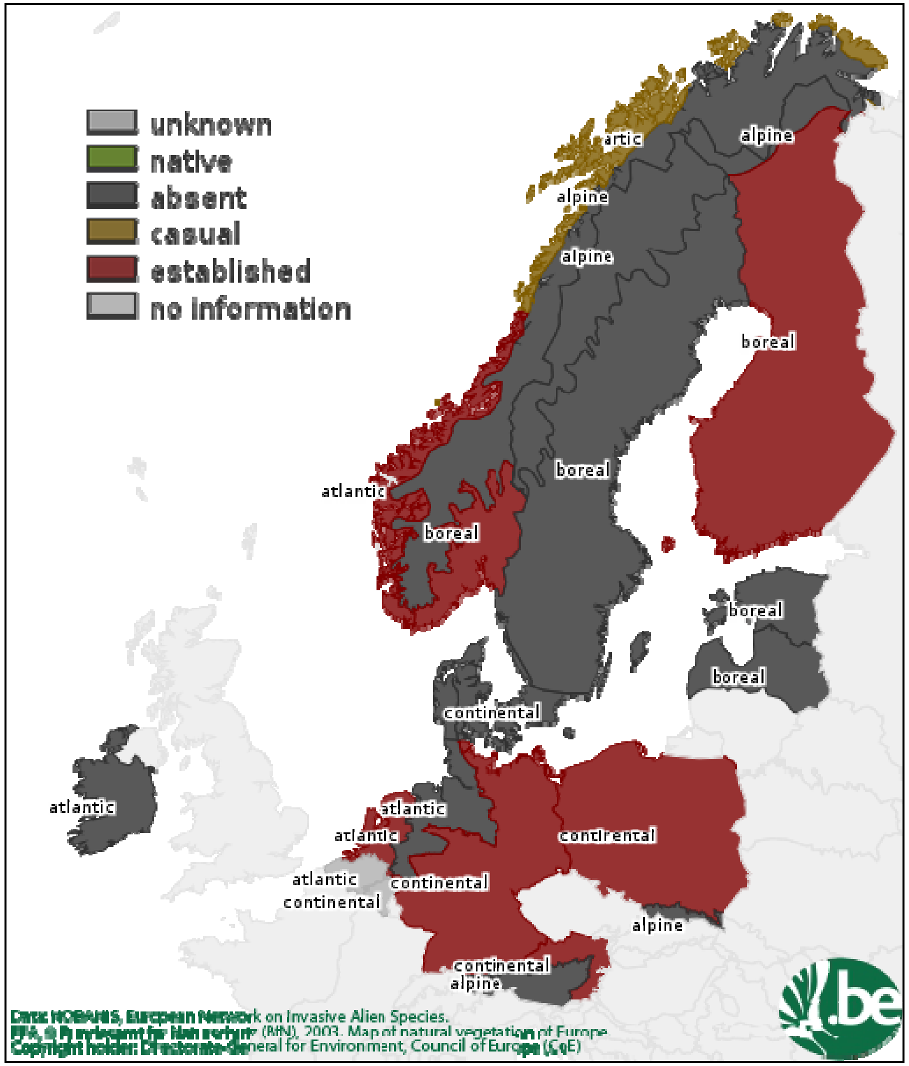


Figure 27: *Ameiurus melas* – EEA. *Ameiurus melas* is established in continental, atlantic and boreal zones. It is casual in the arctic zone. Dispersal rate medium.

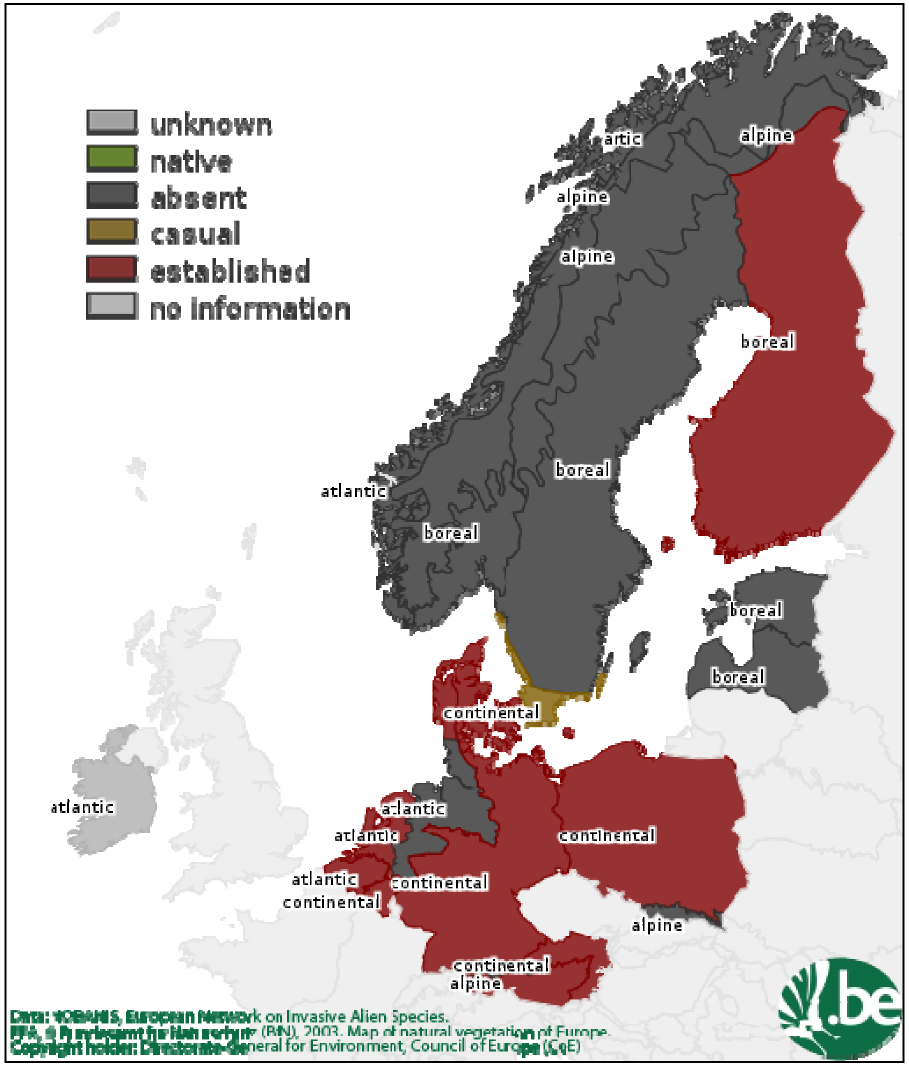


Figure 28: *Ameiurus nebulosus* – EEA. *Ameiurus nebulosus* is established in alpine, continental, atlantic and boreal zones. First record 1871 in BE. Dispersal rate medium.

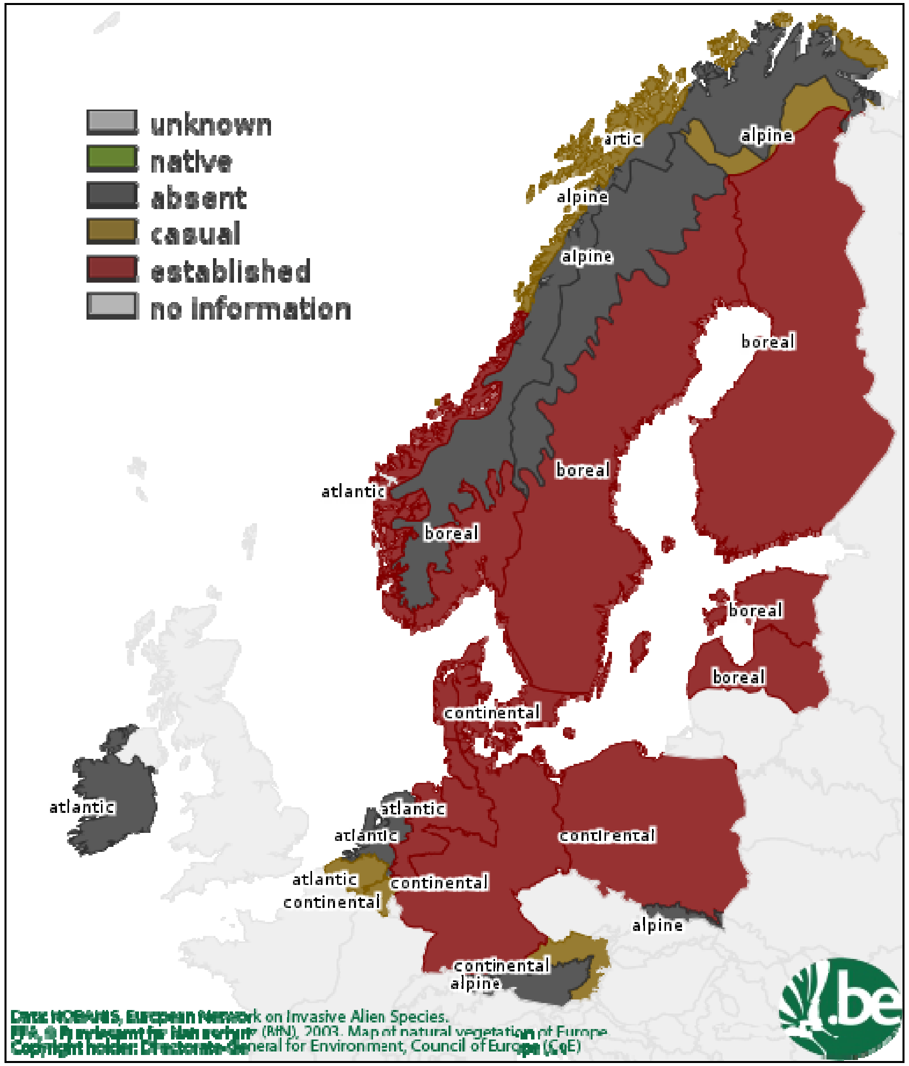


Figure 29: *Amelanchier spicata* – EEA. *Amelanchier spicata* is established in continental, atlantic and boreal zones. It is casual in alpine and arctic zones. First record 1875 in SE. Dispersal rate fairly slow.

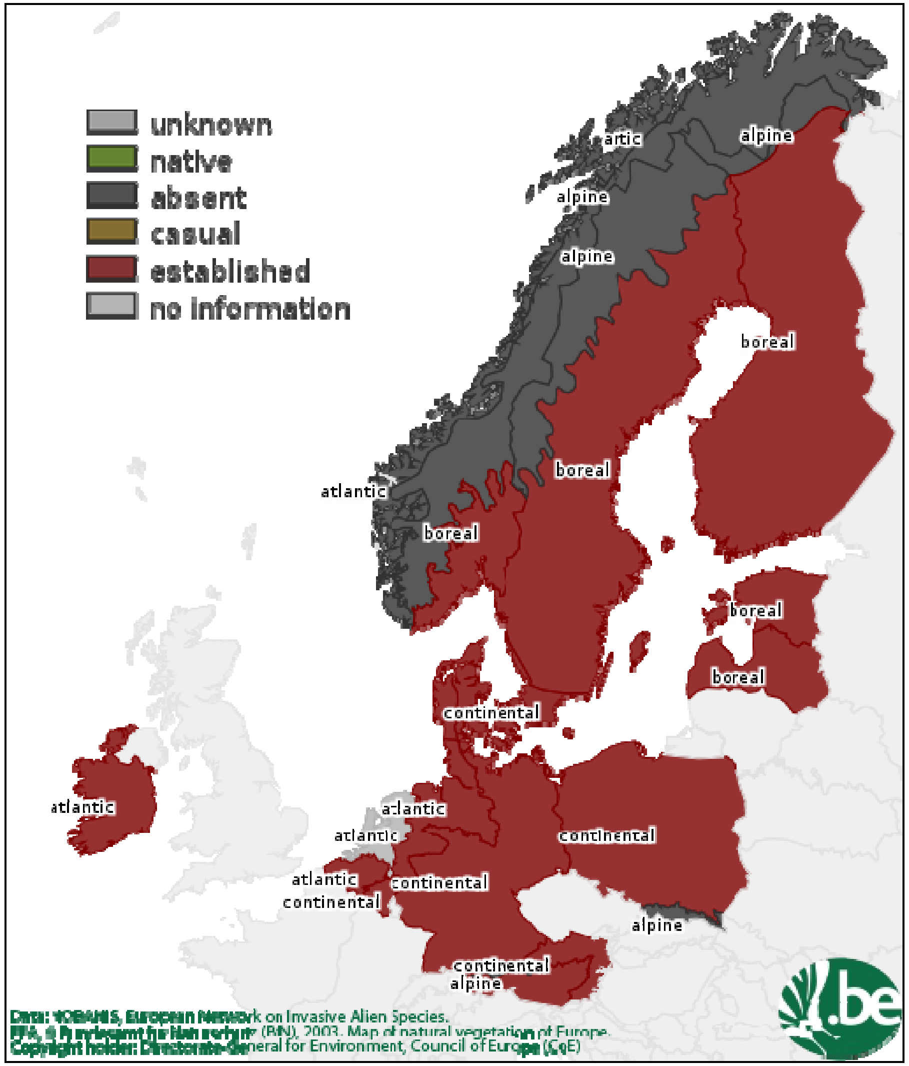


Figure 30: *Aphanomyces astaci* – EEA. *Aphanomyces astaci* is established in alpine, continental, atlantic and boreal zones. First record 1893 in FI. Dispersal rate fairly slow.

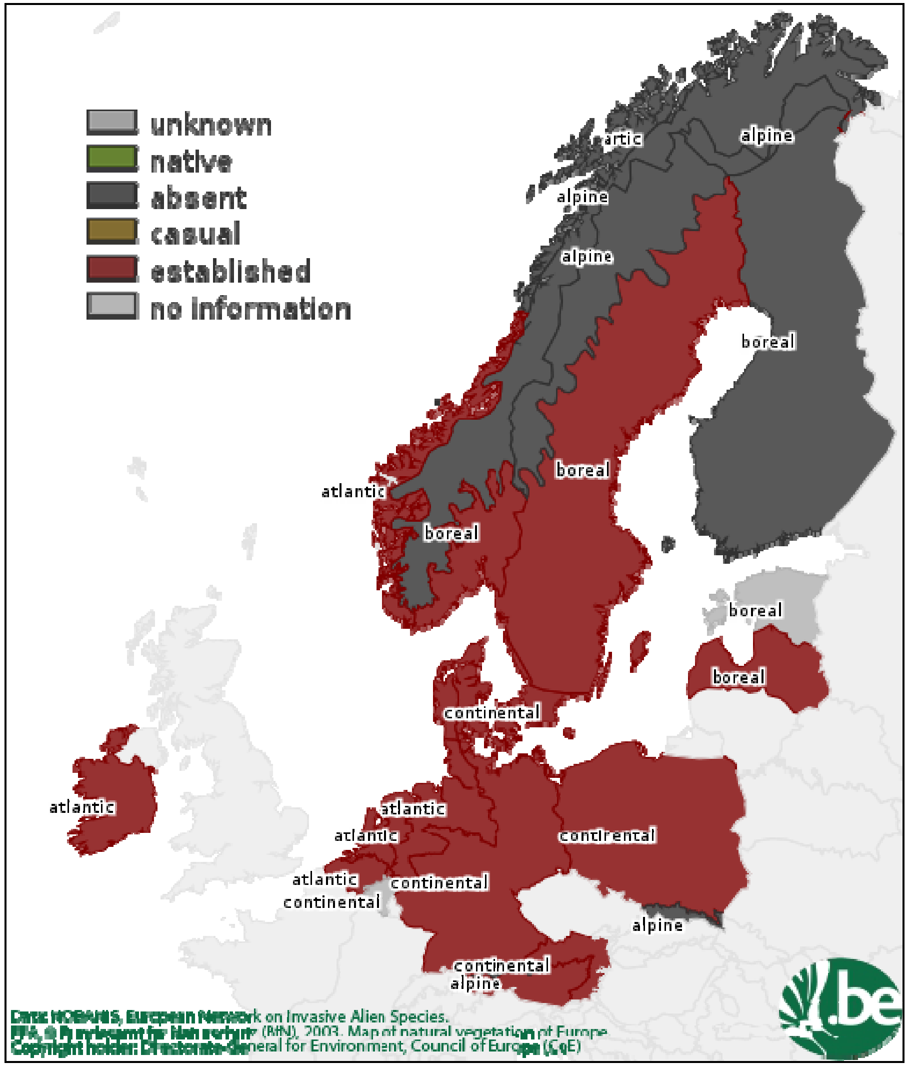


Figure 31: *Campylopus introflexus* – EEA. *Campylopus introflexus* is established in alpine, continental, atlantic and boreal zones. First record 1967 in DE. Dispersal rate fairly high.

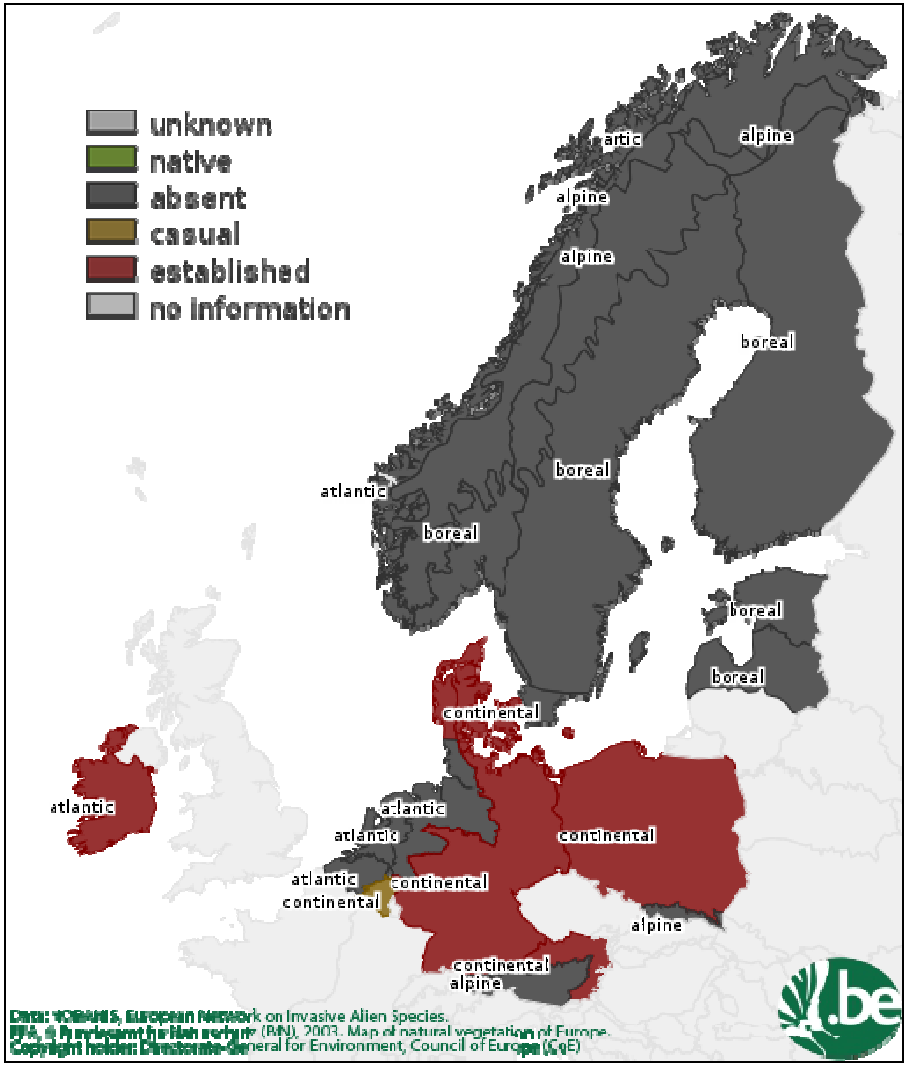


Figure 32: *Cervus nippon* – EEA. *Cervus nippon* is established in continental and atlantic zones. First record 1860 in IE. Dispersal rate medium.

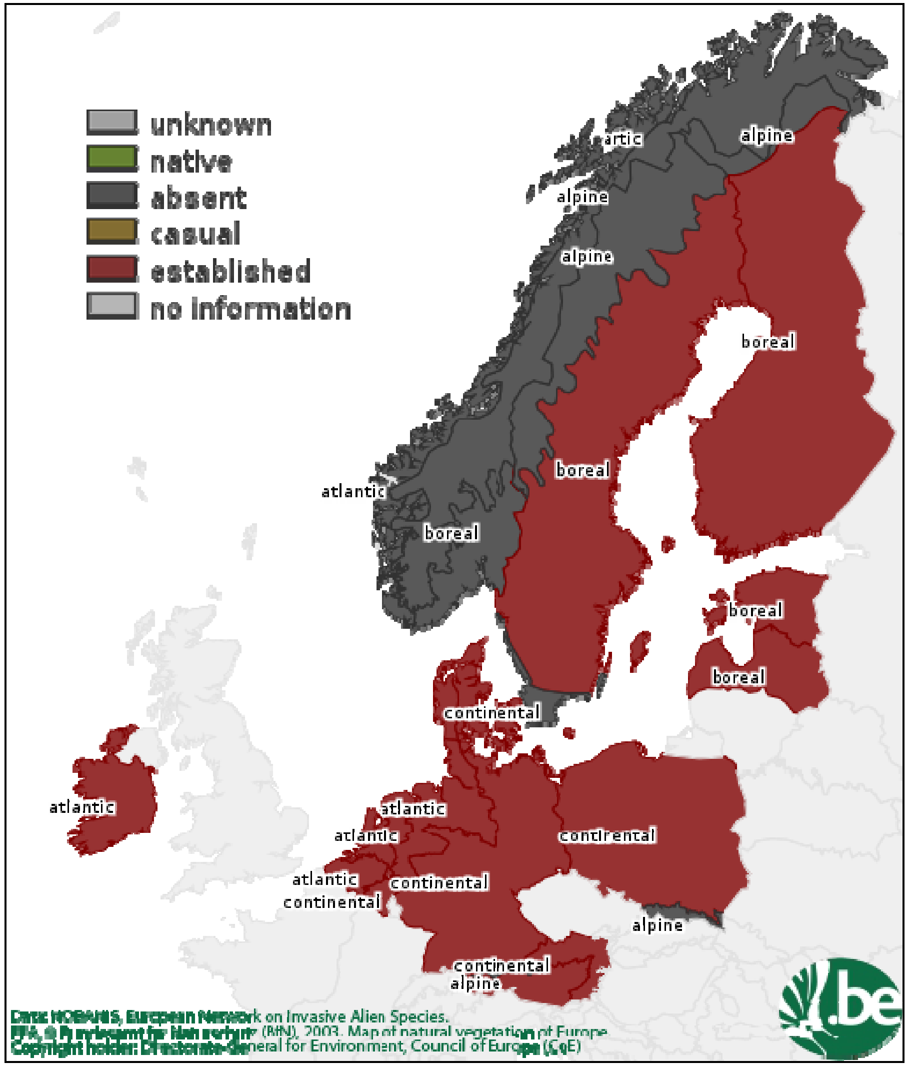


Figure 33: *Dreissena polymorpha* – EEA. *Dreissena polymorpha* is established in alpine, continental, atlantic and boreal zones. First record 1800 in PL. Dispersal rate fairly high.

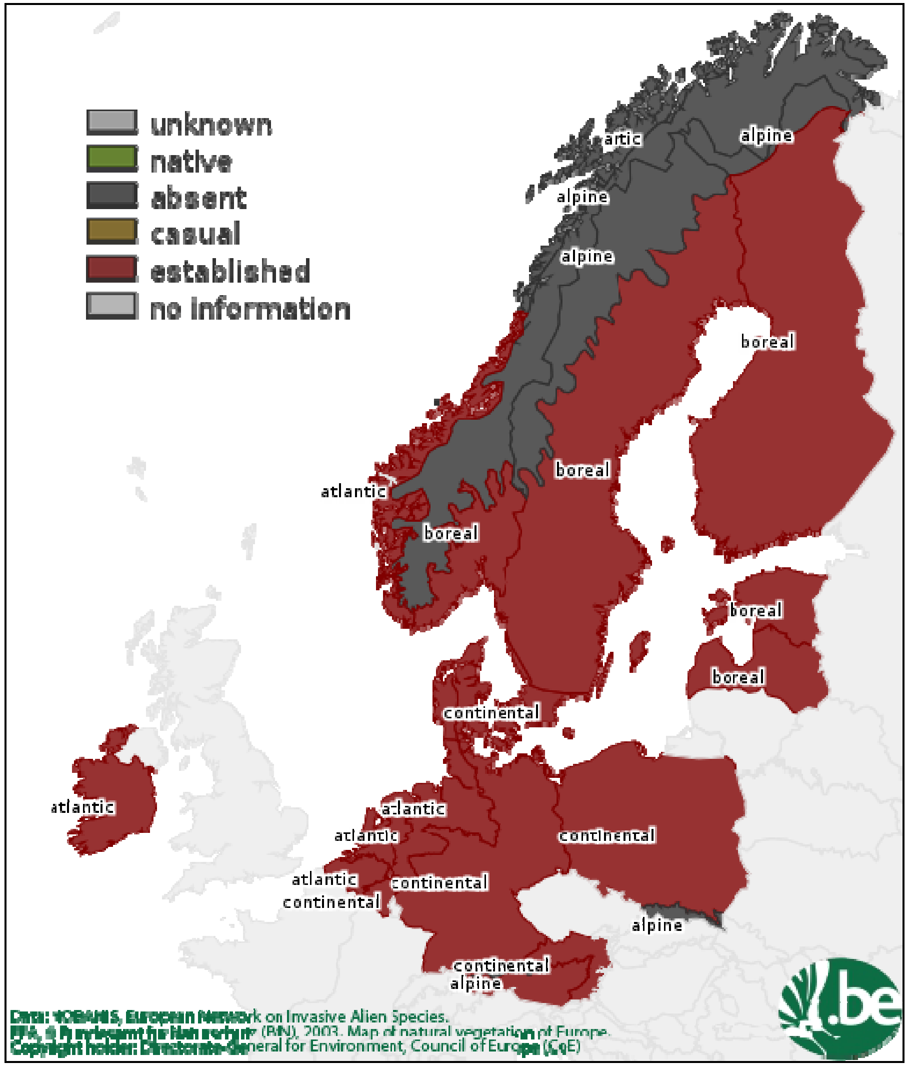


Figure 34: *Elodea canadensis and nuttallii* – EEA. *Elodea canadensis and nuttallii* is established in alpine, continental, atlantic and boreal zones. First record 1800 in AT. Dispersal rate fairly high.

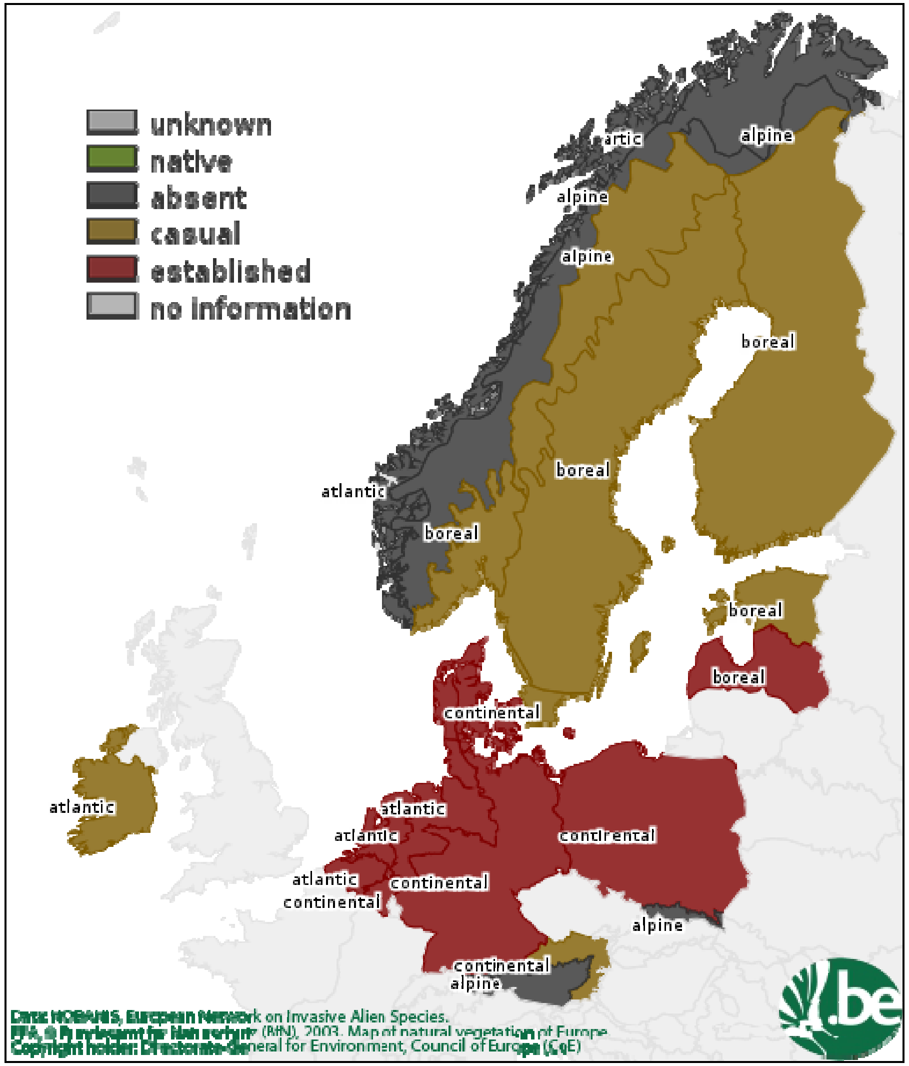


Figure 35: *Eriocheir sinensis* – EEA. *Eriocheir sinensis* is established in continental, atlantic and boreal zones. It is casual in alpine, continental, atlantic and boreal zones. First record pre 1912 in DE. Dispersal rate high.

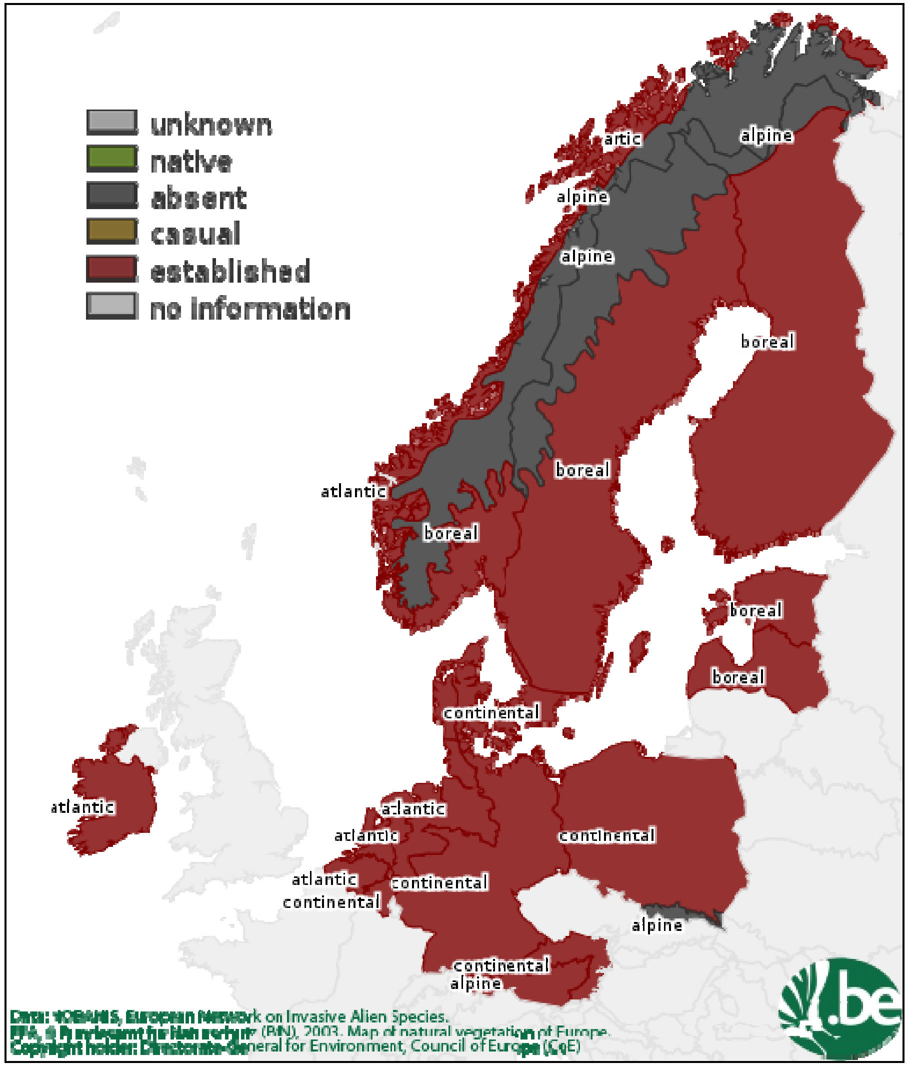


Figure 36: *Fallopia japonica* – EEA. *Fallopia japonica* is established in alpine, continental, atlantic, boreal and arctic zones. First record 1844 in DK. Dispersal rate fairly high.

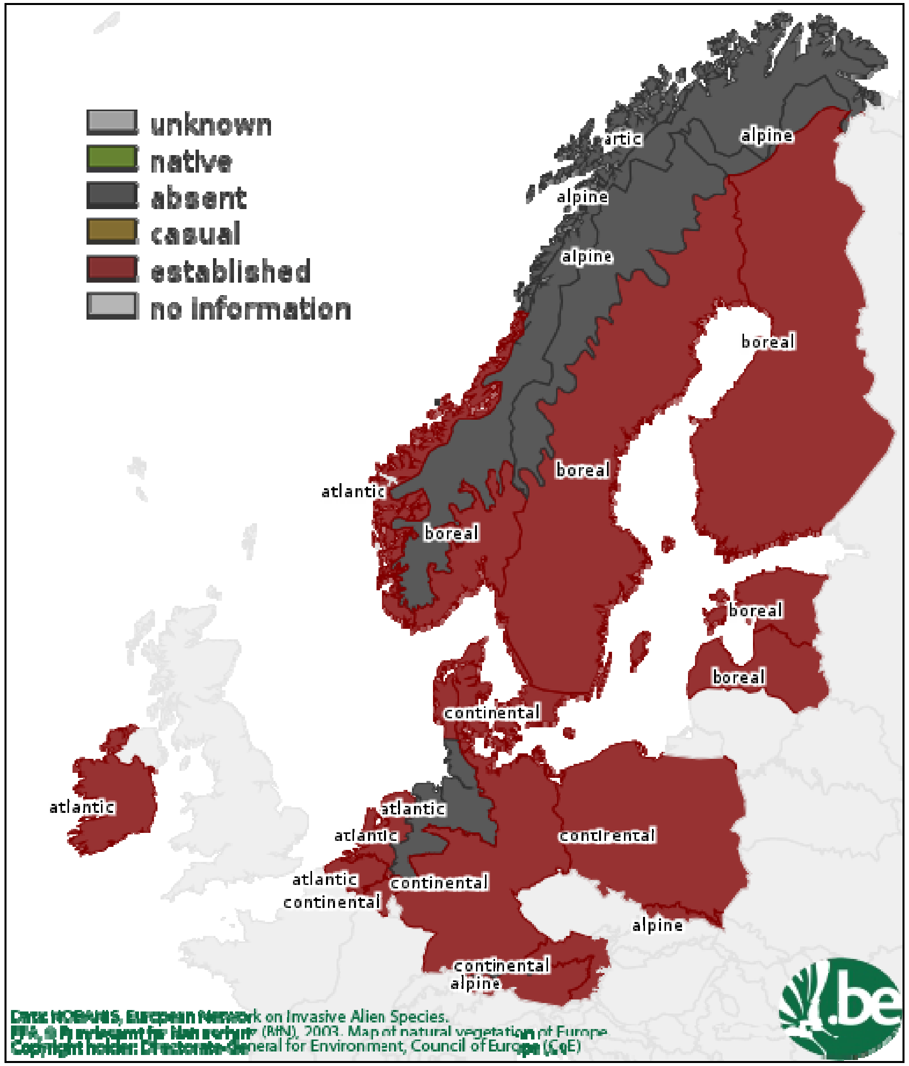


Figure 37: *Galinsoga quadriradiata* – EEA. *Galinsoga quadriradiata* is established in alpine, continental, atlantic and boreal zones. First record 1841 in EE. Dispersal rate fairly high.

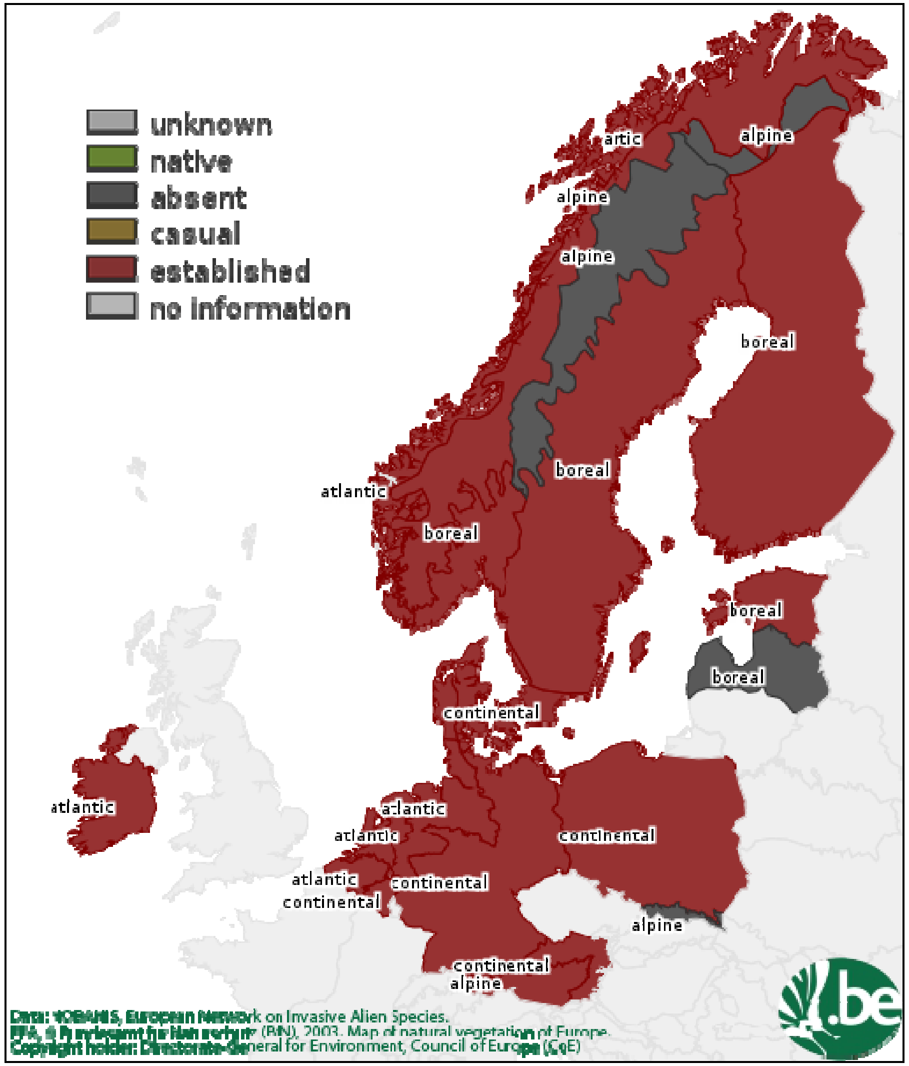


Figure 38: *Heracleum mantegazzianum* – EEA. *Heracleum mantegazzianum* is established in alpine, continental, atlantic, boreal and arctic zones. First record 1814 in EE. Dispersal rate fairly high.

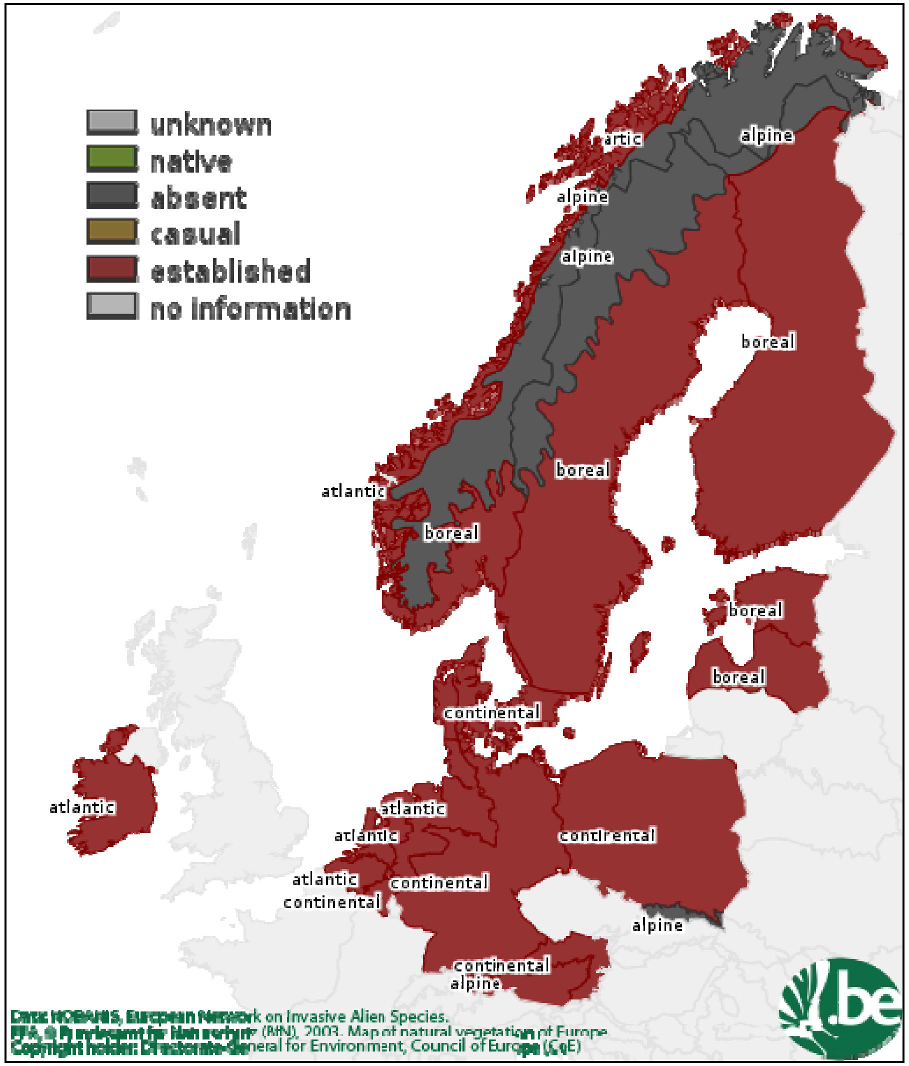


Figure 39: *Impatiens glandulifera* – EEA. *Impatiens glandulifera* is established in alpine, continental, atlantic, boreal and arctic zones. First record 1854 in DE. Dispersal rate fairly high.

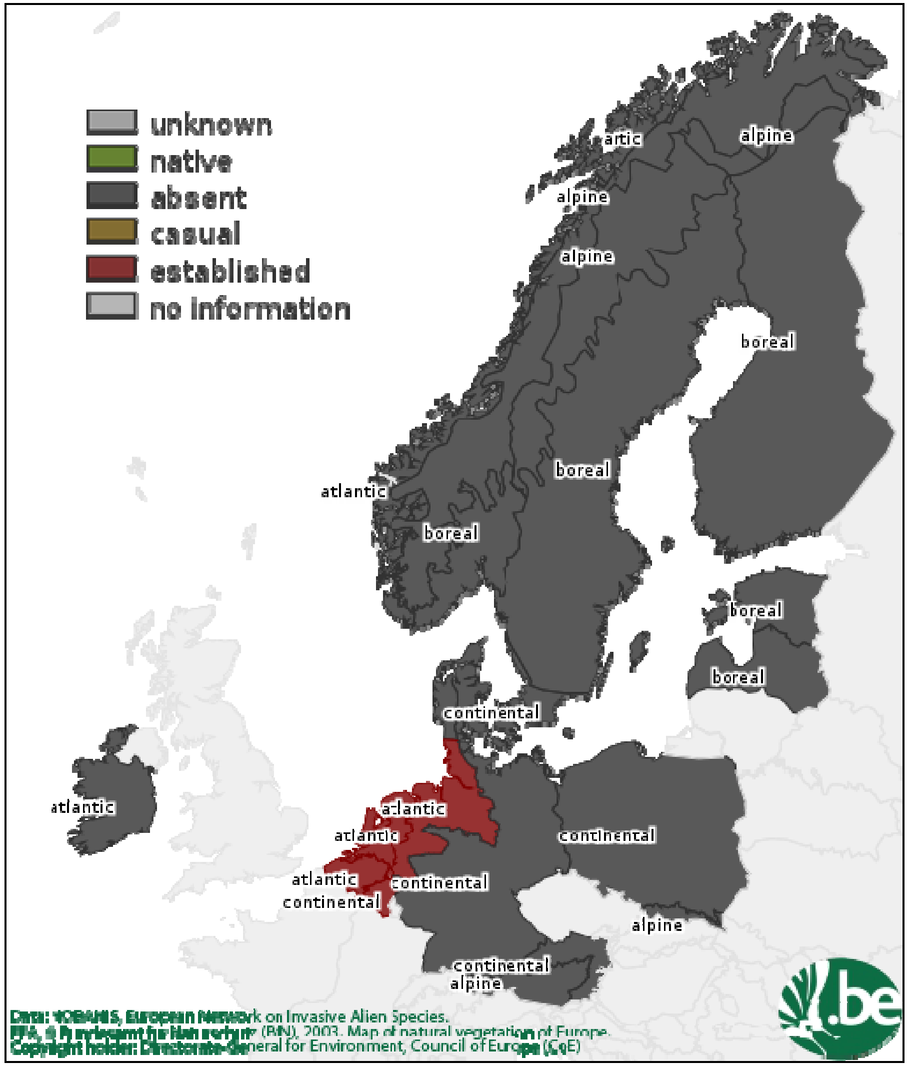


Figure 40: *Ludwigia peploides and L. uruguayensis (=L. grandiflora)* – EEA. *Ludwigia peploides and L. uruguayensis (=L. grandiflora)* is established in continental and atlantic zones. First record 1997 in BE. Dispersal rate fairly slow.

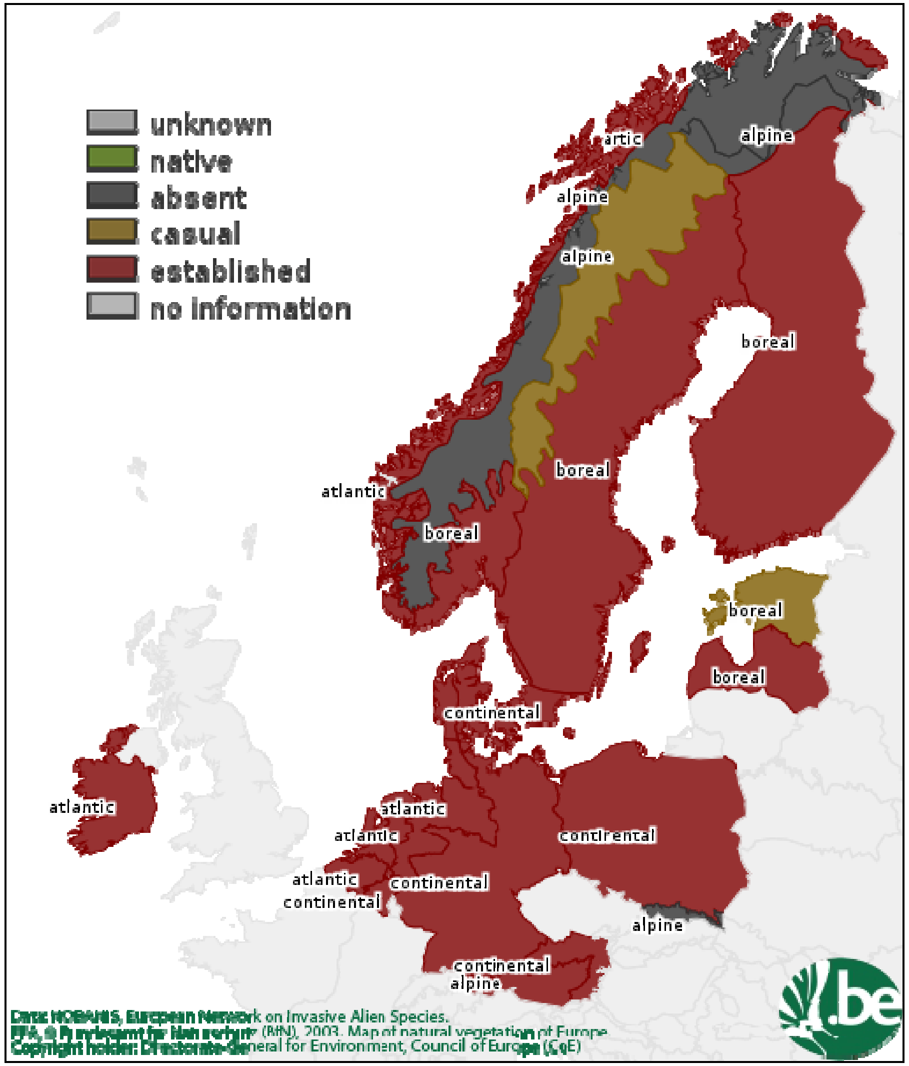


Figure 41: *Mimulus guttatus* – EEA. *Mimulus guttatus* is established in alpine, continental, atlantic, boreal and arctic zones. It is casual in boreal and alpine zones. First record 1800 in AT. Dispersal rate fairly slow.

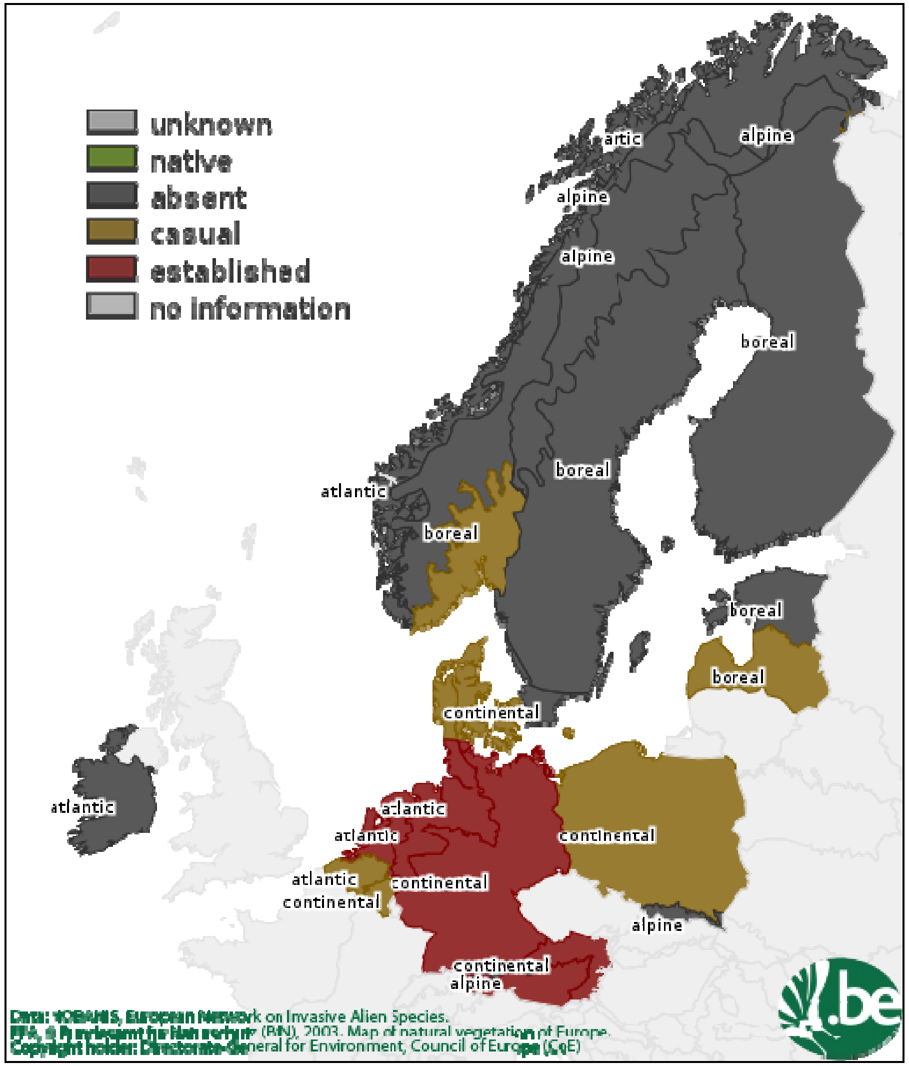


Figure 42: *Myocastor coypus* – EEA. *Myocastor coypus* is established in alpine, continental and atlantic zones. It is casual in continental, atlantic and boreal zones. First record 1920 in PL. Dispersal rate medium.

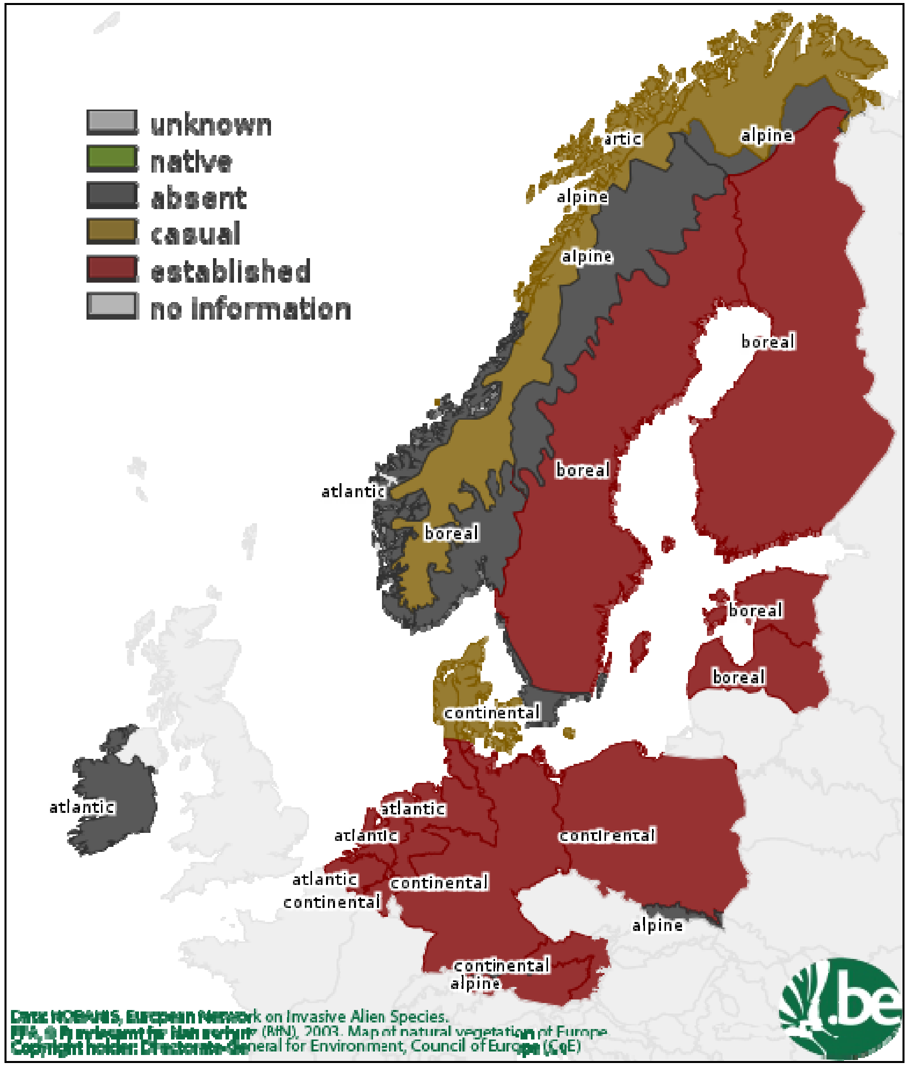


Figure 43: ***Ondatra zibethicus* – EEA.** *Ondatra zibethicus* is established in alpine, continental, atlantic and boreal zones. It is casual in alpine, continental, boreal and arctic zones. First record 1900 in DK. Dispersal rate medium.

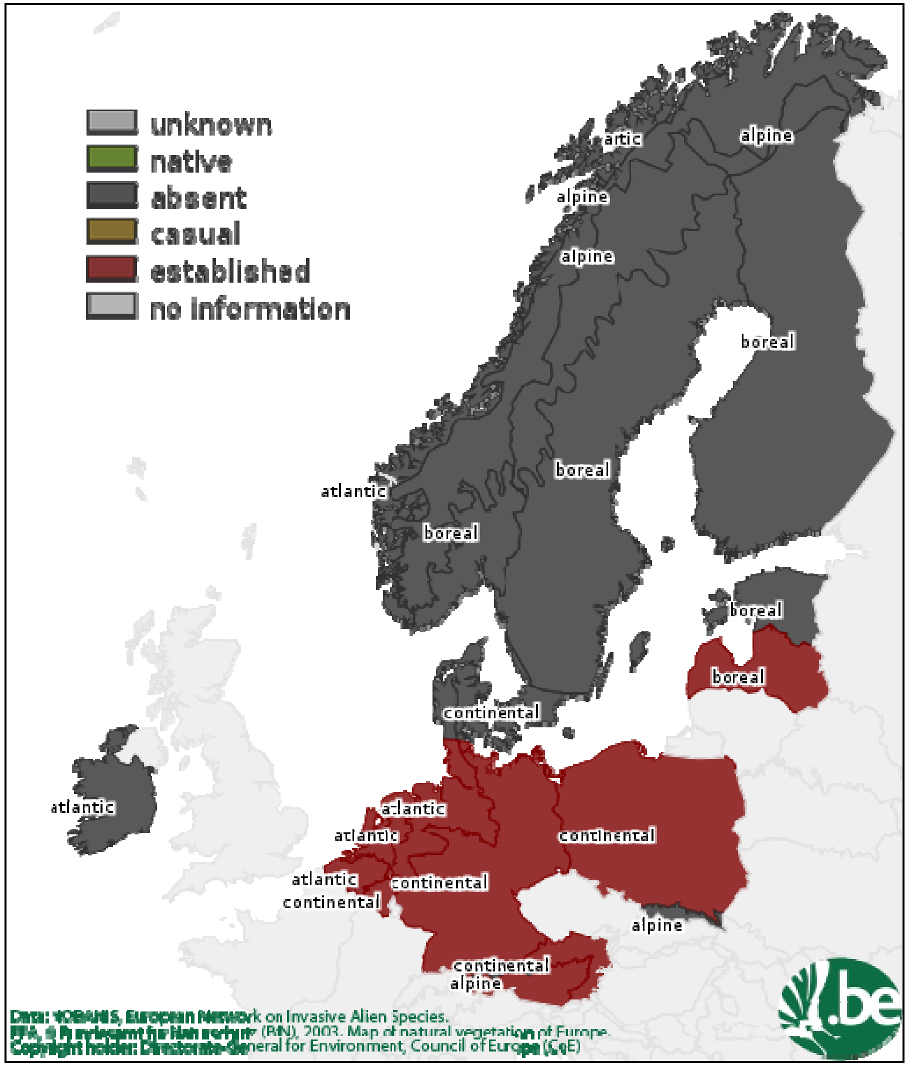


Figure 44: ***Orconectes limosus* – EEA.** *Orconectes limosus* is established in alpine, continental, atlantic and boreal zones. First record 1880 in DE. Dispersal rate fairly slow.

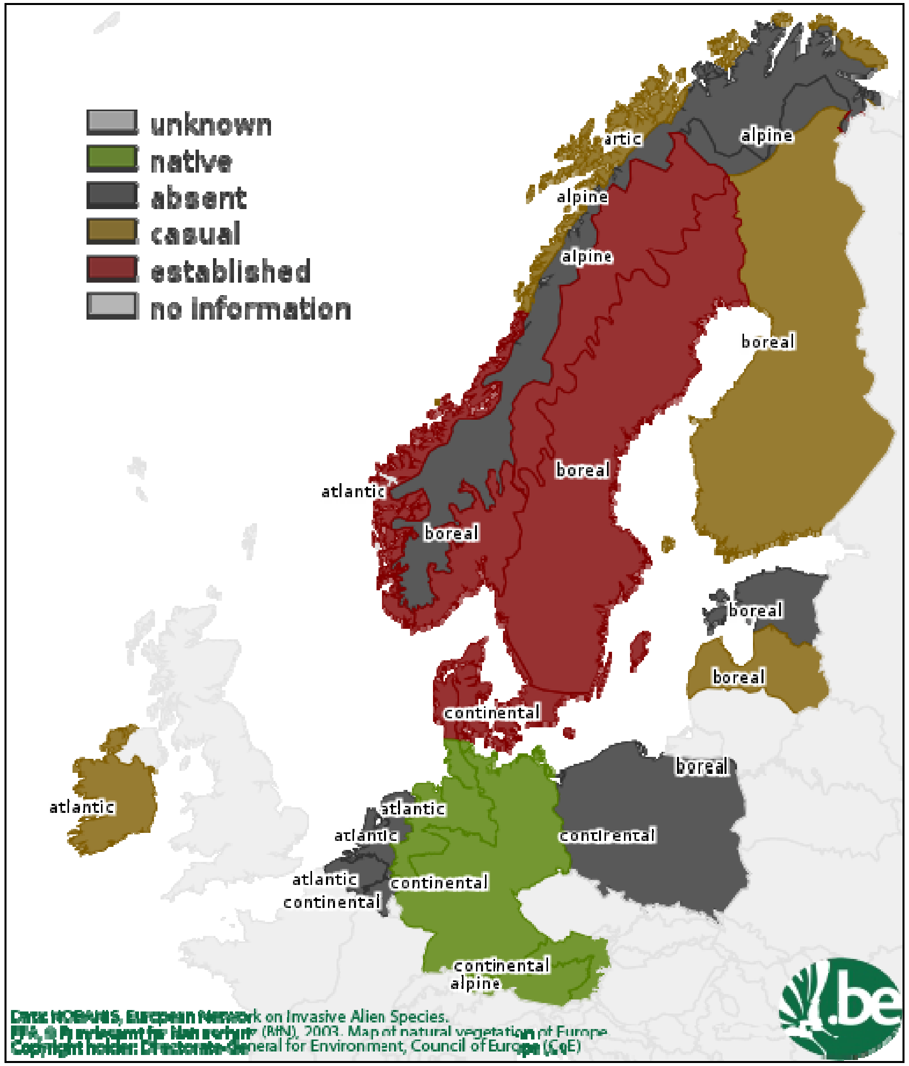


Figure 45: *Pinus mugo* – EEA. *Pinus mugo* is established in alpine, continental, atlantic and boreal zones. It is native to alpine, continental and atlantic zones. First record1902 in SE. Dispersal rate slow.

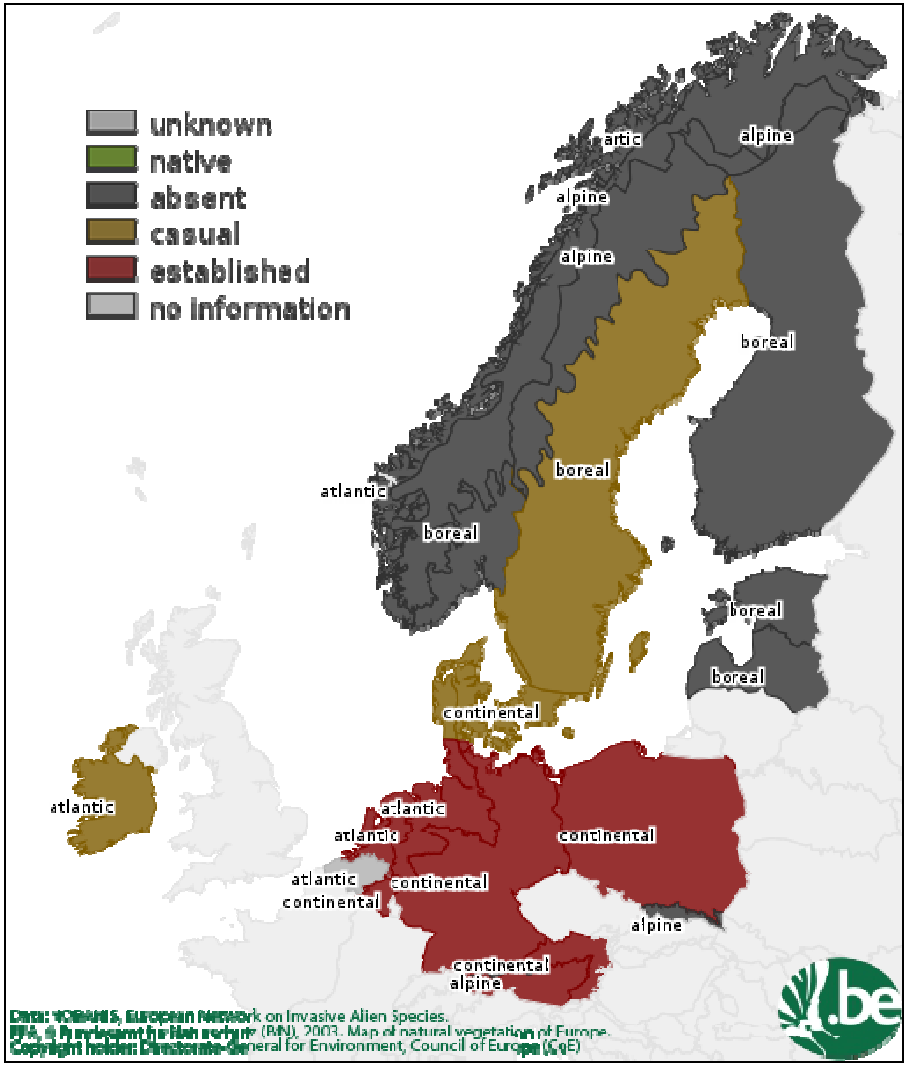


Figure 46: *Procyon lotor* – EEA. *Procyon lotor* is established in alpine, continental and atlantic zones. It is casual in atlantic, continental and boreal zones. First record 1927 in PL, DE. Dispersal rate slow.

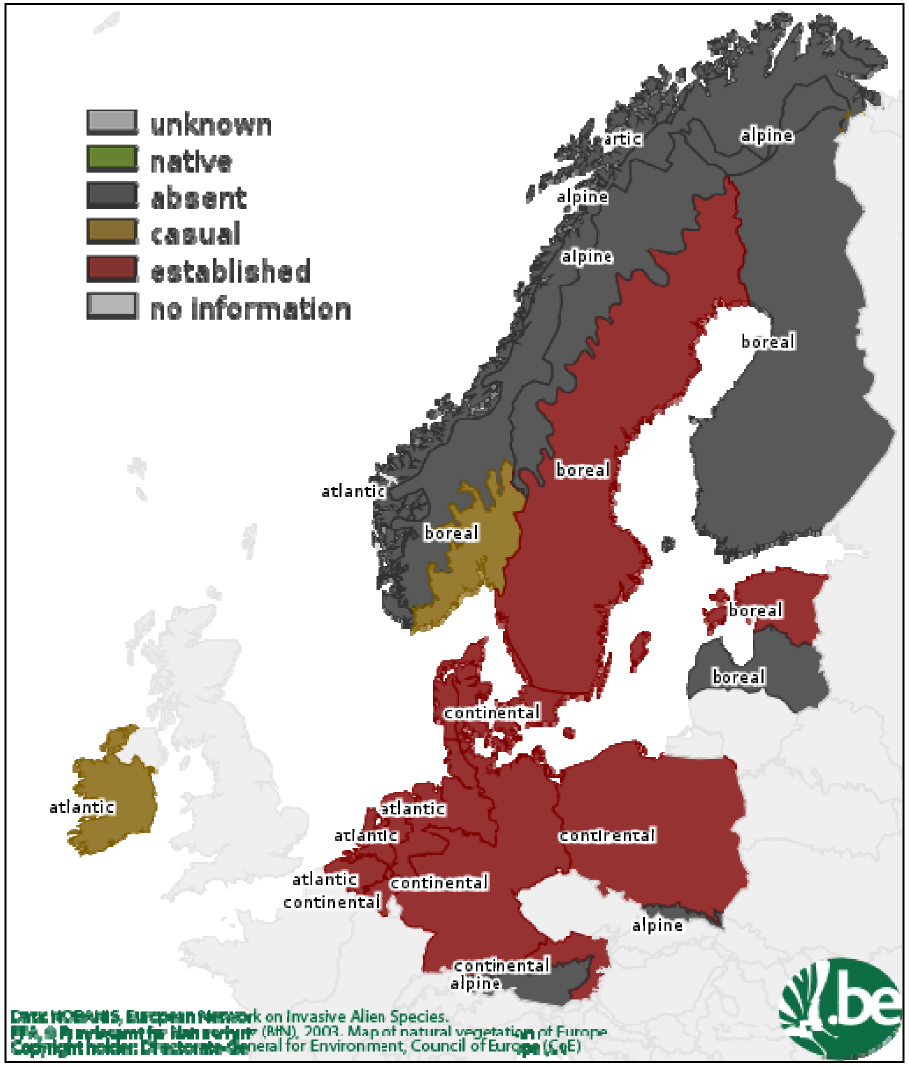


Figure 47: ***Prunus serotina*** **– EEA.** *Prunus serotina* is established in continental, atlantic and boreal zones. It is casual in atlantic and boreal zones. First record 1800 in AT. Slow dispersal rate.

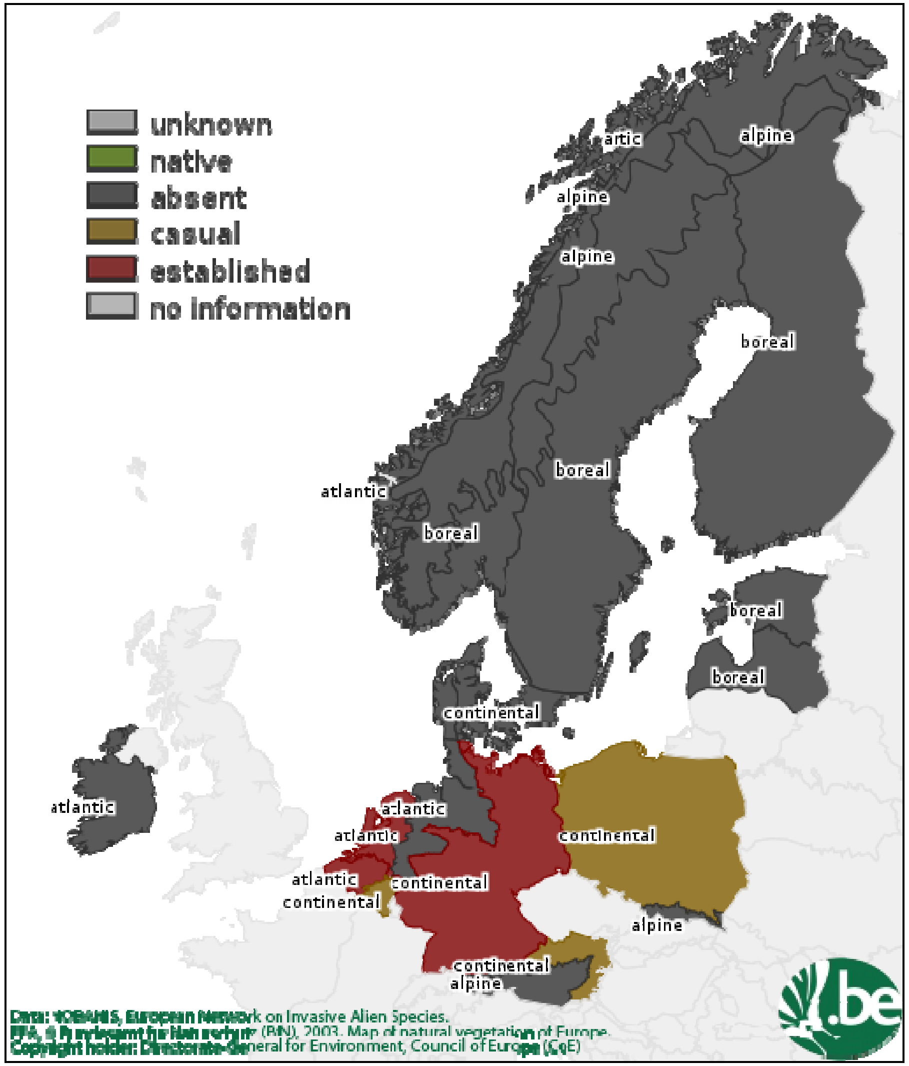


Figure 48: ***Psittacula krameri*** **– EEA.** *Psittacula krameri* is established in continental and atlantic zones. It is casual in continental zones. First record 1966 in BE. Dispersal rate high.

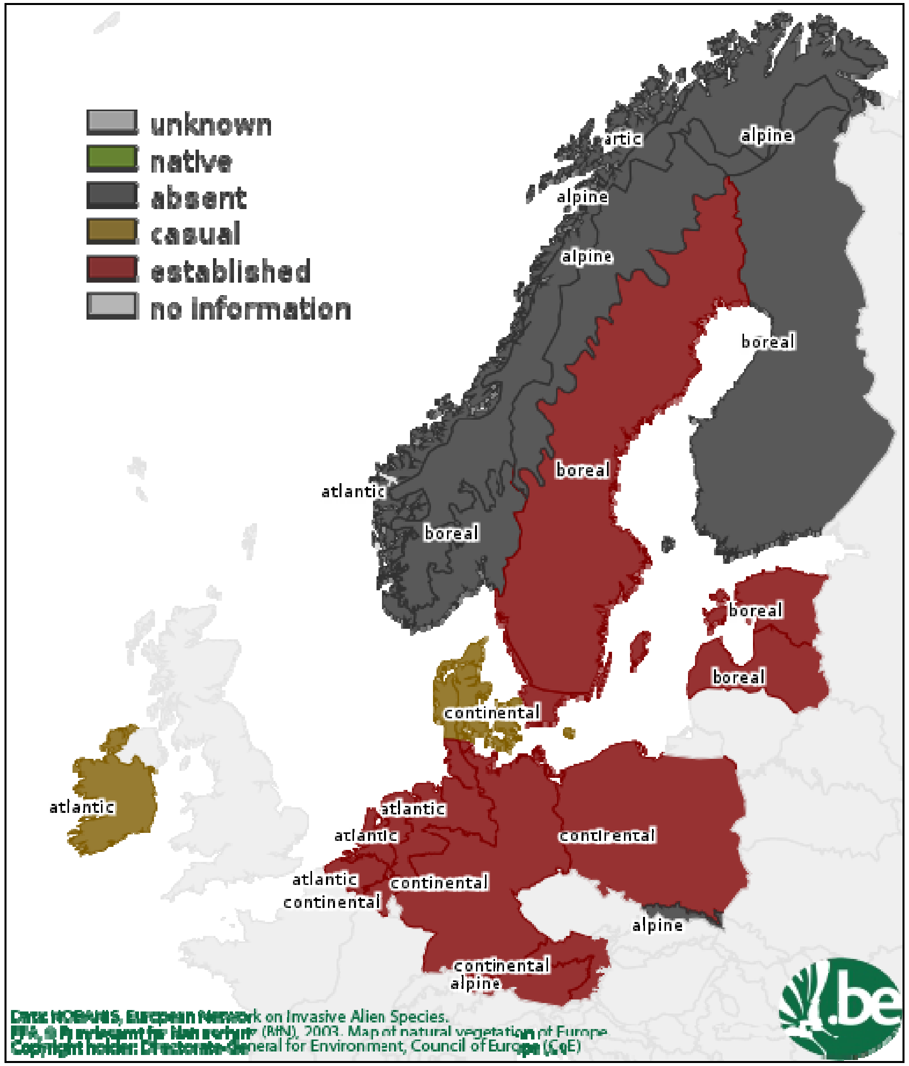


Figure 49: ***Robinia pseudoacacia*** **– EEA.** *Robinia pseudoacacia* is established in alpine, continental, atlantic and boreal zones. It is casual in continental and atlantic zones. First record 1750 in PL. Fairly slow dispersal rate.

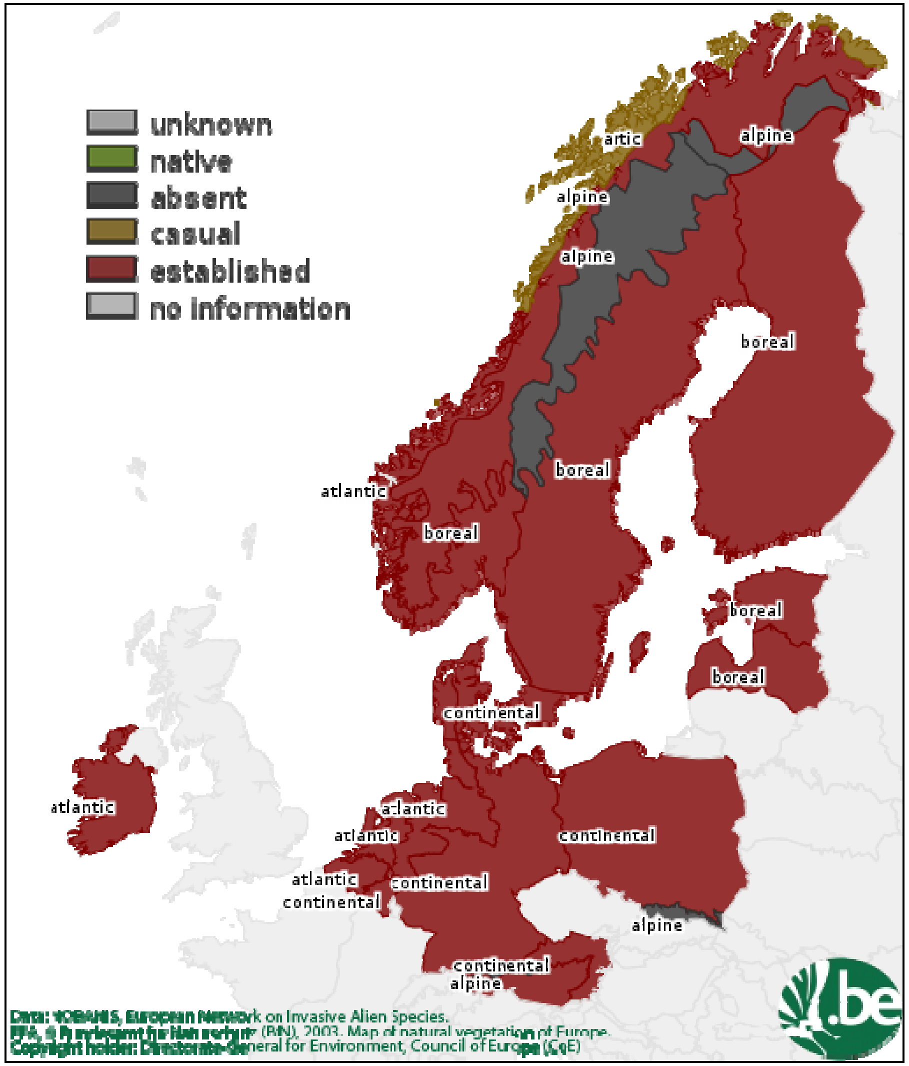


Figure 50: *Rosa rugosa* – EEA. *Rosa Rugosa* is established in alpine, continental, atlantic and boreal zones. It is casual in arctic zones. First record 1800 in AT. Dispersal rate fairly slow.

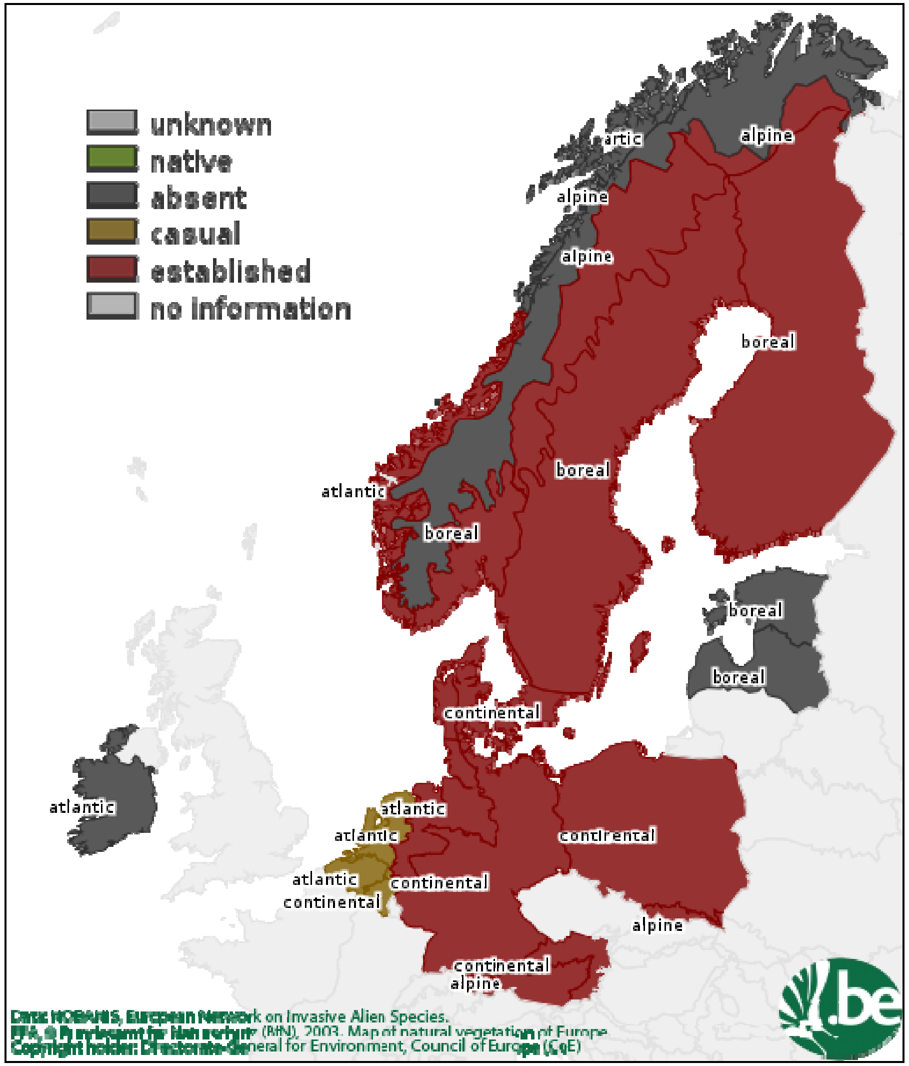


Figure 51: *Salvelinus fontinalis* – EEA. *Salvelinus fontinalis* is established in alpine, continental, atlantic and boreal zones. First record 1876 in NO. Dispersal rate medium.

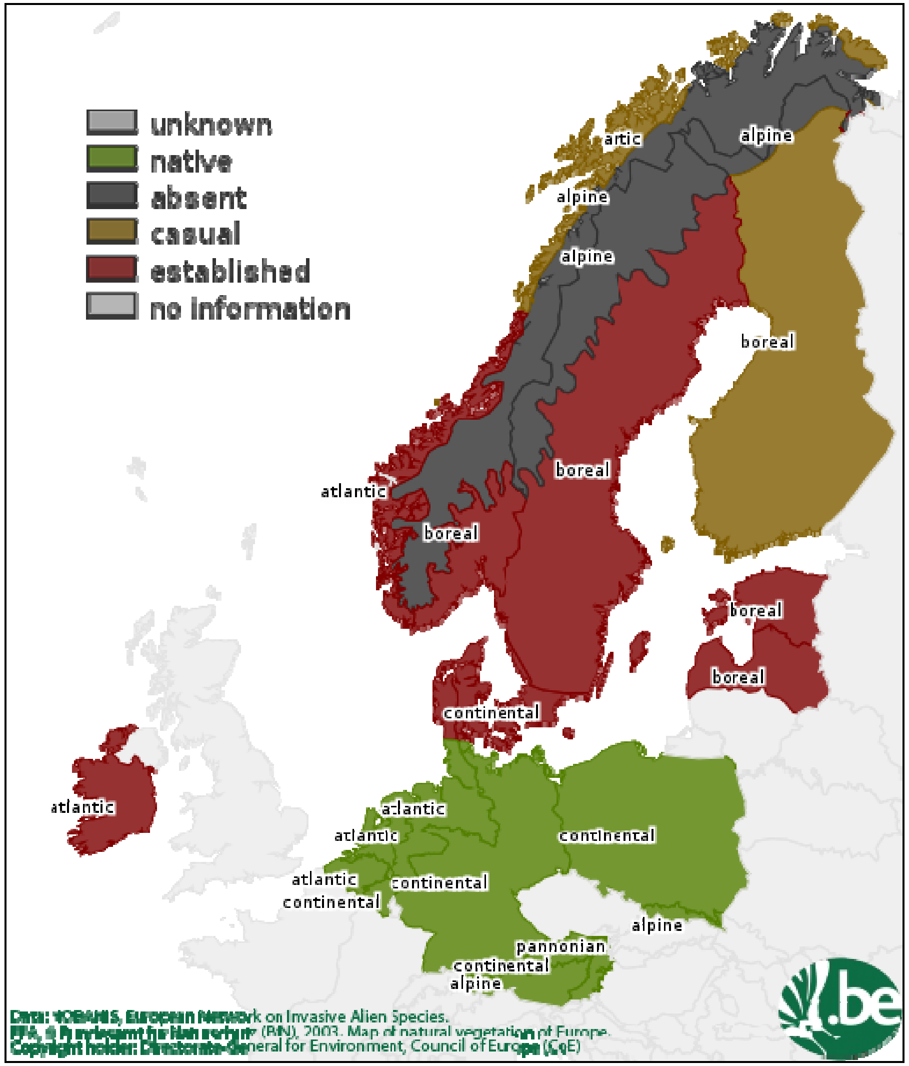


Figure 52: *Sambucus nigra* – EEA. *Sambucus nigra* is established in continental, atlantic and boreal zones. It is casual in arctic zones and native to alpine, continental and atlantic zones. First record 1777 in EE. Dispersal rate fairly slow.

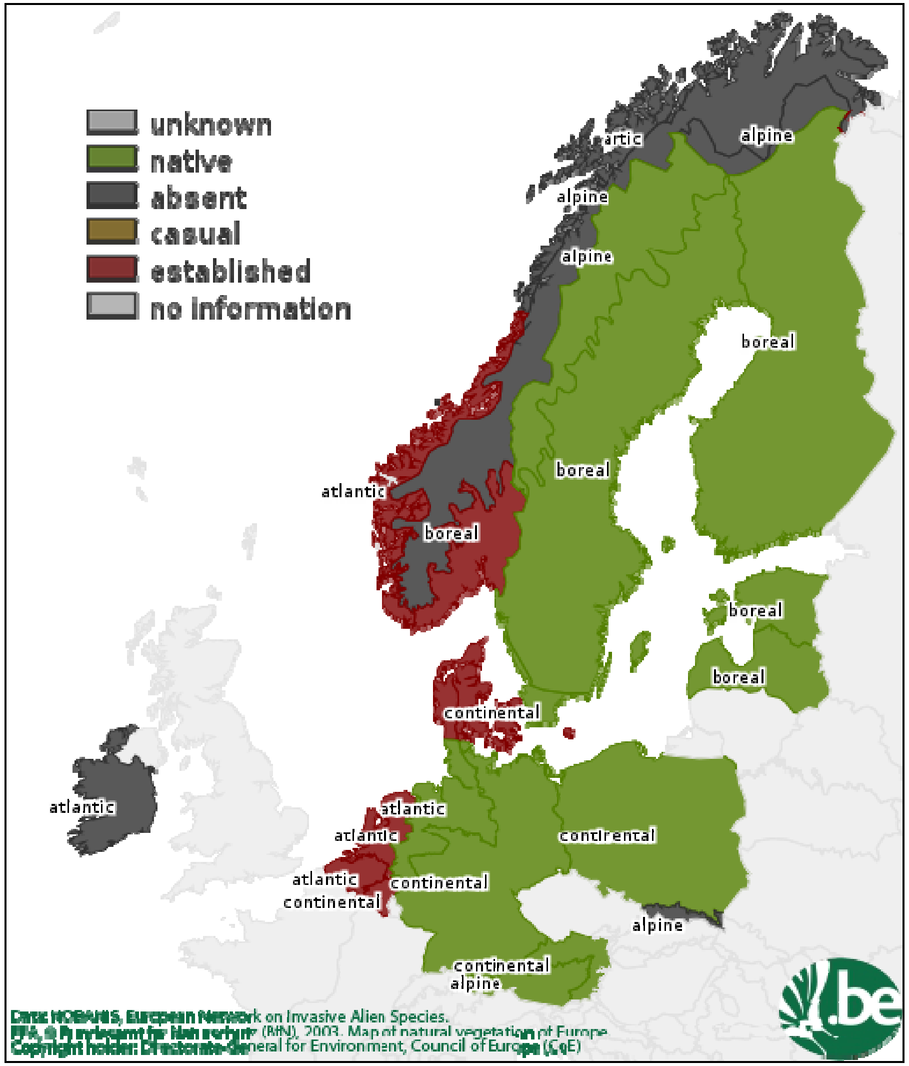


Figure 53: *Sander lucioperca* – EEA. *Sander lucioperca* is established in continental, atlantic and boreal zones. It is native to alpine, continental and boreal zones. First record 1879 in DK. Dispersal rate medium.

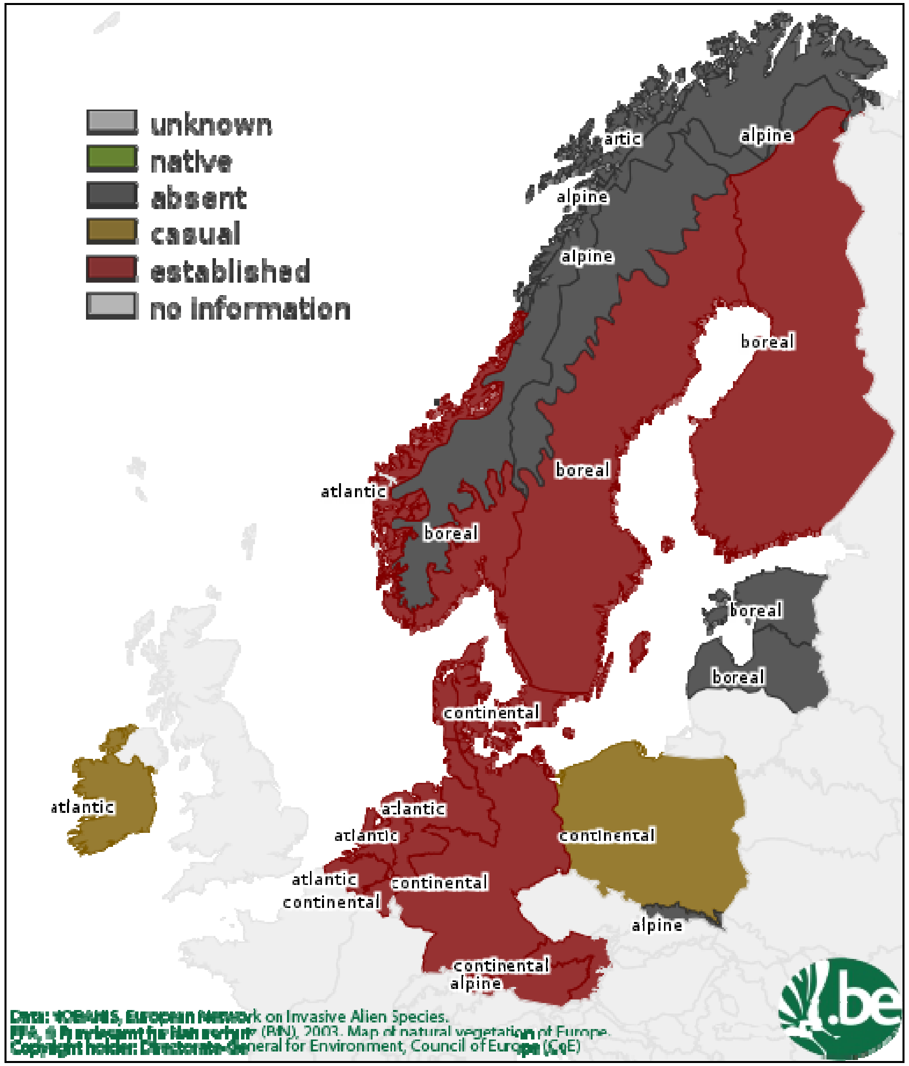


Figure 54: *Senecio inaequidens* – EEA. *Senecio inaequidens* is established in alpine, continental, atlantic and boreal zones. First record 1889 in DE. Dispersal rate fairly high.

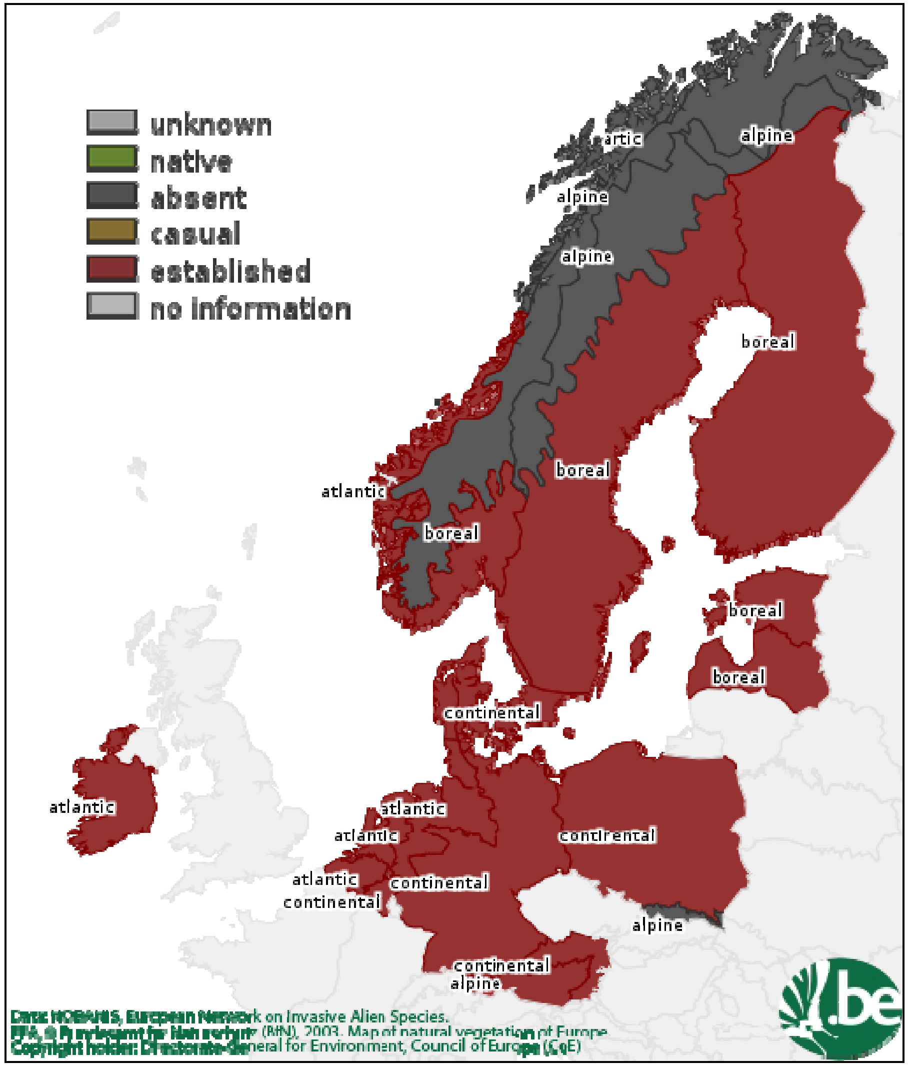


Figure 55: ***Solidago canadensis* – EEA.** *Solidago canadensis* is established in alpine, continental, atlantic and boreal zones. First record 1807 in EE. Dispersal rate fairly high.

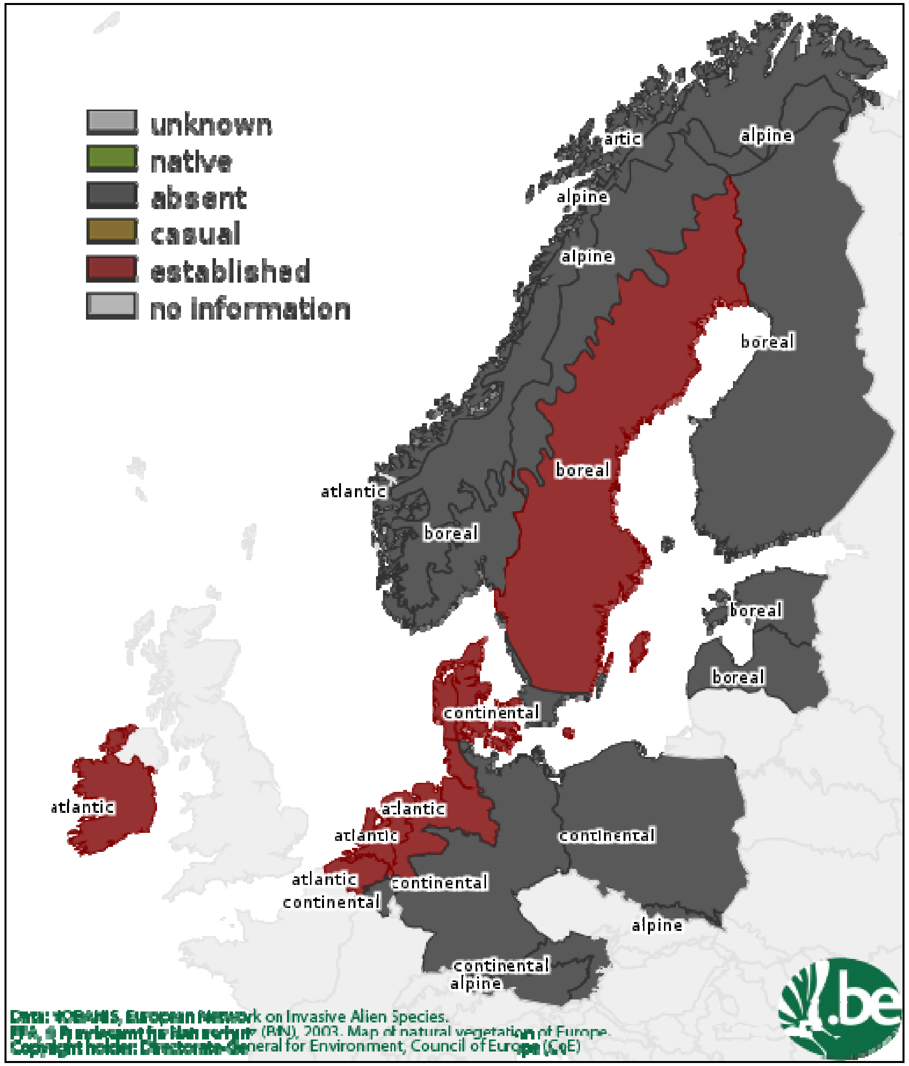


Figure 56: ***Spartina anglica* – EEA.** *Spartina anglica* is established in continental, atlantic and boreal zones. First record 1925 in IE. Dispersal rate slow.

Category 3 maps

The following 55 maps from **Figure 57** to **Figure 111** are Category 3-maps.

Common for the Category 3-maps is that they are species with isolated local populations. Species may be present in captivity all over the region, but they are not yet widely established in the wild. These include pet species, terrarium, and aquarium species. Prior to the mapping of the species, knowledge of the species' distribution range in the project area was not necessarily well known, hence some maps can turn out to be without data.

Risk profiles of Category 3 species will be useful for countries to create their alarm list.

The distributions of the species are displayed on maps with EEA-biogeographical partitions.

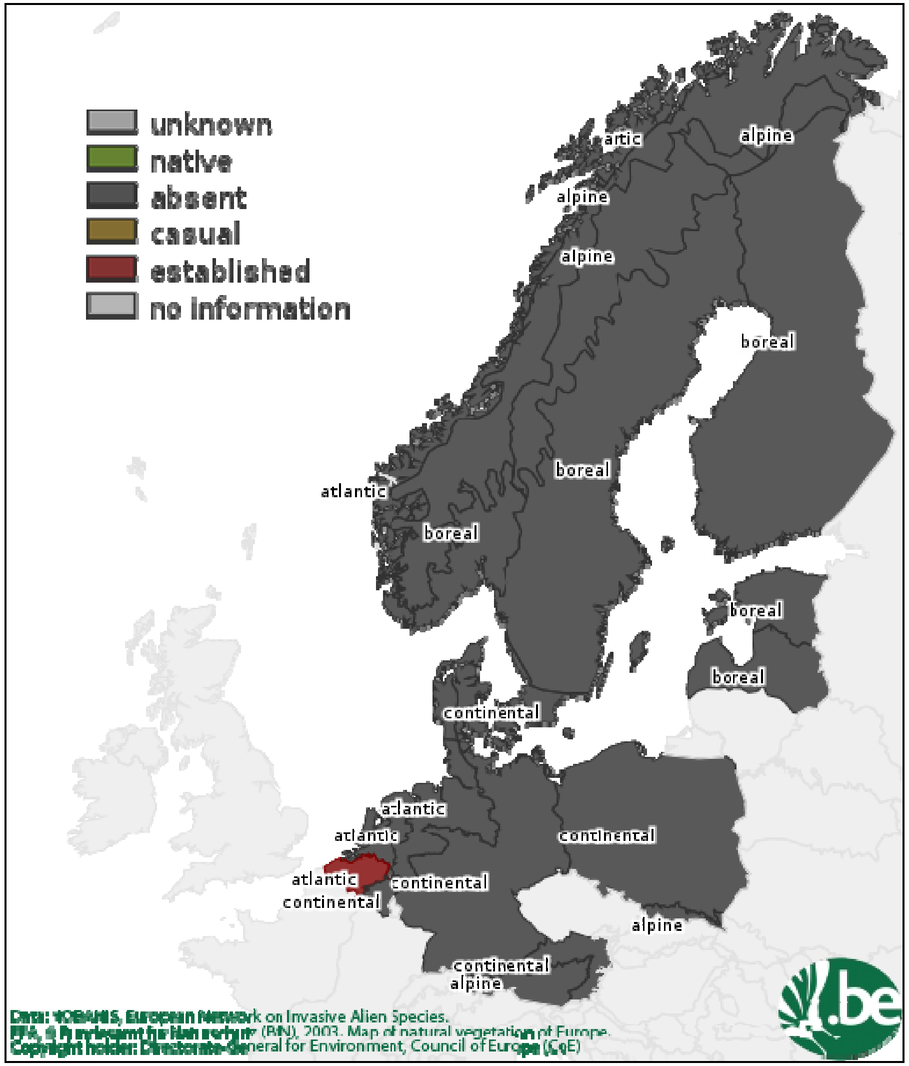


Figure 57: *Acer rufinerve* – EEA. *Acer rufinerve* is established in the atlantic zone. First record 1990 in BE. Slow dispersal rate.

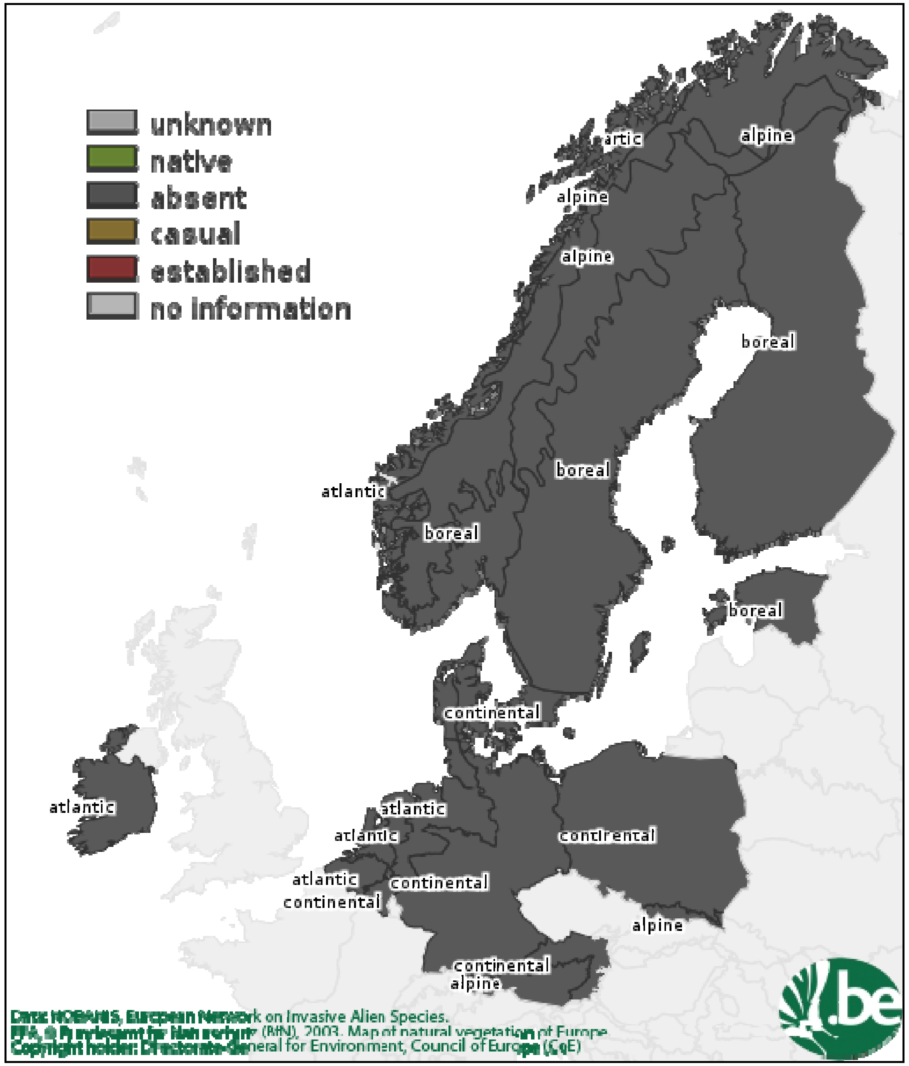


Figure 58: ***Agrilus planipennis* – EEA.** *Agrilus planipennis* is not established in any zones yet. Slow dispersal rate.

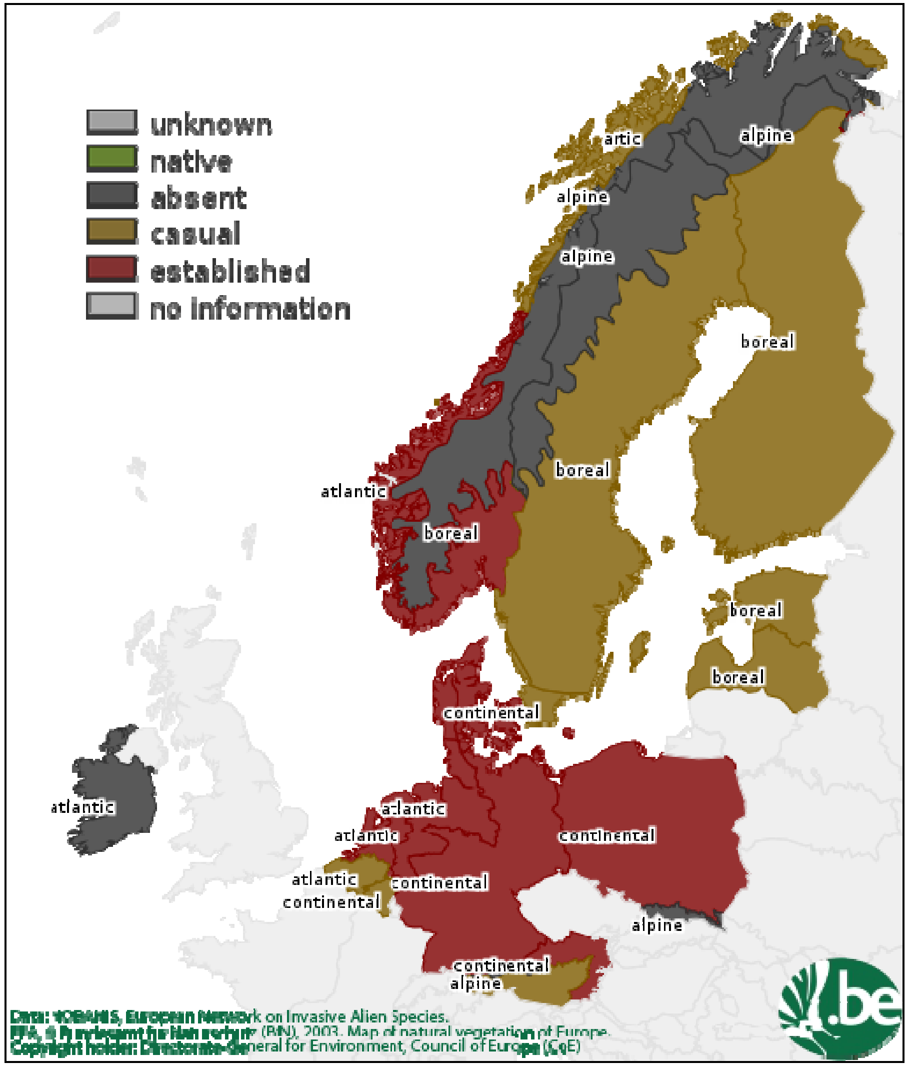


Figure 59: ***Ambrosia artemisifolia* – EEA.** *Ambrosia artemisifolia* is established in continental, atlantic and boreal zones. It is casual in the alpine and arctic zones. First record 1613 in PL. Slow dispersal rate.

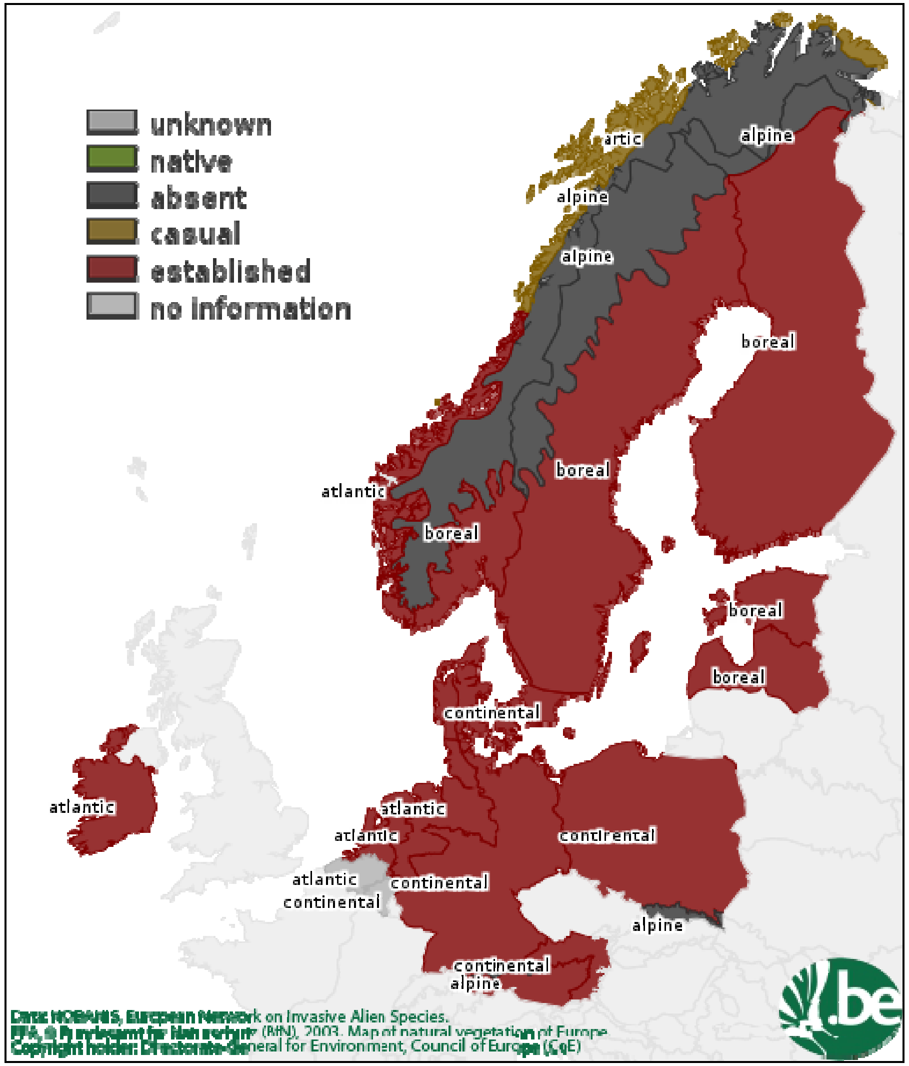


Figure 60: ***Anguillicola crassus*** **– EEA.** *Anguillicola crassus* is established in alpine, continental, atlantic and boreal zones. It is casual in the arctic zones. First record 1985 in DE and DK. High dispersal rate.

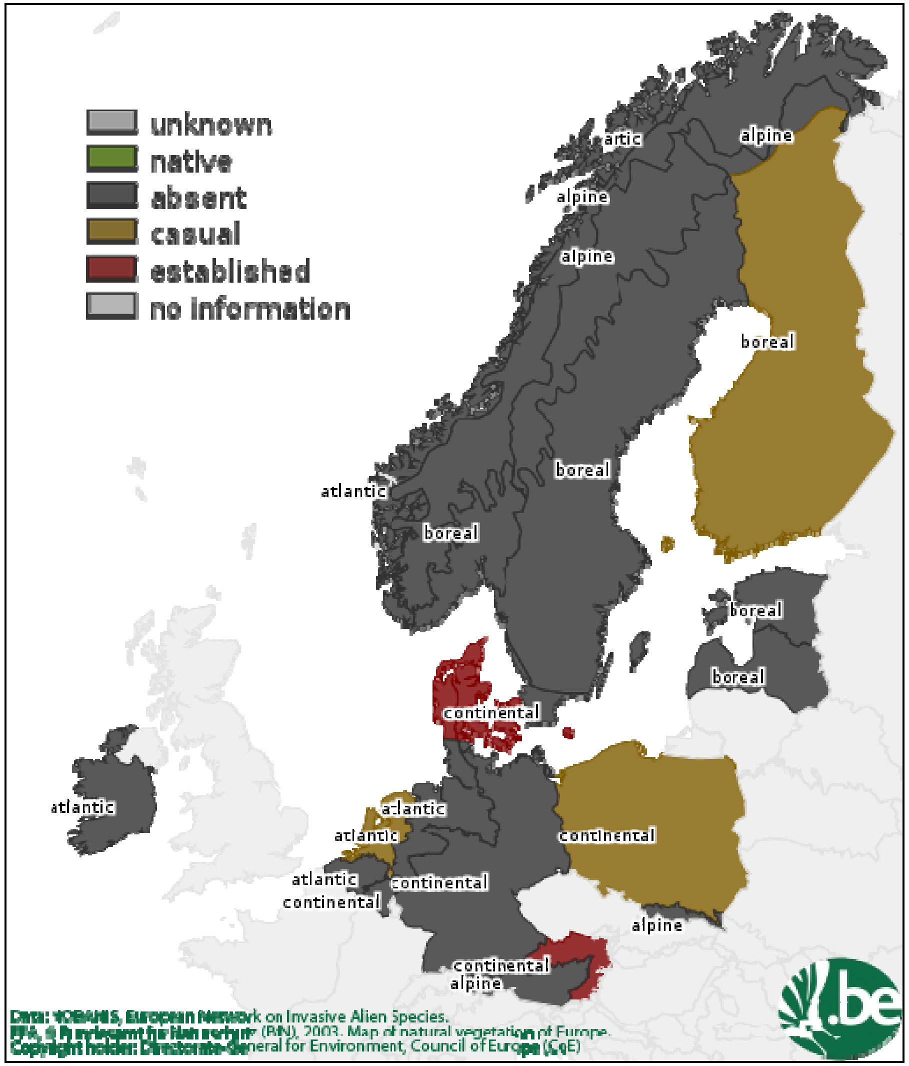


Figure 61: ***Anoplophora glabripennis*** **– EEA.** *Anoplophora glabripennis* is established in continental and atlantic zones. It is casual in the boreal zone. First record 2001 in AT. Slow dispersal rate.

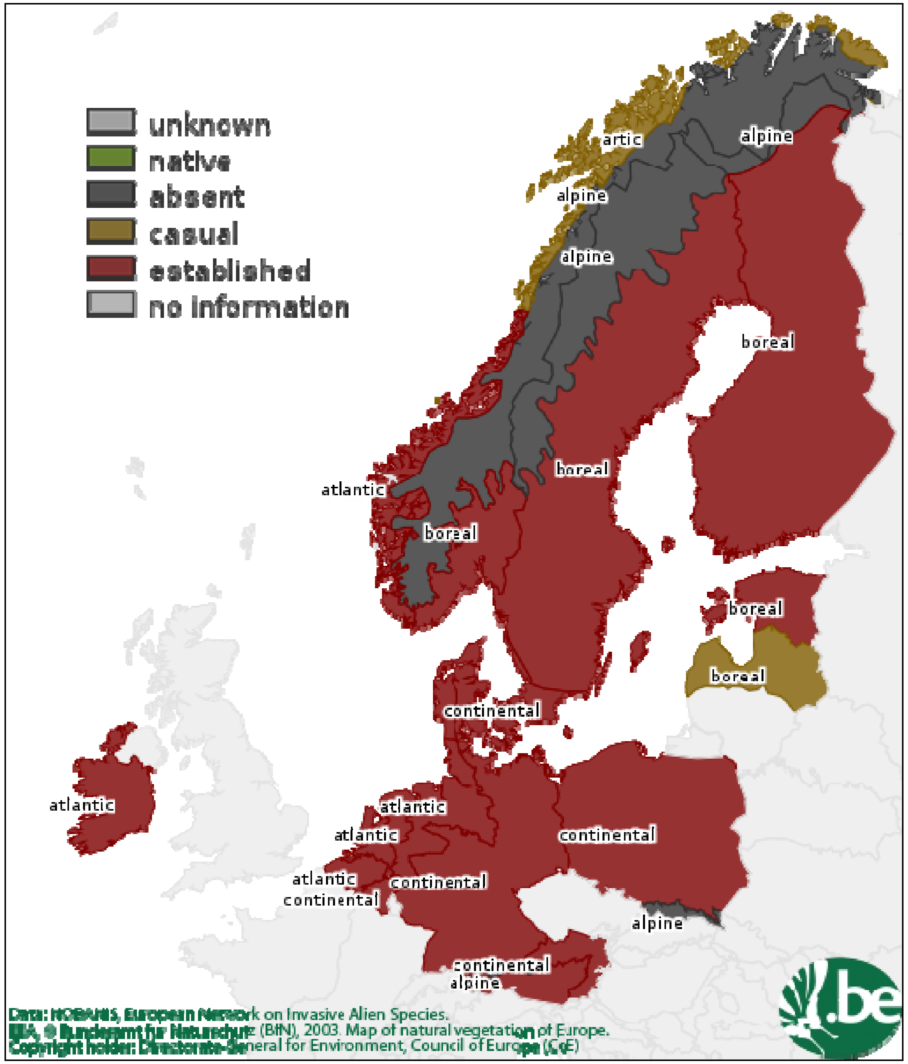


Figure 62: ***Arion lusitanicus* – EEA**. *Arion lusitanicus* is established in alpine, continental, atlantic and boreal zones. It is casual in the arctic zone. First record 1969 in DE. Slow dispersal rate.

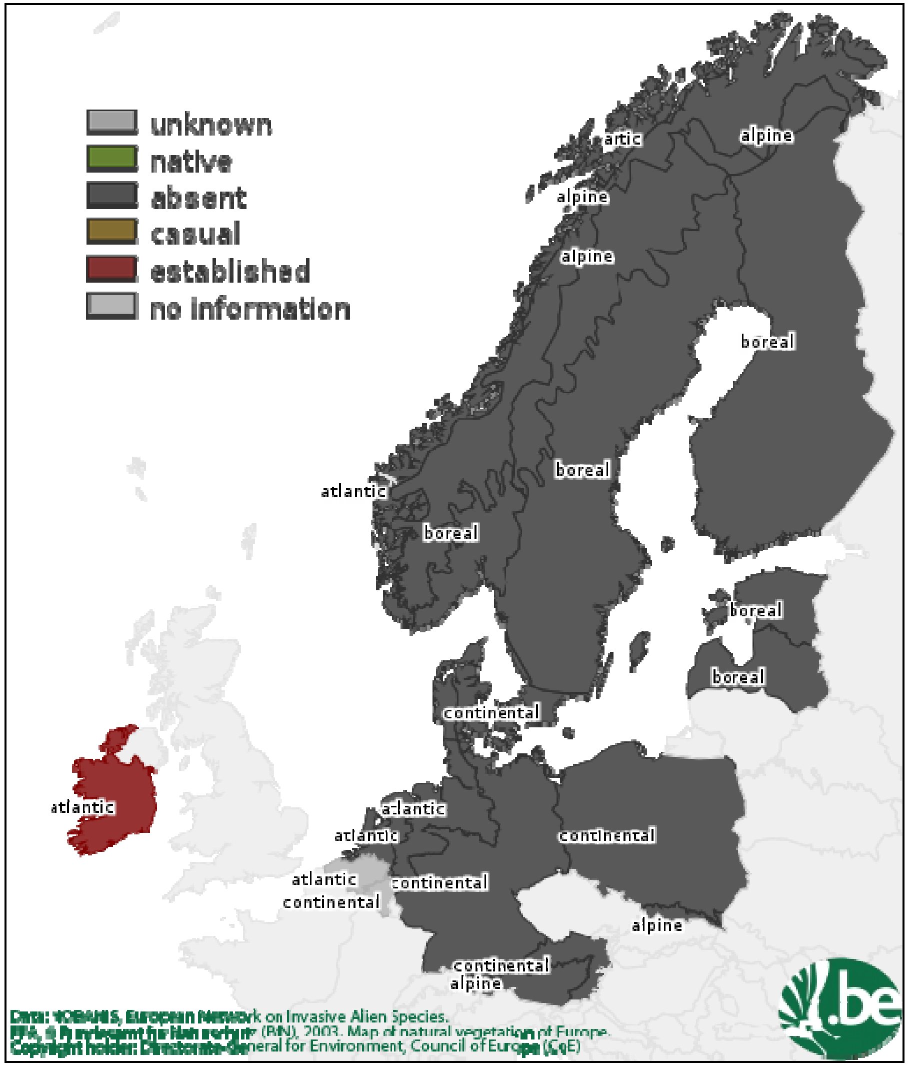


Figure 63: *Arthurdendyus triangulatus* – EEA. *Arthurdendyus triangulatus* is established in the atlantic zone. Slow dispersal rate.

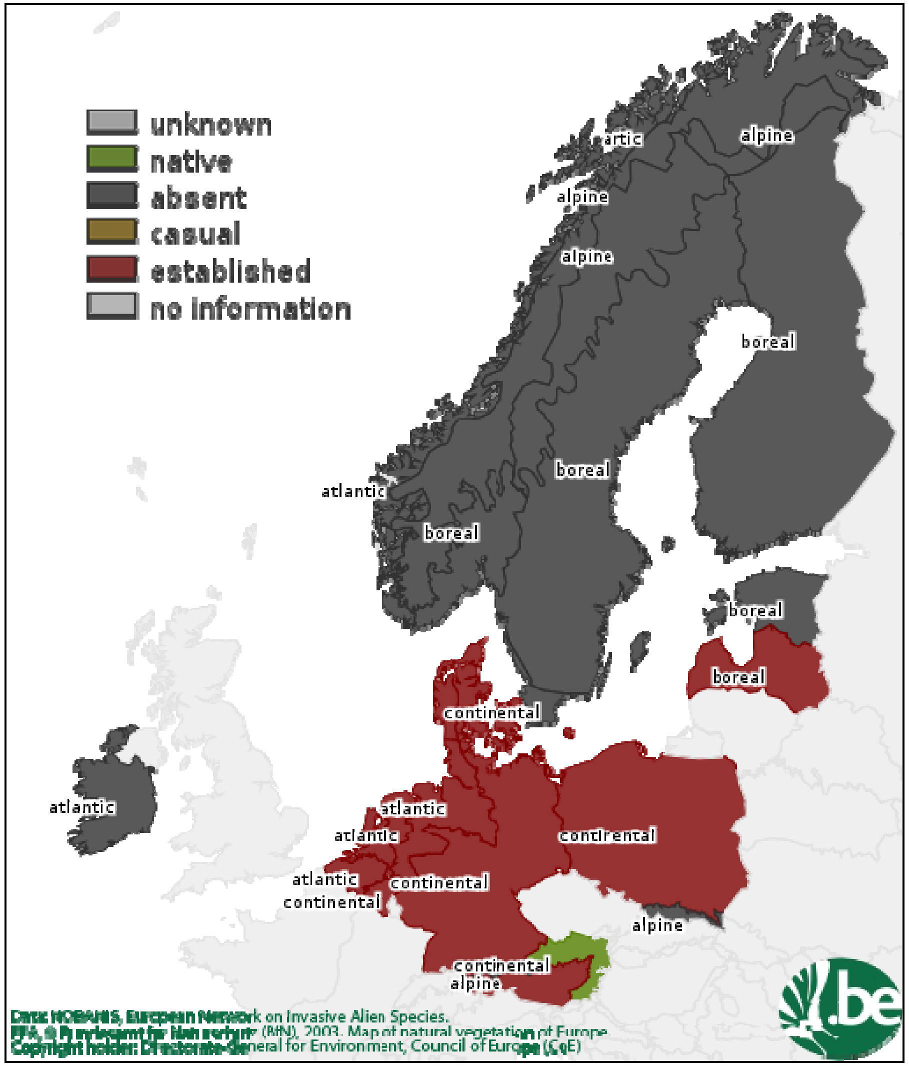


Figure 64: *Astacus leptodactylus* – EEA. *Astacus leptodactylus* is established in alpine, continental, atlantic and boreal zones. It is native to the continental zone. Fairly slow dispersal rate.

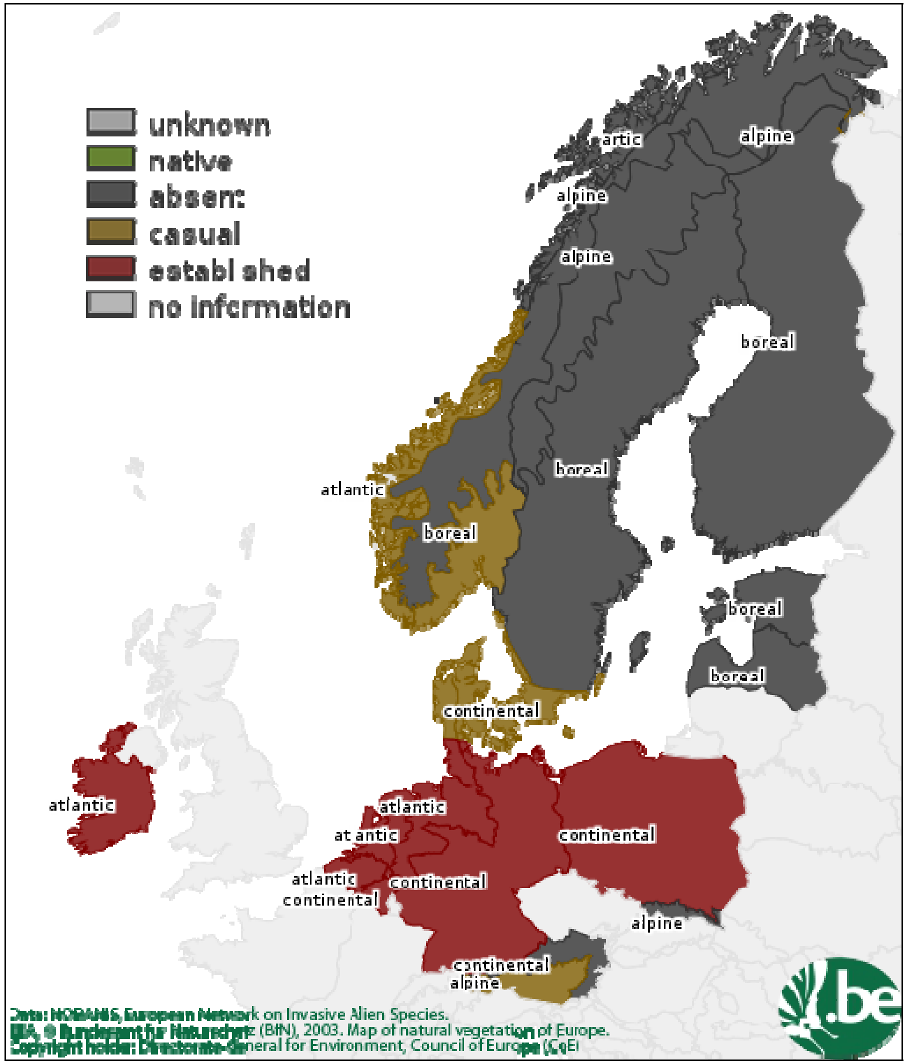


Figure 65: *Azolla filiculoides* – EEA. *Azolla filiculoides* is established in continental and atlantic zones. It is casual in the alpine and boreal zones. First record 1800 in AT. Fairly slow dispersal rate.

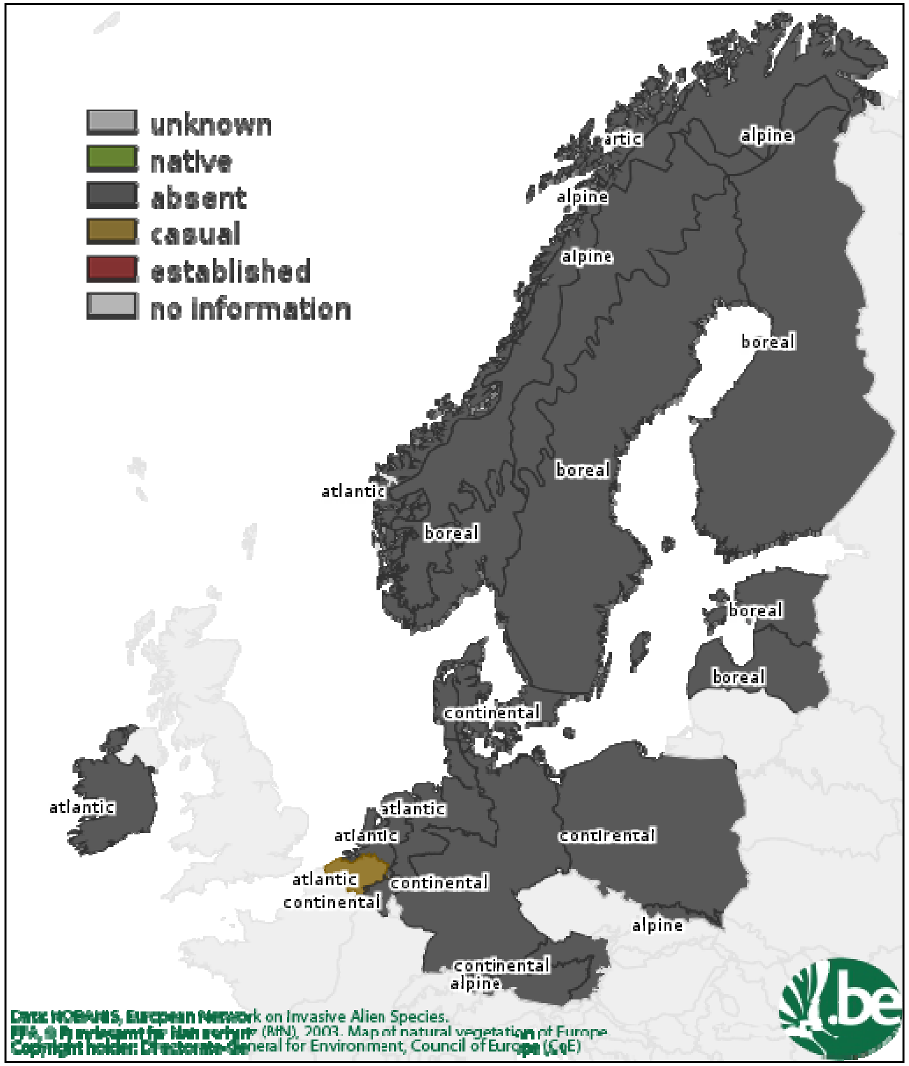


Figure 66: *Bufo marinus* – EEA. *Bufo marinus* has not established in any zones yet. It is casual in the atlantic zone. Slow dispersal rate.

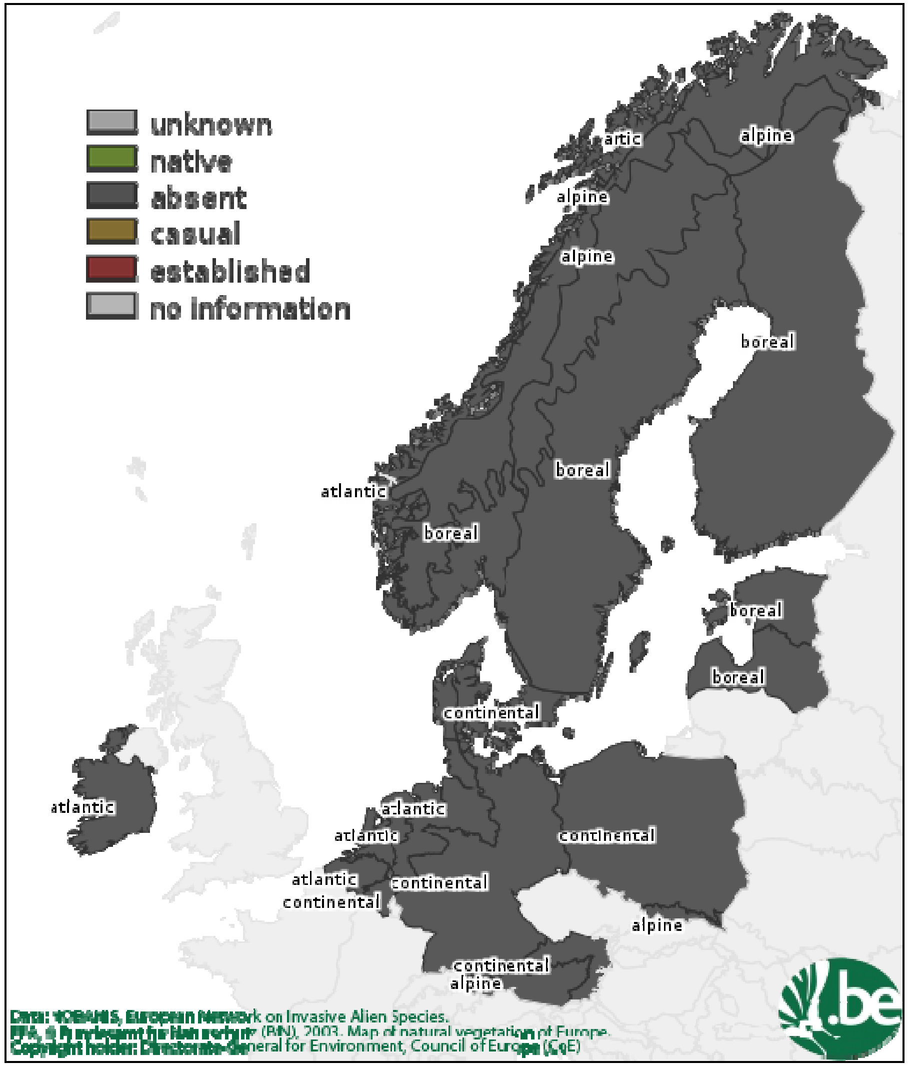


Figure 67: *Bursaphelenchus xylophilus* – EEA. *Bursaphelenchus xylophilus* has not established in any zones yet. Slow dispersal rate.

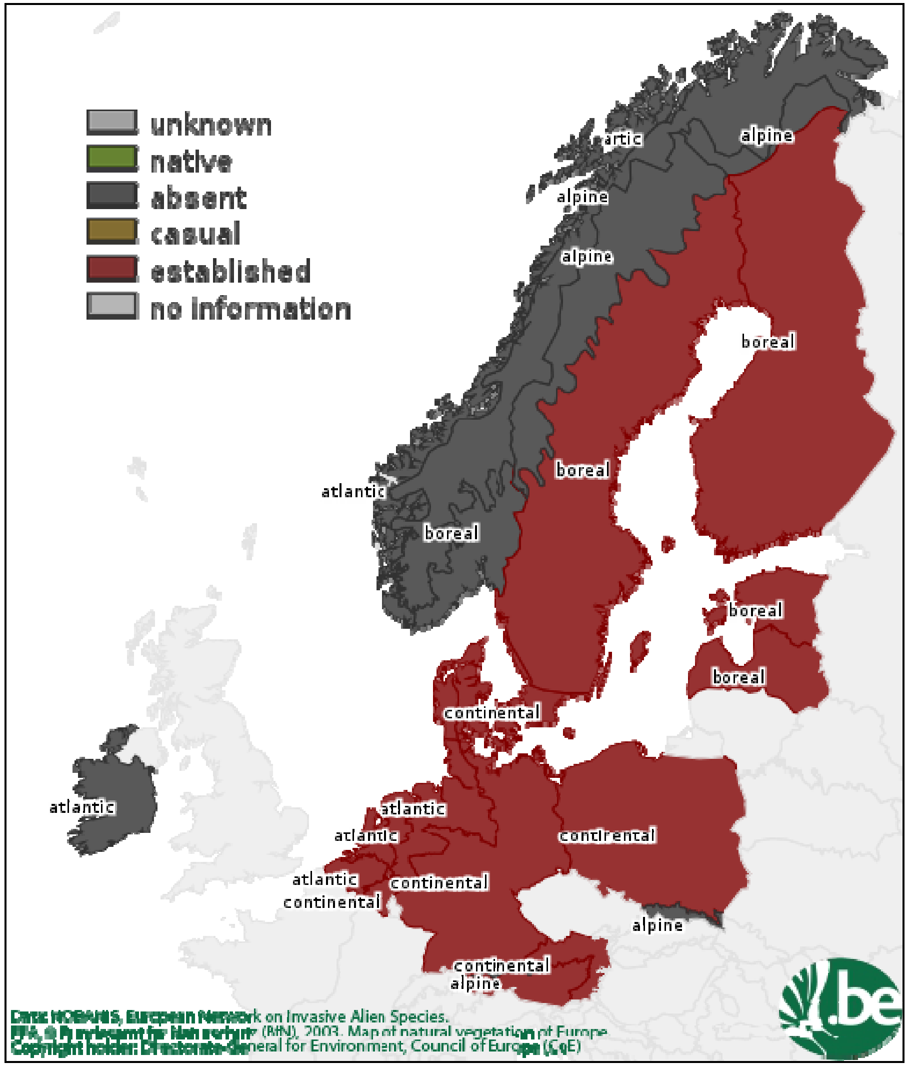


Figure 68: *Cameraria ohridella* – EEA. *Cameraria ohridella* is established in alpine, continental, atlantic and boreal zones. First record 1989 in AT. Medium dispersal rate.

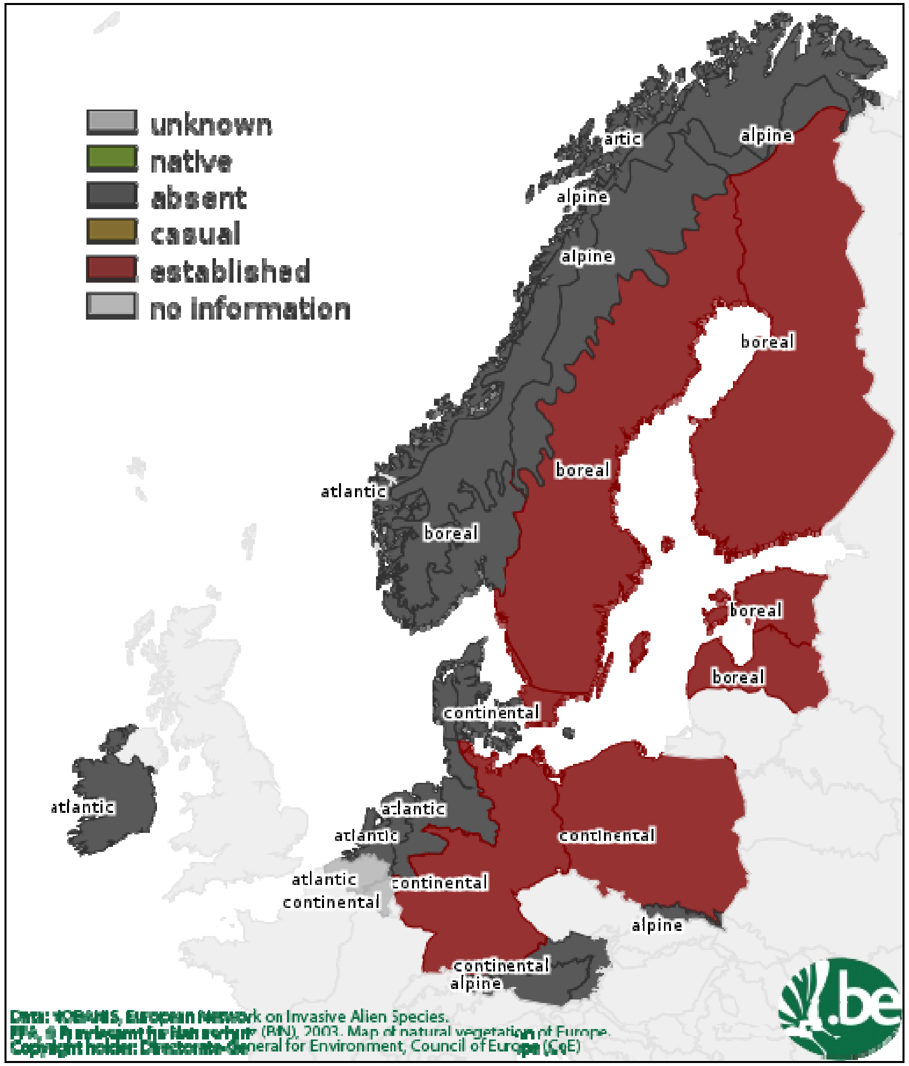
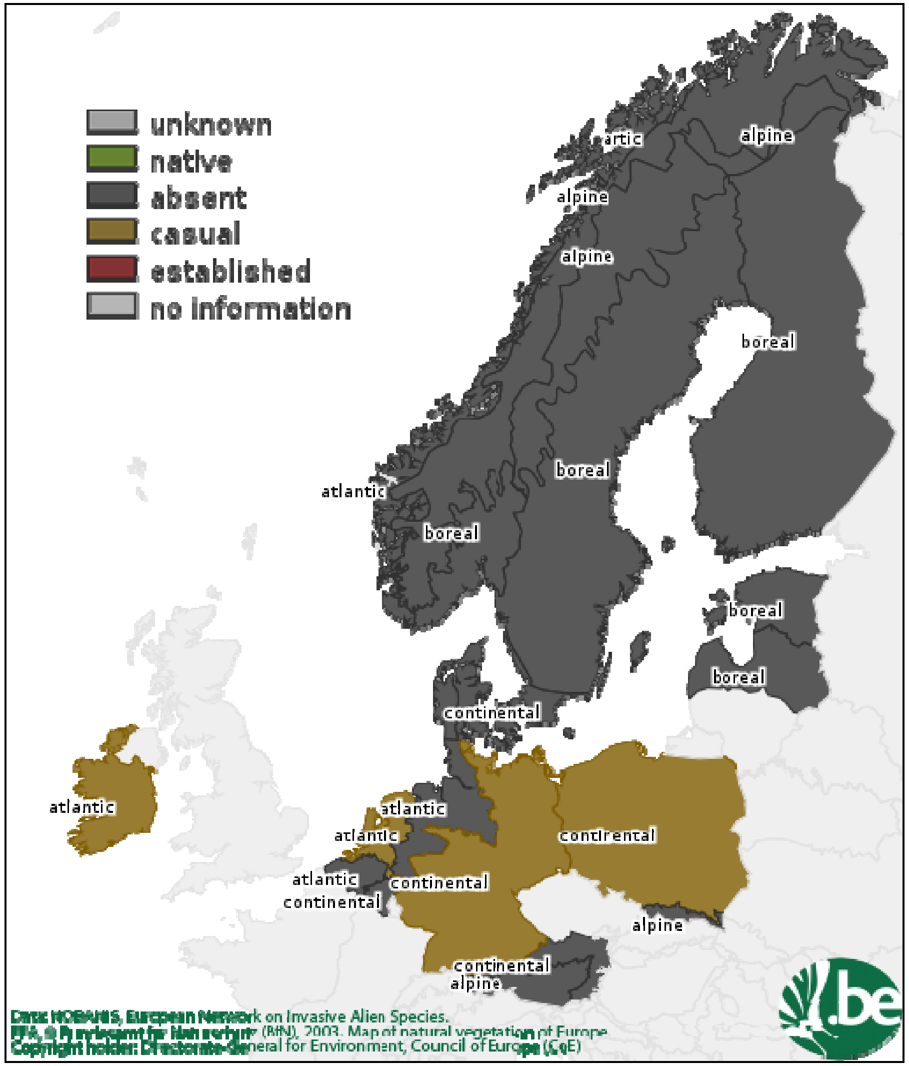


Figure 69: *Cercopagis pengoi* – EEA. *Cercopagis pengoi* is established in continental and boreal zones. First record 1992 in EE. High dispersal rate.



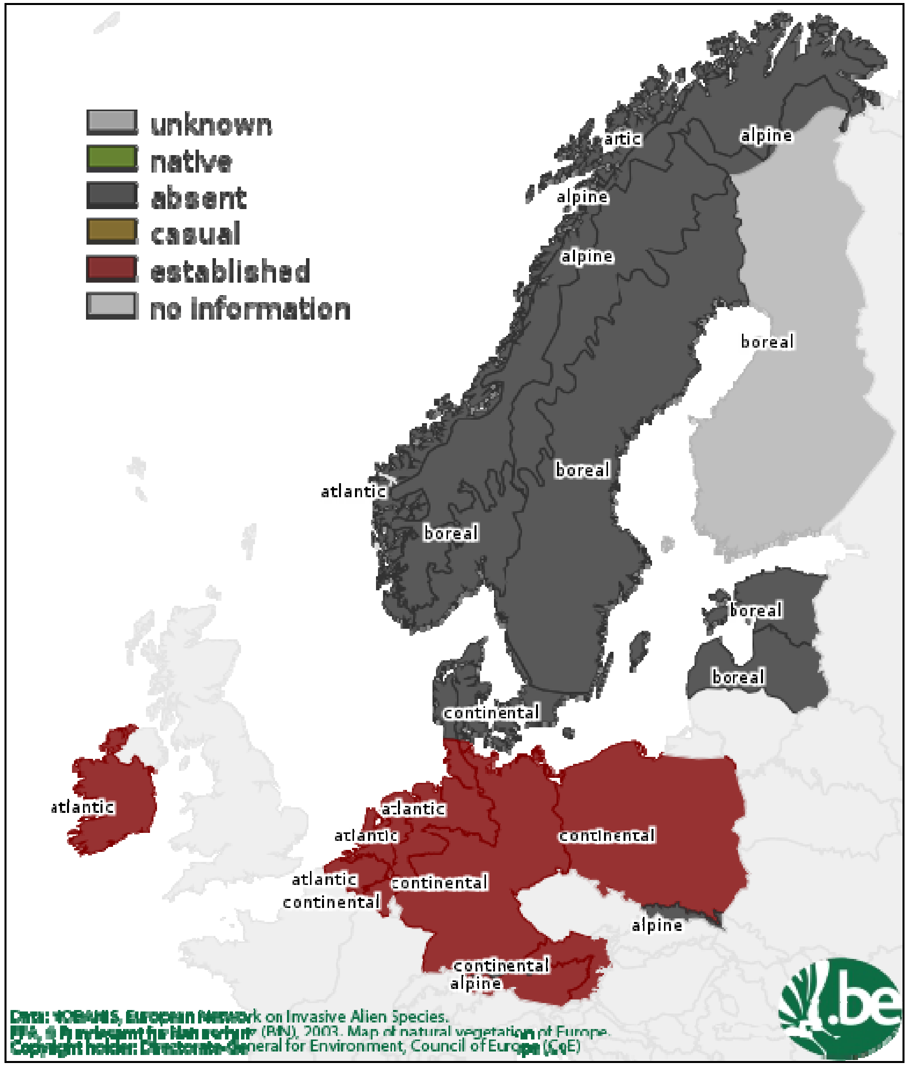


Figure 70: *Chelydra serpentina* – EEA. *Chelydra serpentina* is casual in continental and atlantic zones. First record 1997 in DE. Slow dispersal rate.

Figure 71: *Corbicula fluminea* – EEA. *Corbicula fluminea* is established in alpine, continental and atlantic zones. First record pre 1994 in DE. Dispersal rate fairly high.

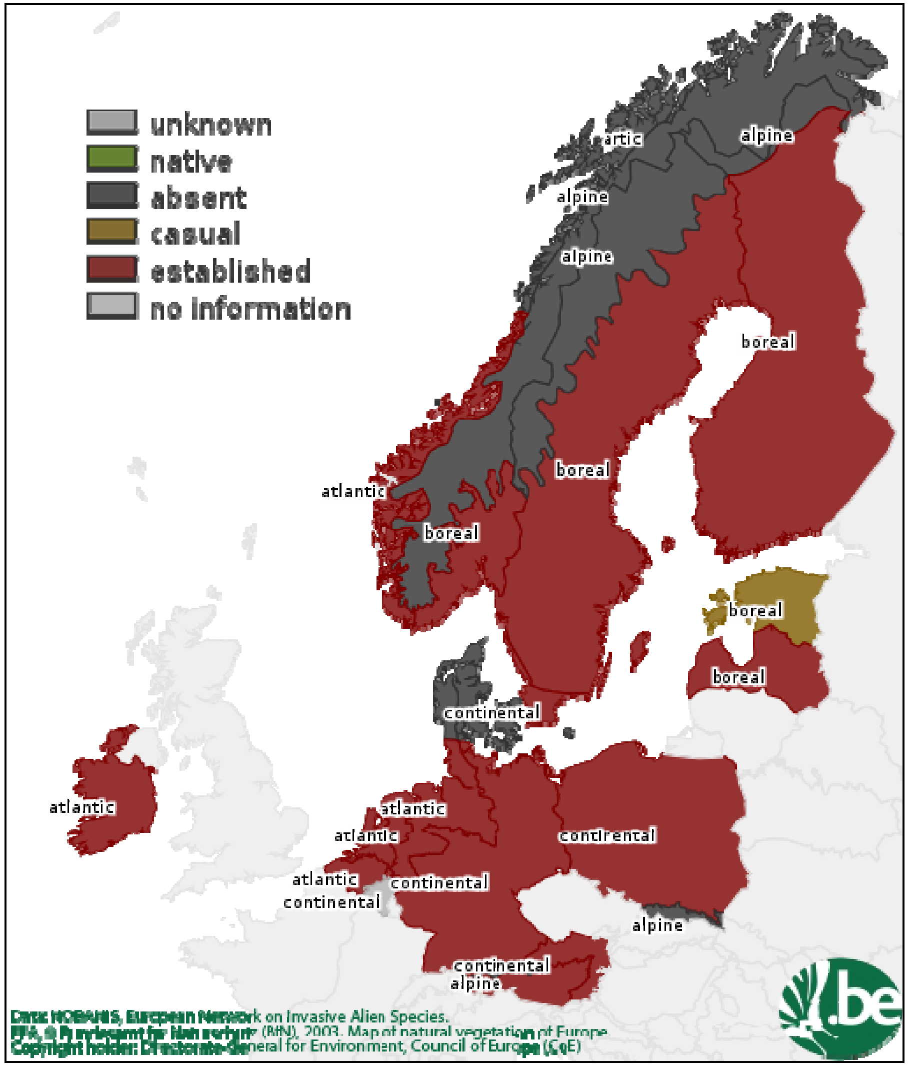


Figure 72: ***Cornus sericea*** **– EEA.** *Cornus sericea* is established in alpine, continental, atlantic and boreal zones. First record 1850 in AT. Fairly slow dispersal rate.

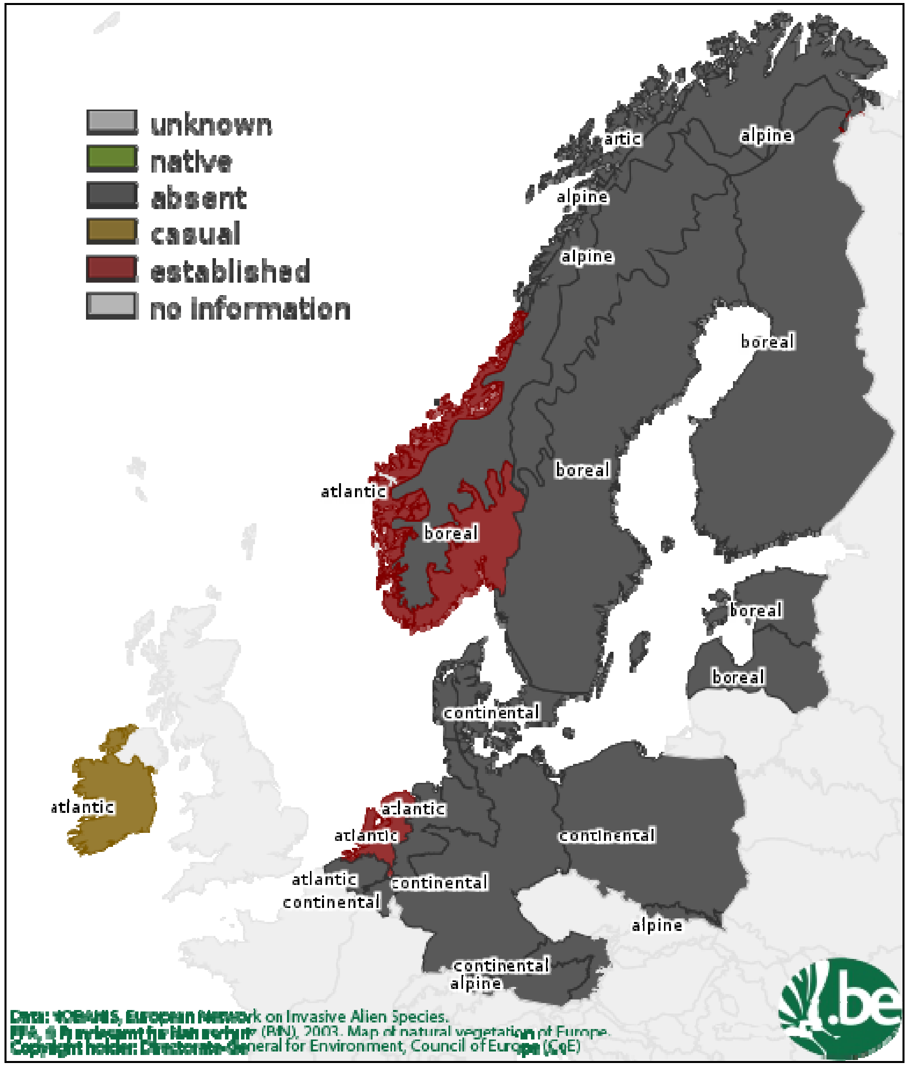


Figure 73: ***Corvus splendens*** **– EEA.** *Corvus splendens* is established in atlantic and boreal zones. High dispersal rate.

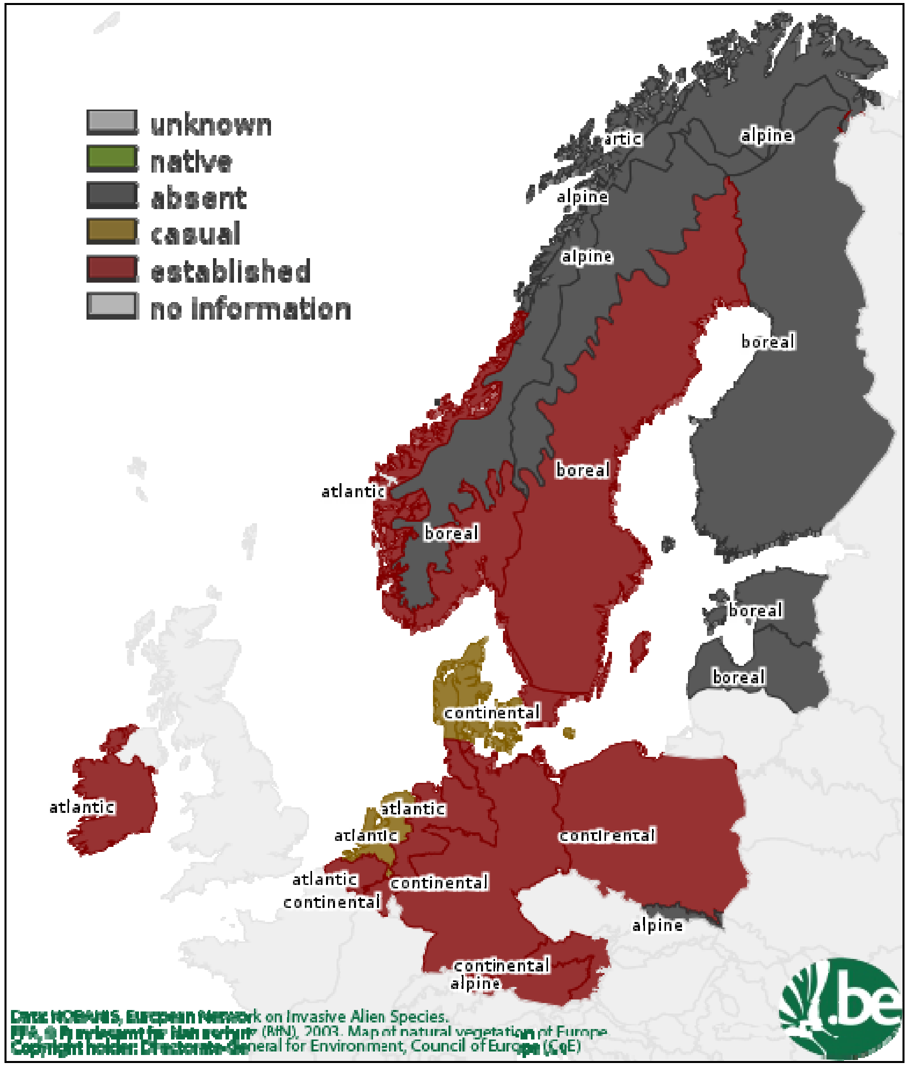


Figure 74: *Cotoneaster horizontalis* – EEA. *Cotoneaster horizontalis* is established in alpine, continental, atlantic and boreal zones. First record 1990 in AT. Slow dispersal rate.

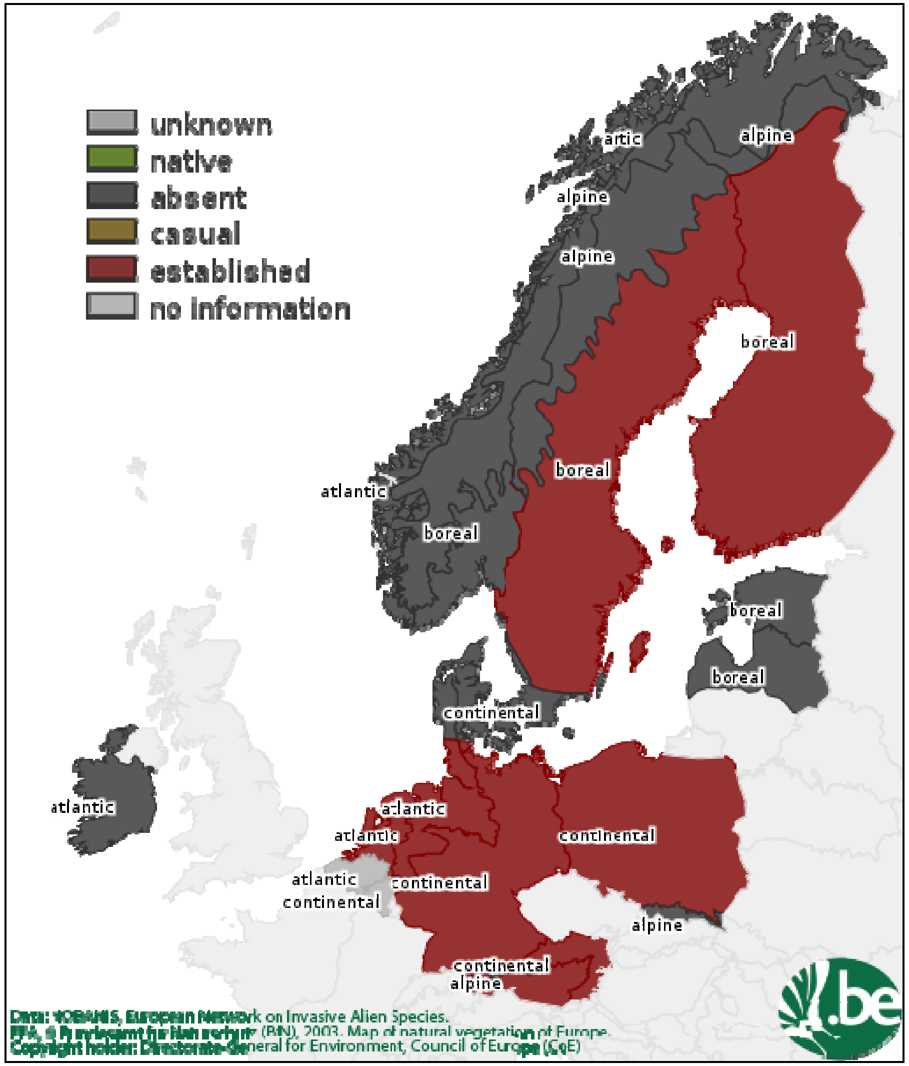


Figure 75: *Craspedacusta sowerbyi* – EEA. *Craspedacusta sowerbyi* is established in alpine, continental, atlantic and boreal zones. First record 1905 in DE. High dispersal rate.

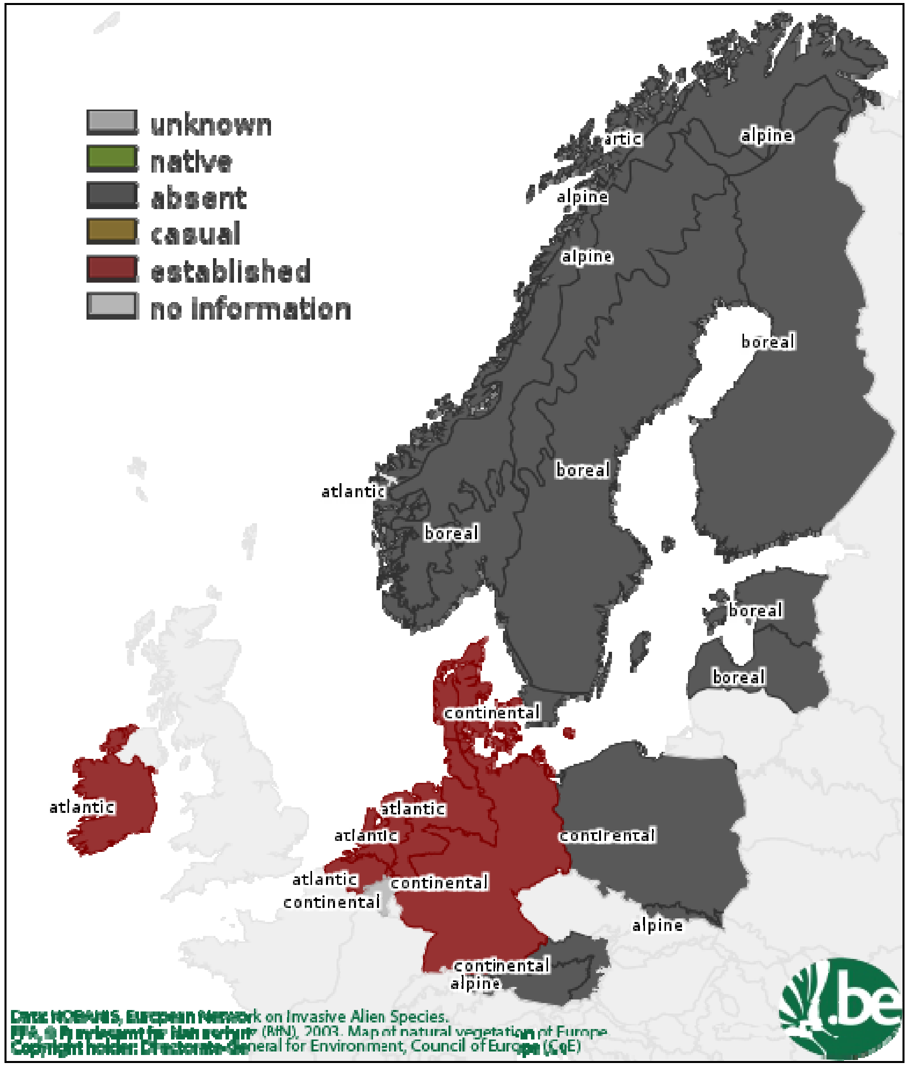


Figure 76: ***Crassula helmsii*** **– EEA.** *Crassula helmsii* is established in continental and atlantic zones. First record 1981 in DE. Medium dispersal rate.

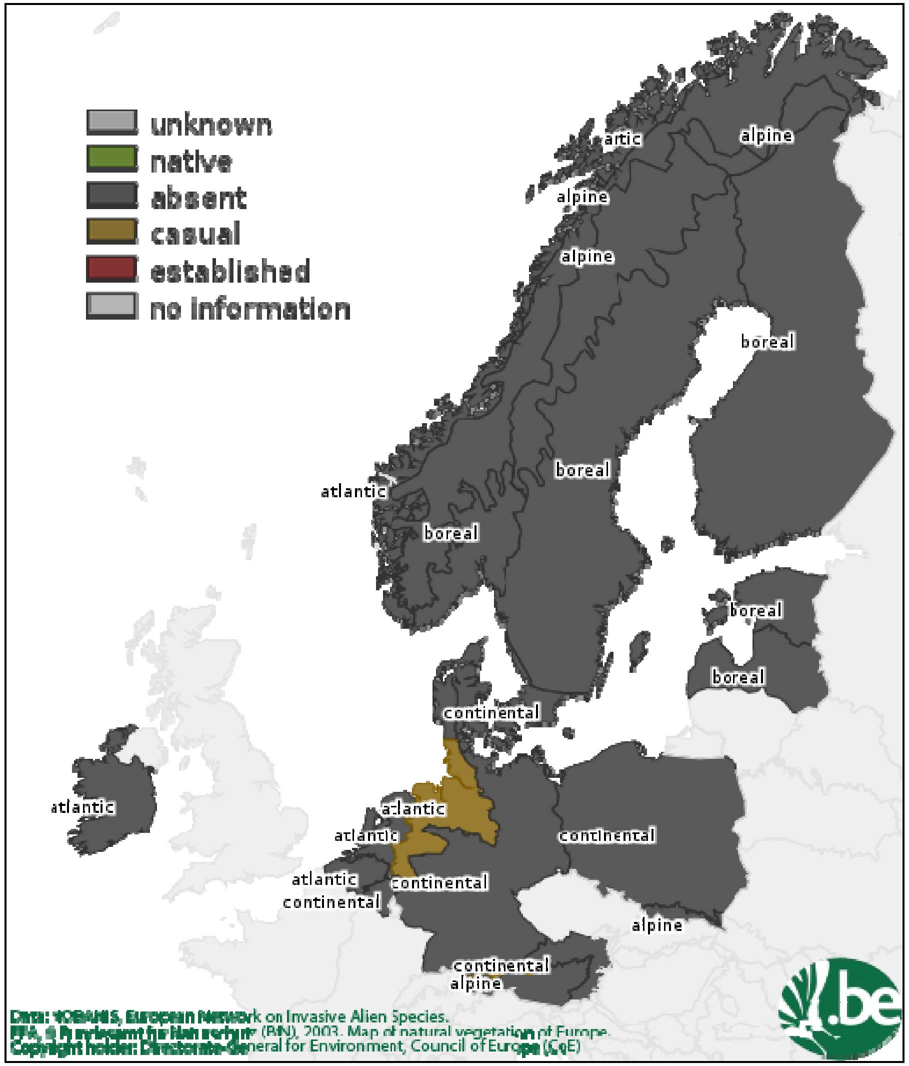


Figure 77: ***Gambusia holbrooki*** **– EEA.** *Gambusia holbrooki* is casual in the atlantic zone. Medium dispersal rate.

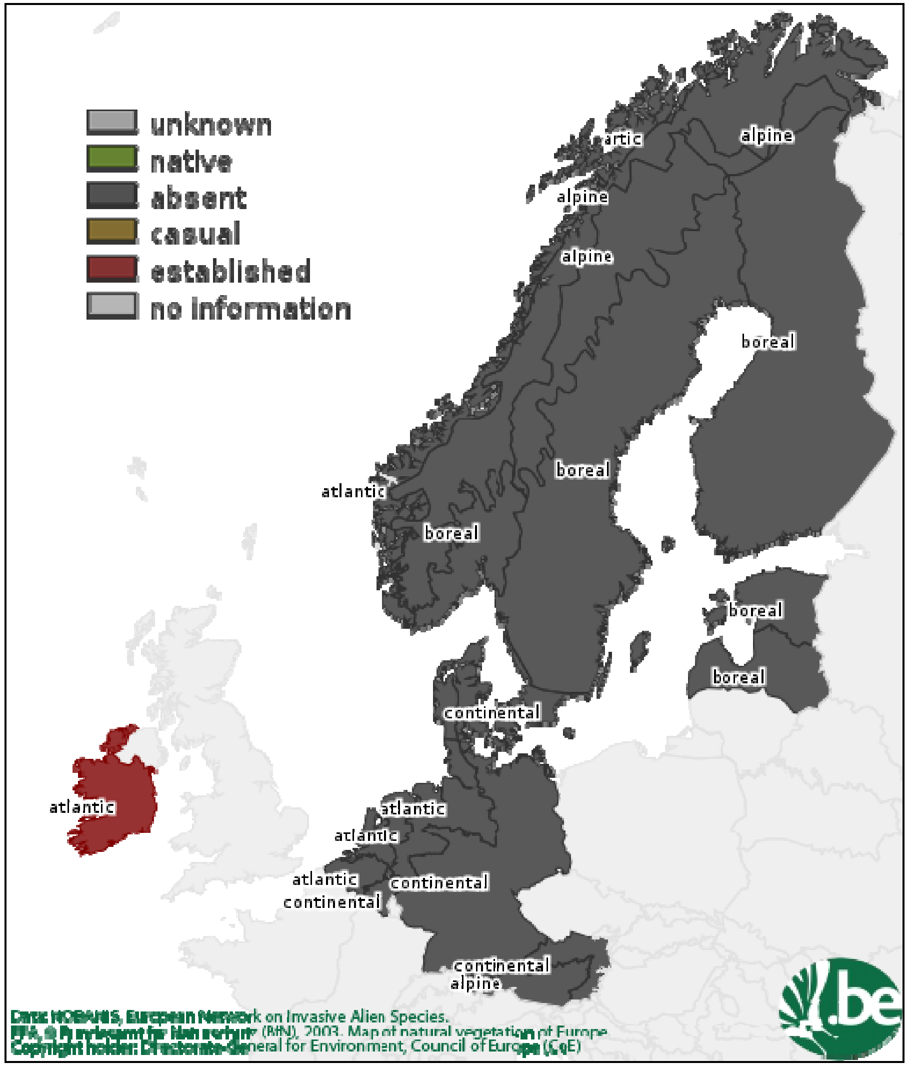


Figure 78: ***Gunnera tinctoria* – EEA.** *Gunnera tinctoria* is established in the atlantic zone. Medium dispersal rate.

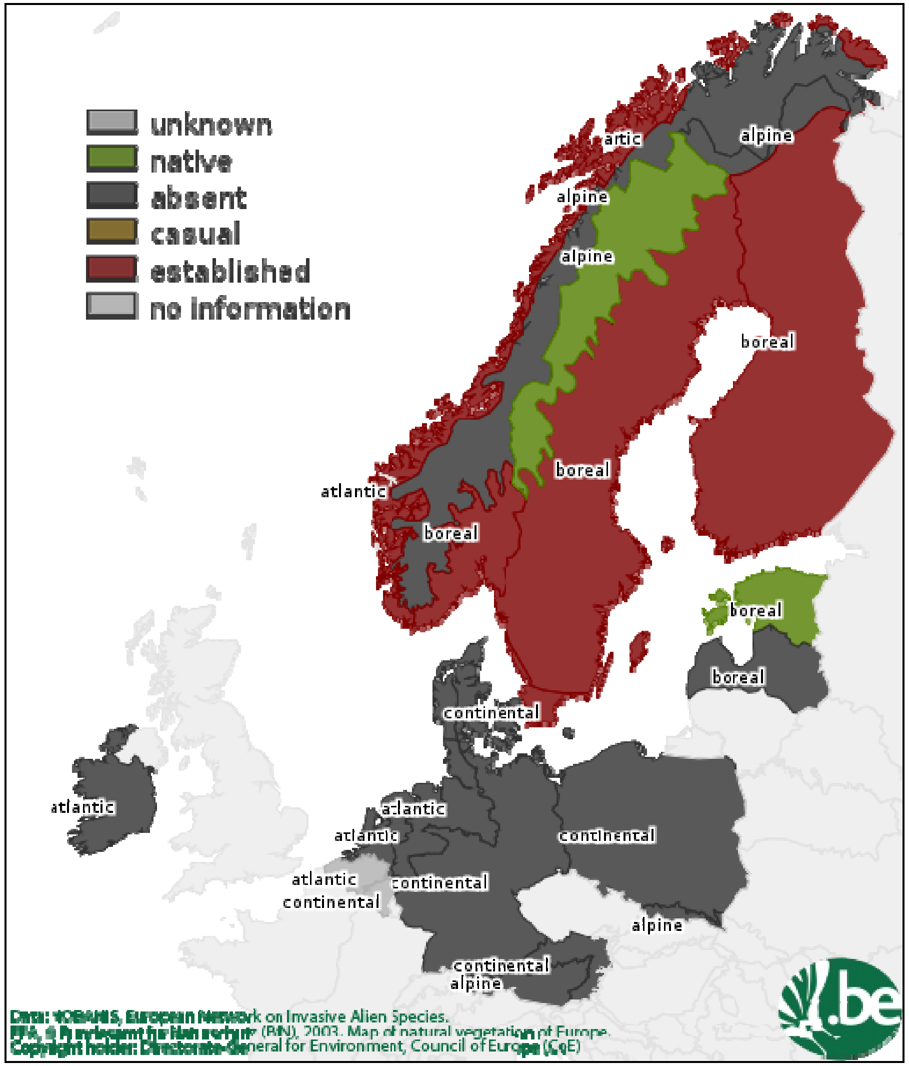


Figure 79: *Gyrodactylus salaris* – EEA. *Gyrodactylus salaries* is established in boreal, atlantic, alpine and arctic zones. First record 1975 in NO. Medium dispersal rate.

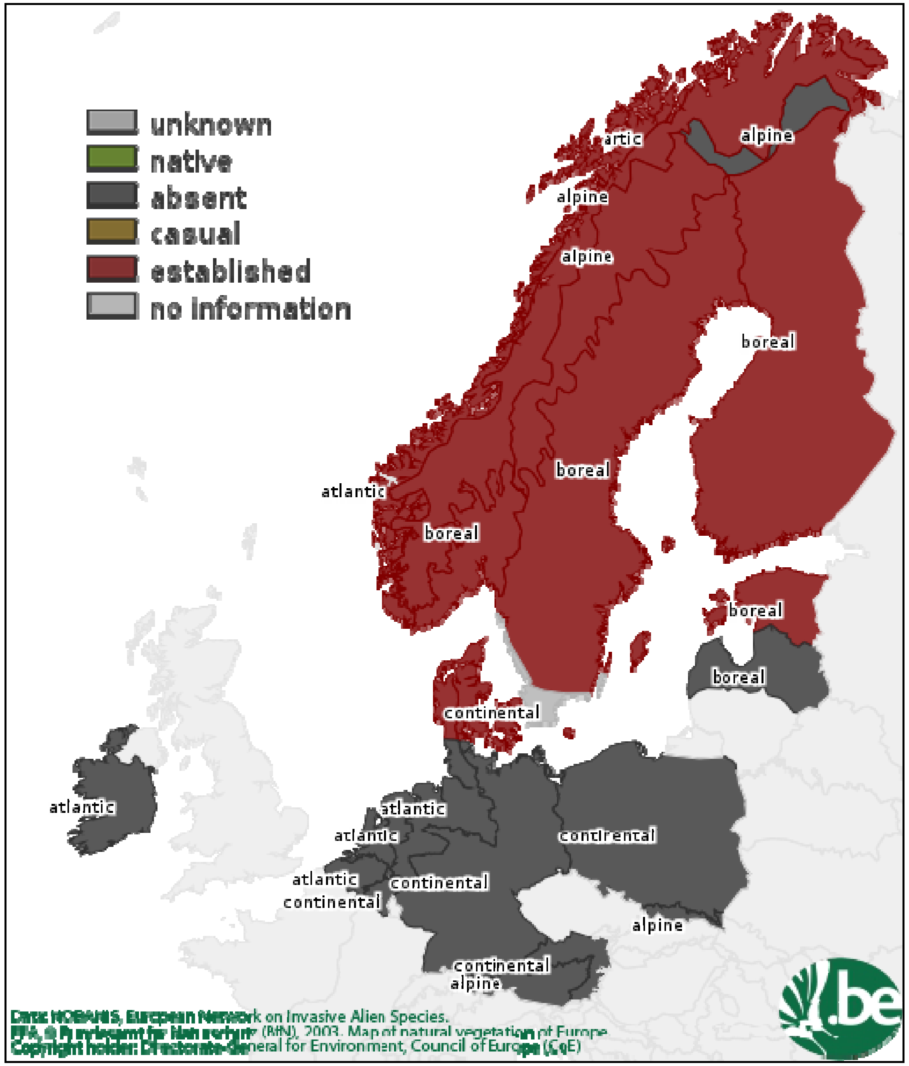


Figure 80: ***Heracleum persicum*** **– EEA.** *Heracleum persicum* is established in continental, atlantic, boreal, alpine and arctic zones. First record 1777 in EE. Slow dispersal rate.

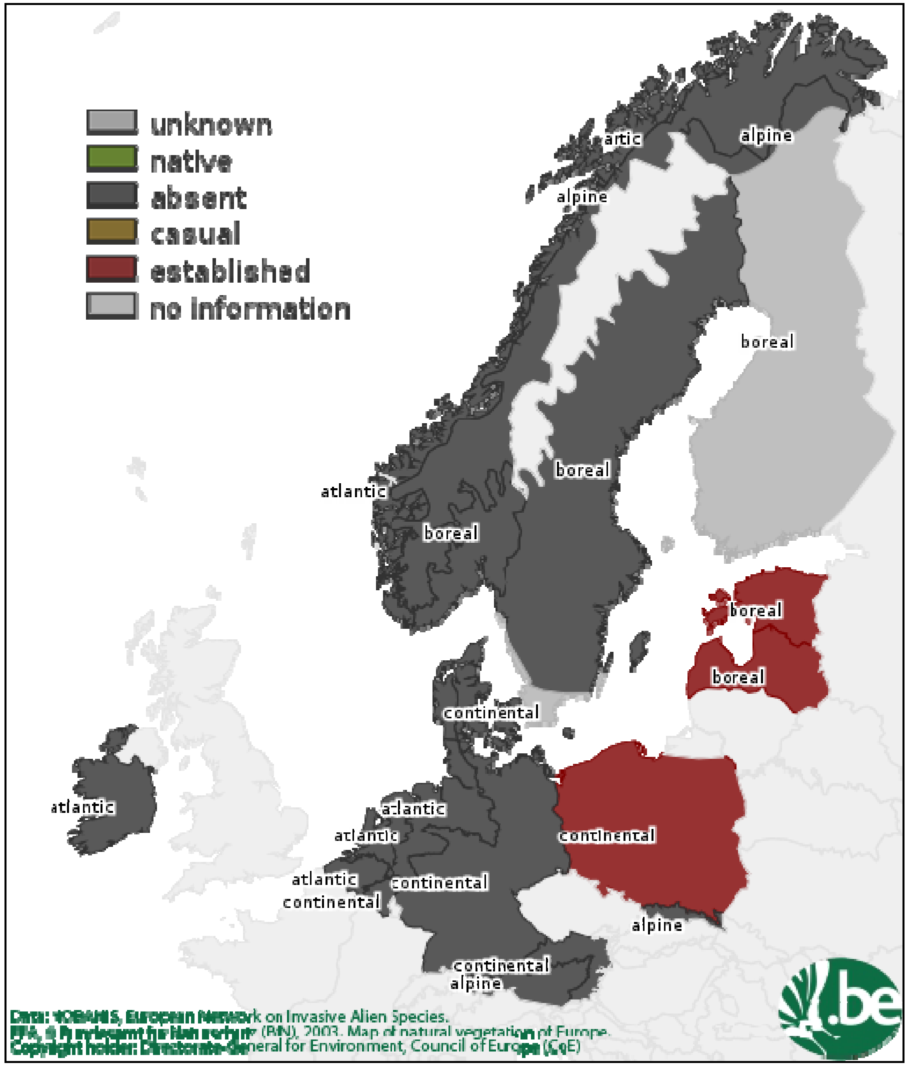


Figure 81: ***Heracleum sosnowskyi*** **– EEA.** *Heracleum sosnowskyi* is established in continental and boreal zones. First record 1948 in LV. Slow dispersal rate.

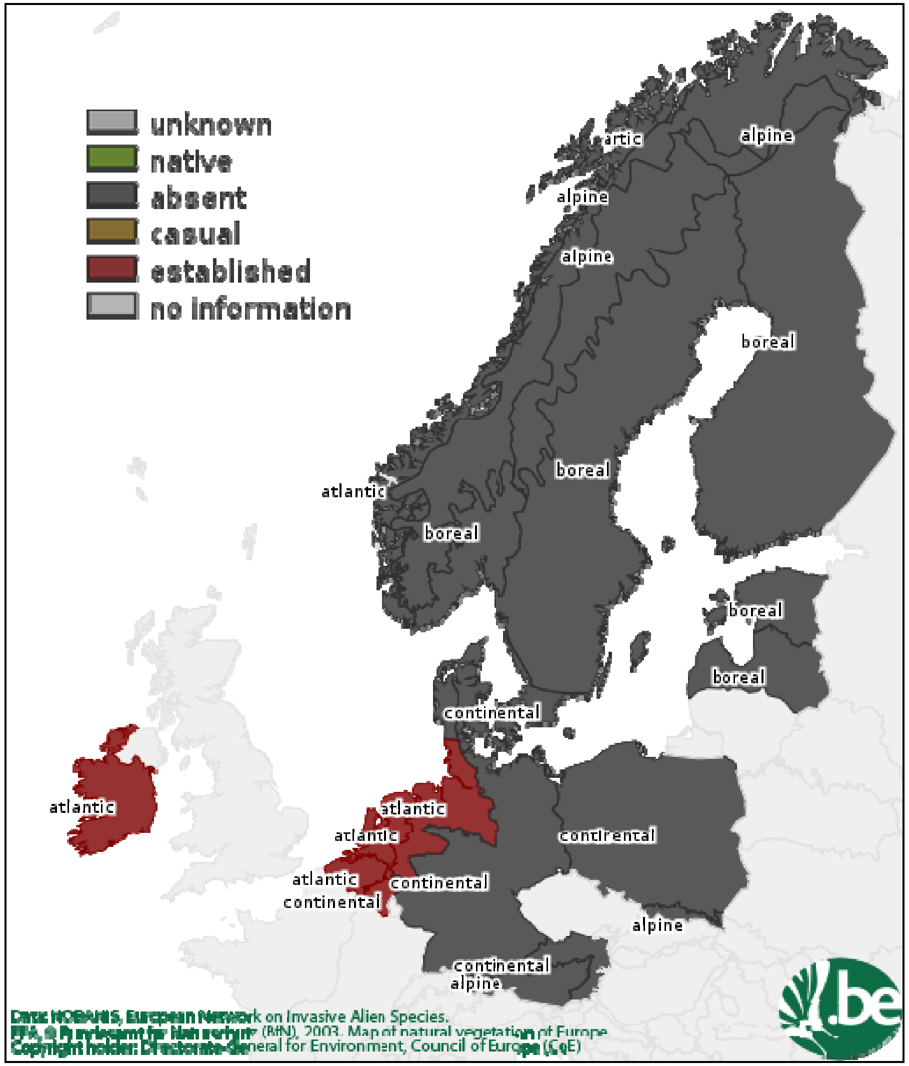


Figure 82: *Hydrocotyle ranunculoides* – EEA. *Hydrocotyle ranunculoides* is established in continental and atlantic zones. First record 1992 in BE. Medium dispersal rate.

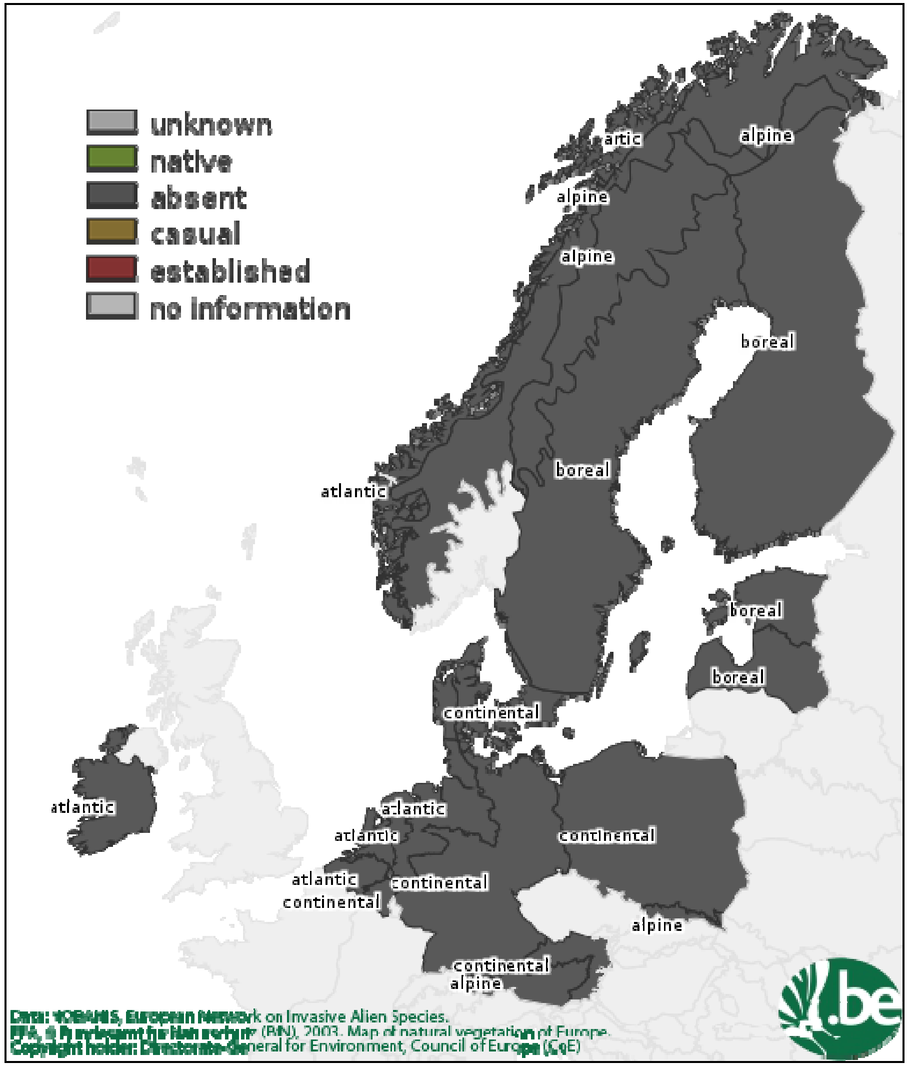


Figure 83: *Hydropotes inermis* – EEA. *Hydropotes inermis* is not established in any zones yet. Slow dispersal rate.

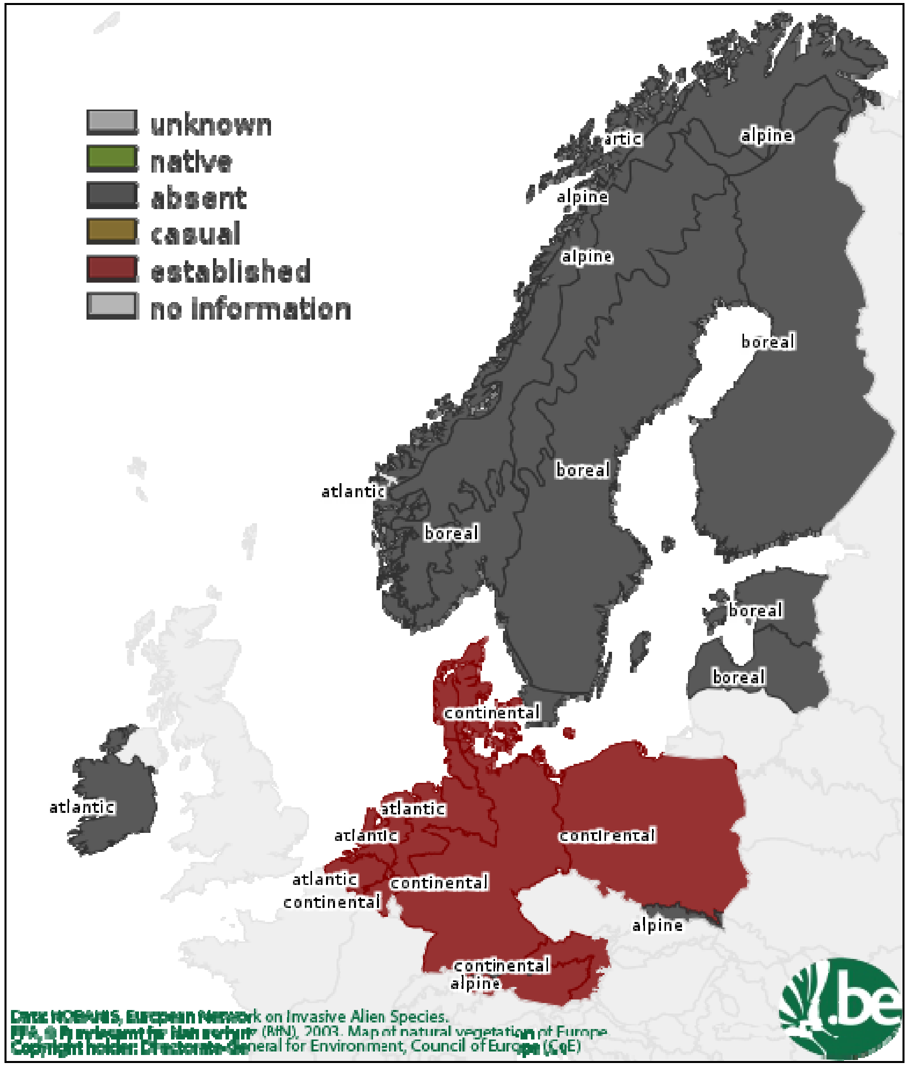


Figure 84: ***Lepomis gibbosus*** **– EEA.** *Lepomis gibbosus* is established in the alpine, continental and atlantic zones. First record 1880 in DE. Medium dispersal rate.

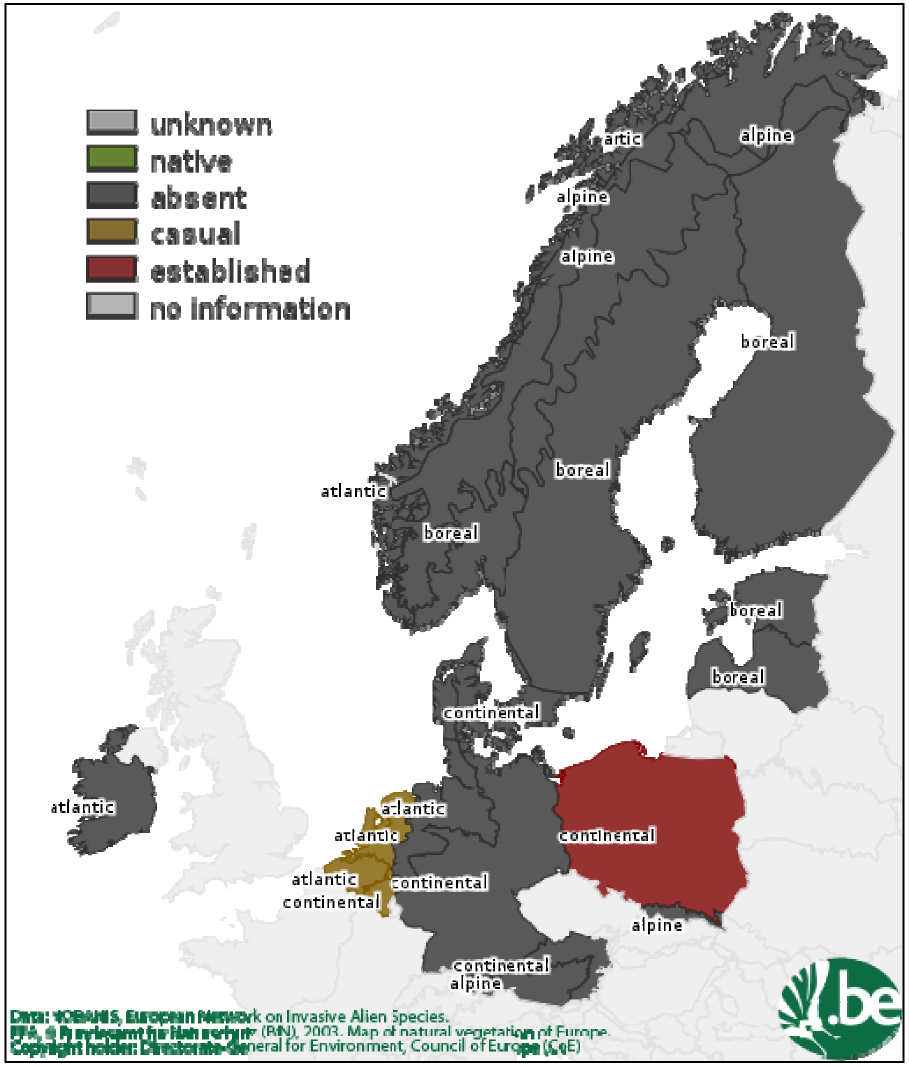


Figure 85: ***Linepithema humile*** **– EEA.** *Linepithema humile* is established in the continental zone and casual in the atlantic zone. Slow dispersal rate.

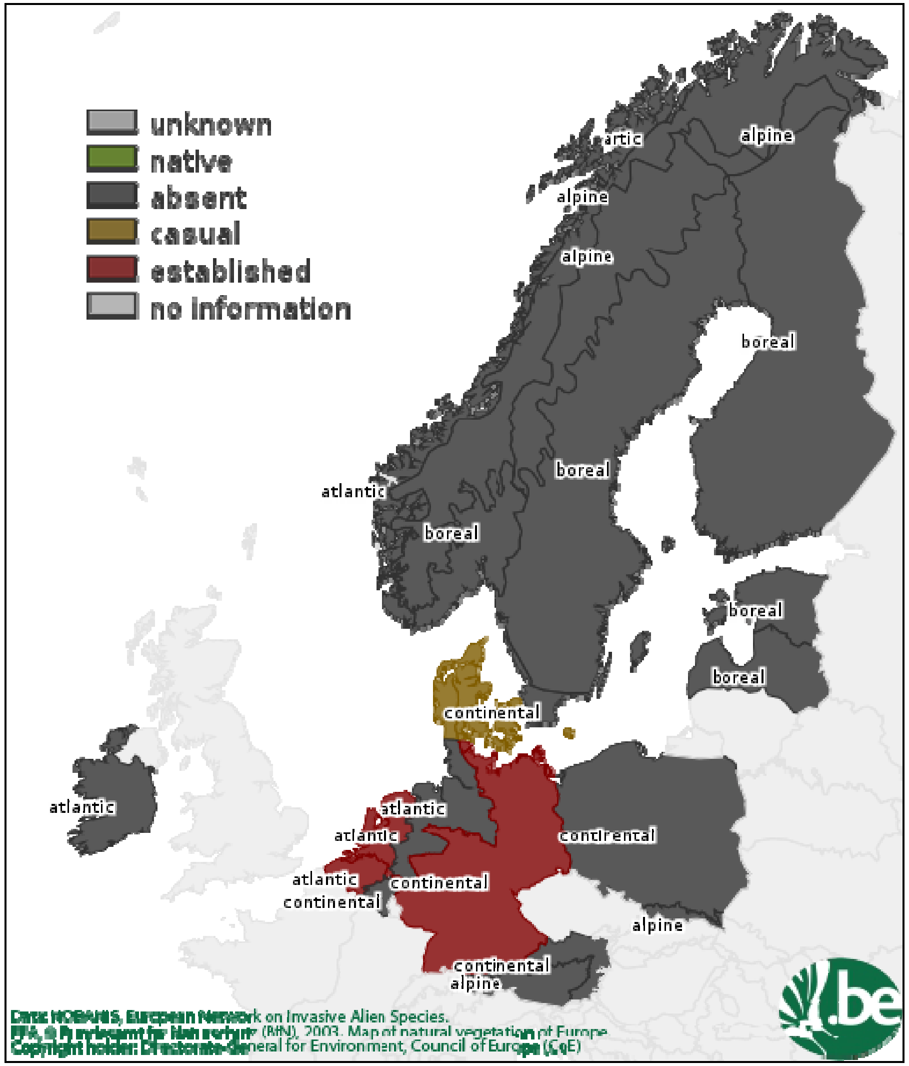


Figure 86: *Lithobates catesbeiana* – EEA. *Lithobates catesbeiana* is established in the continental and atlantic zones. Slow dispersal rate.

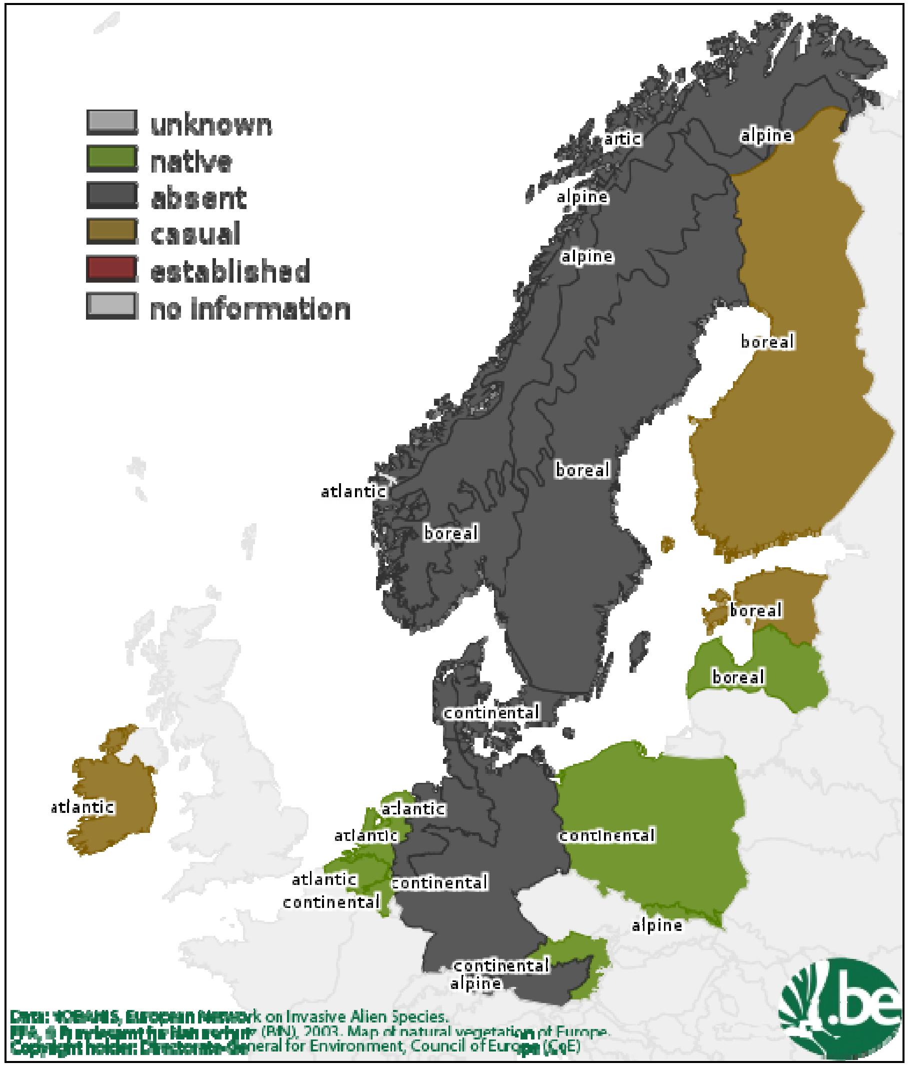


Figure 87: *Lymantria dispar* – EEA. *Lymantria dispar* is casual in the atlantic and boreal zone. It is native to the alpine, continental, atlantic and boreal zones. Slow dispersal rate.

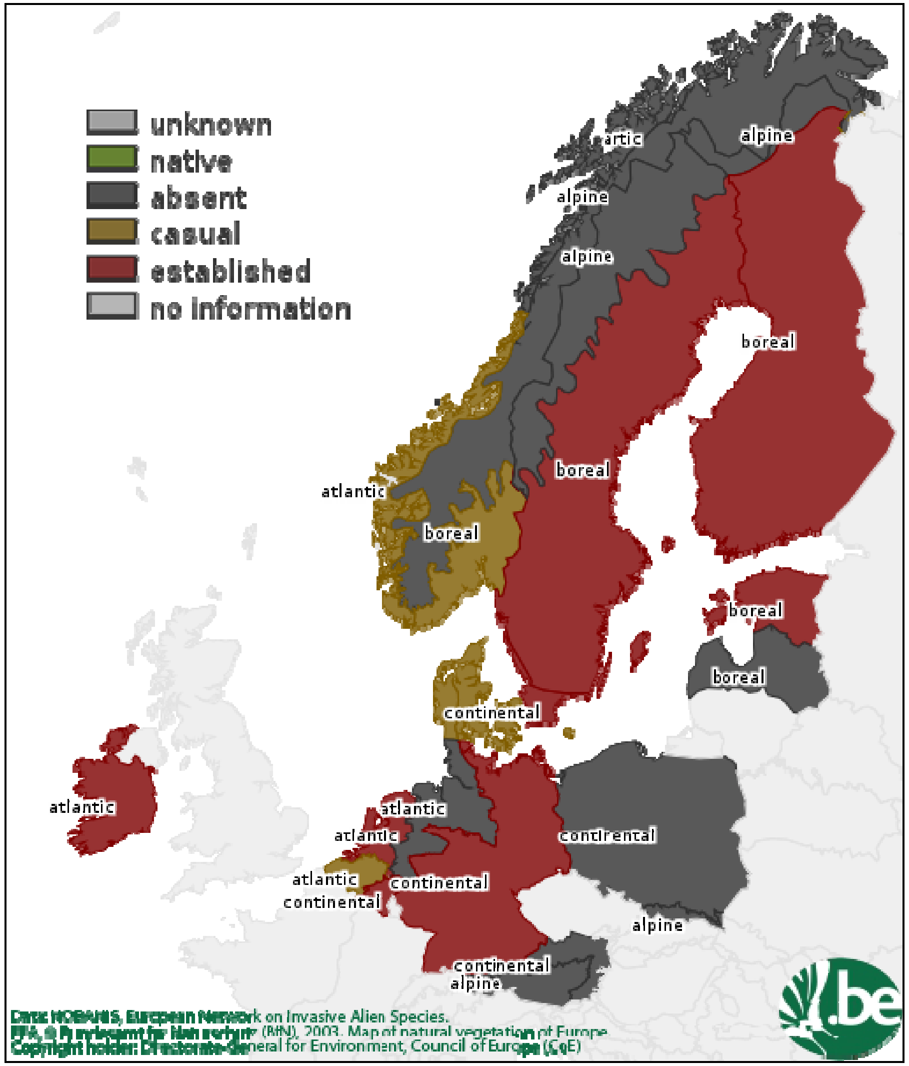


Figure 88: ***Lysichiton americanus*** **– EEA.** *Lysichiton americanus* is established in continental, atlantic and boreal zones. First record 1930´s in IE. Fairly slow dispersal rate.

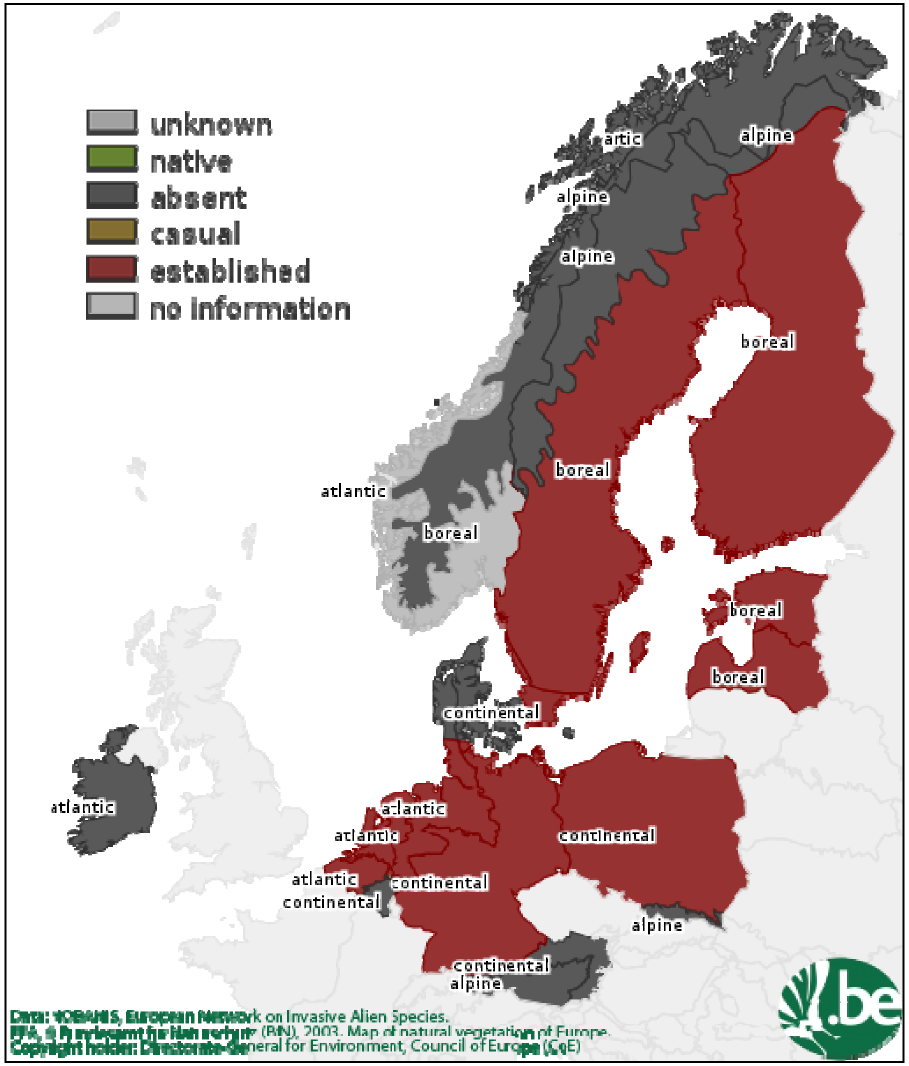


Figure 89: ***Marenzelleria neglecta*** **– EEA.** *Marenzelleria neglecta* is established in continental, atlantic and boreal zones. First record 1985 in FI. High dispersal rate.

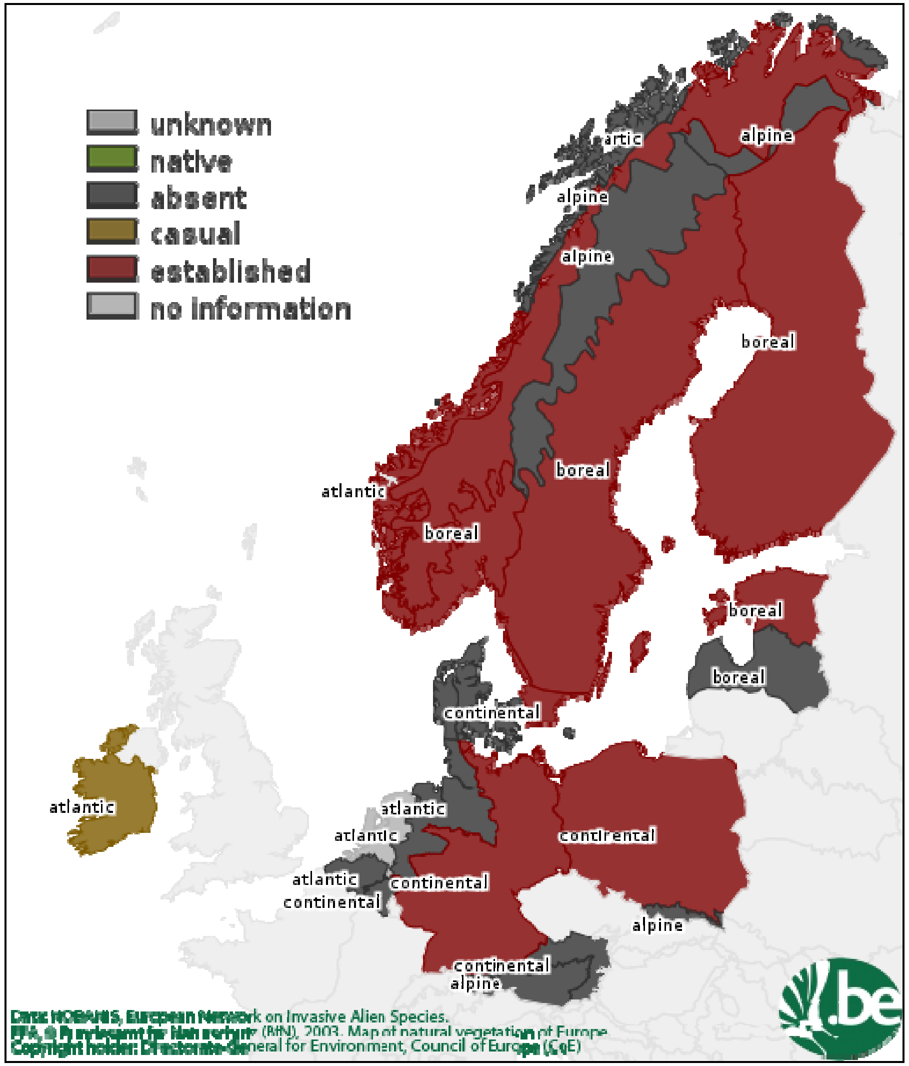


Figure 90: *Melampsoridium hiratsukanum* – EEA. *Melampsoridium hiratsukanum* is established in continental, atlantic and boreal zones. First record 1999 in PL. Dispersal rate medium.

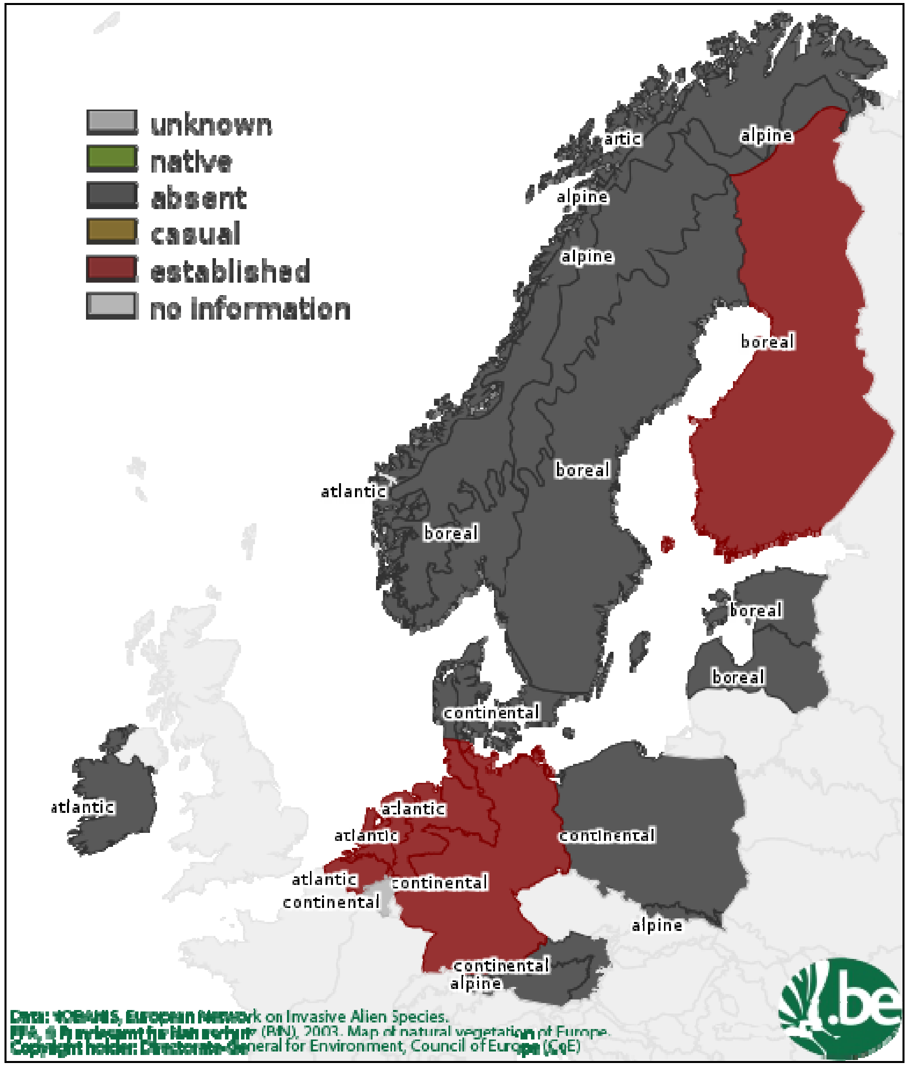


Figure 91: *Mytilopsis leucophaeata* – EEA. *Mytilopsis leucophaeata* is established in continental, atlantic and boreal zones. Fairly high dispersal rate.

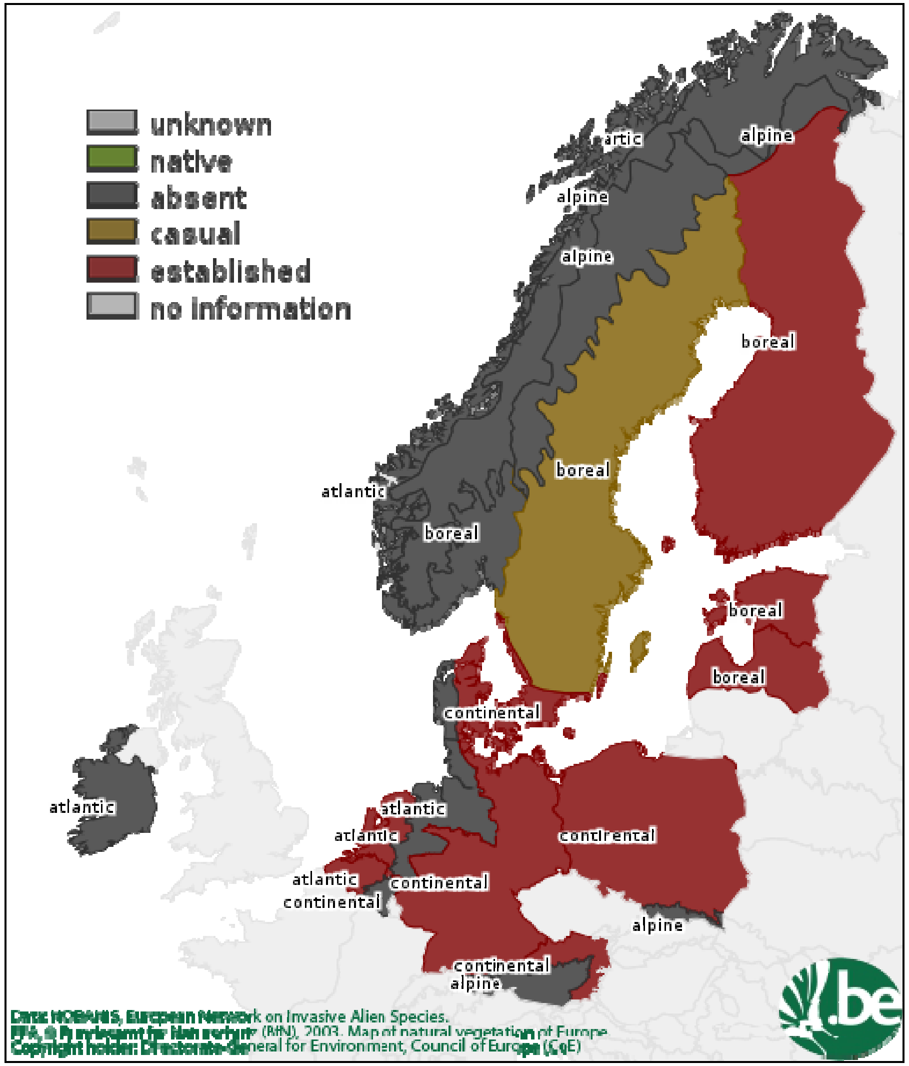


Figure 92: *Neogobius melanostomus* – EEA. *Neogobius melanostomus* is established in continental, atlantic and boreal zones. First record 1990 in PL. Slow dispersal rate.

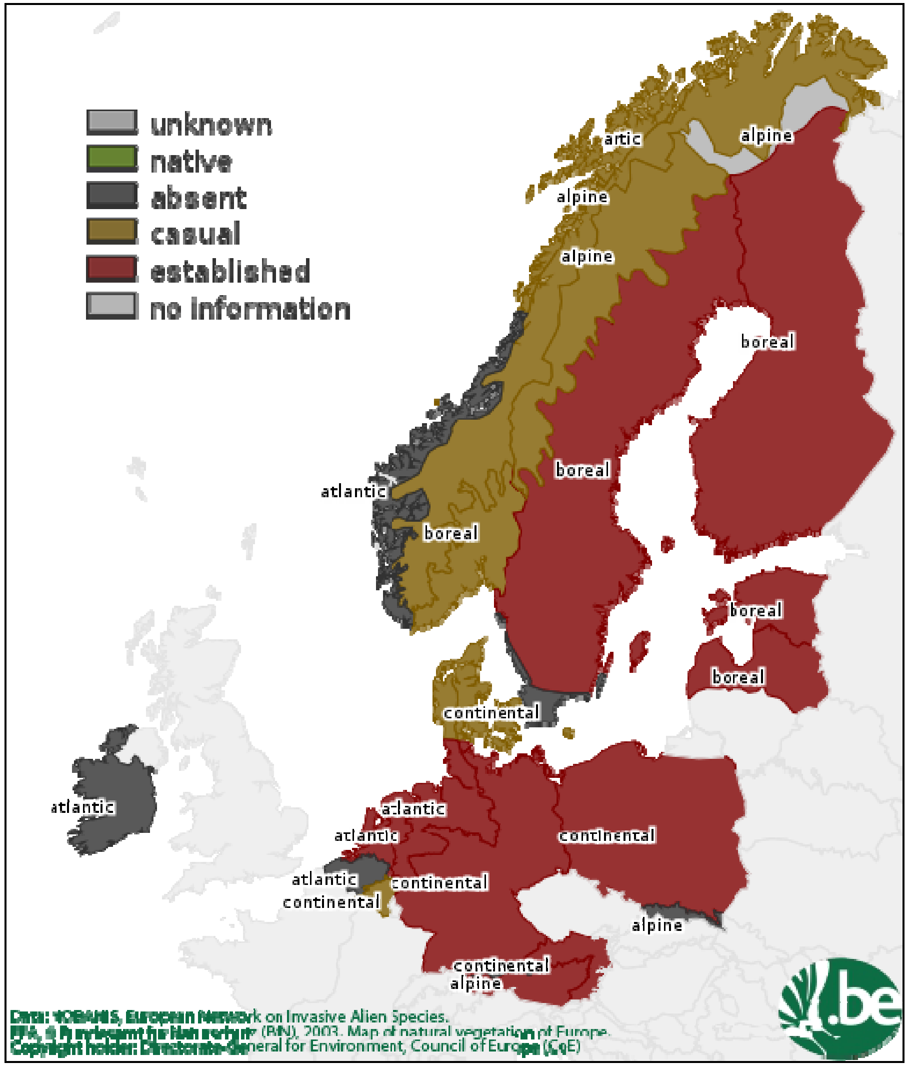


Figure 93: *Nyctereutes procyonoides* – EEA. *Nyctereutes procyonoides* is established in alpine, continental, atlantic and boreal zones. It is casual in the arctic zone. First record 1930 in DK. Medium dispersal rate.

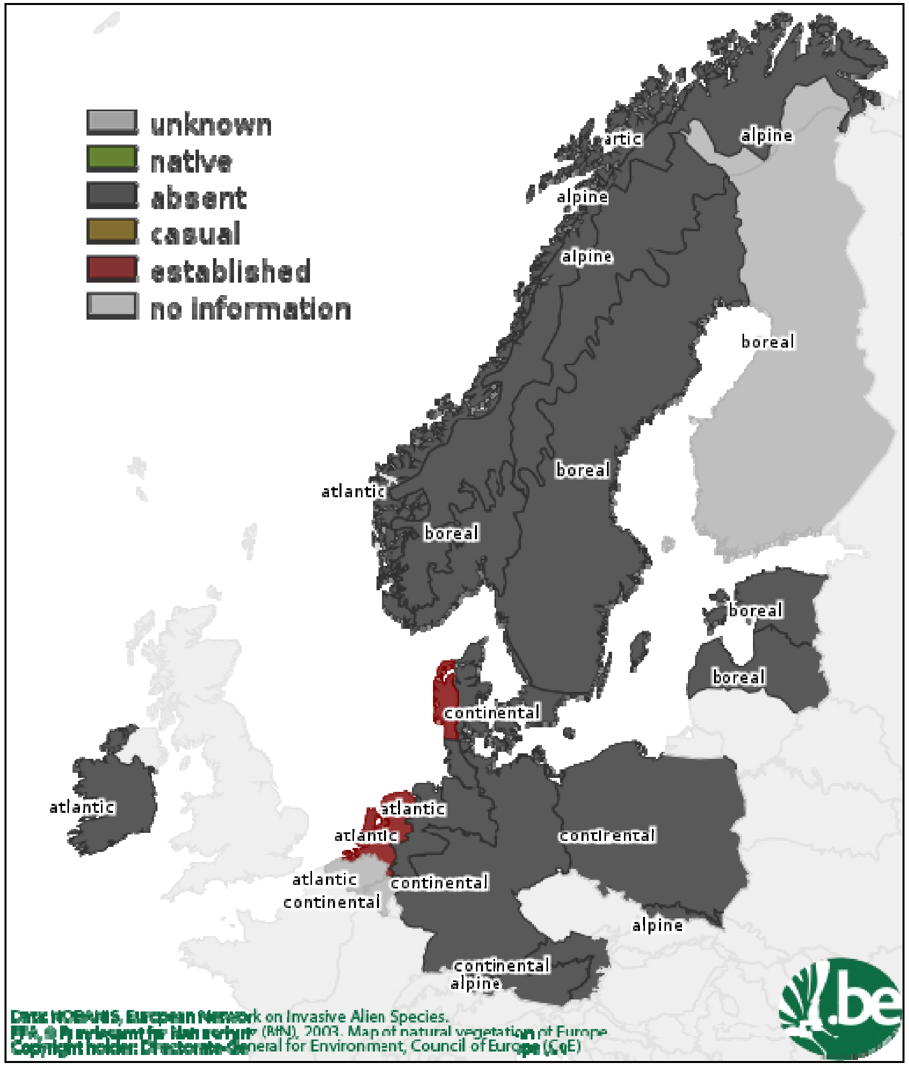


Figure 94: ***Ocinebrellus inornatus* – EEA.** *Ocinebrellus inornatus* is established in the atlantic zone. Fairly high dispersal rate.

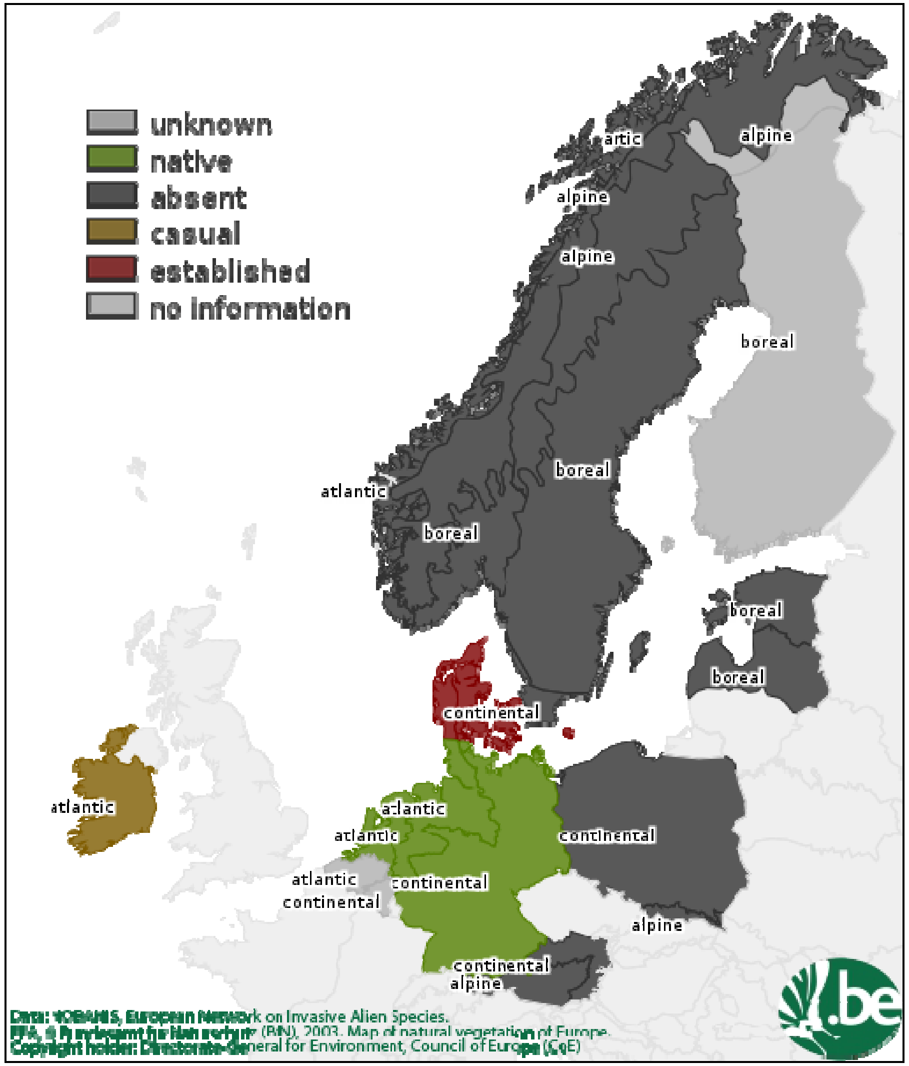


Figure 95: ***Odiellus spinosus* – EEA.** *Odiellus spinosus* is established in the continental and atlantic zones. It is native to the alpine, continental and atlantic zones. Slow dispersal rate.

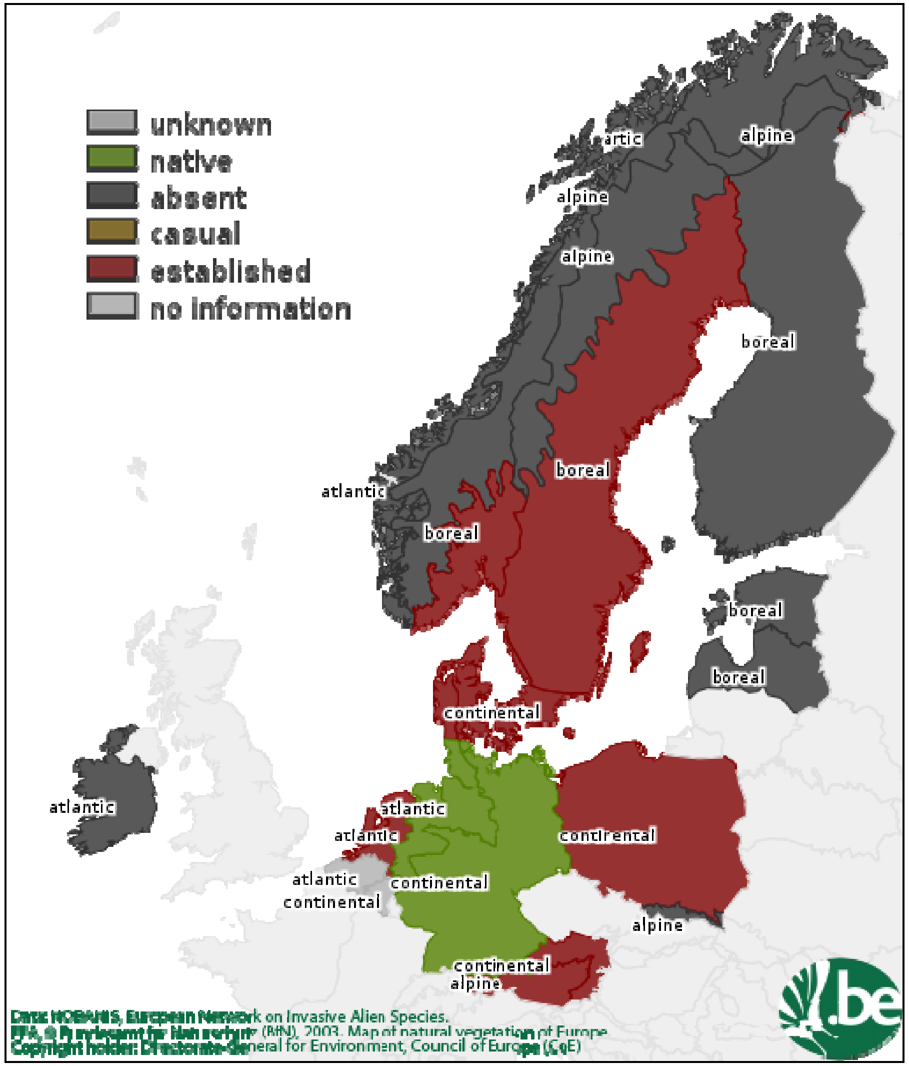


Figure 96: *Opilio canestrinii* – EEA. *Opilio canestrinii* is established in the alpine, continental, atlantic and boreal zones. It is native to the continental and atlantic zones. First record 1968 in AT. Slow dispersal rate.

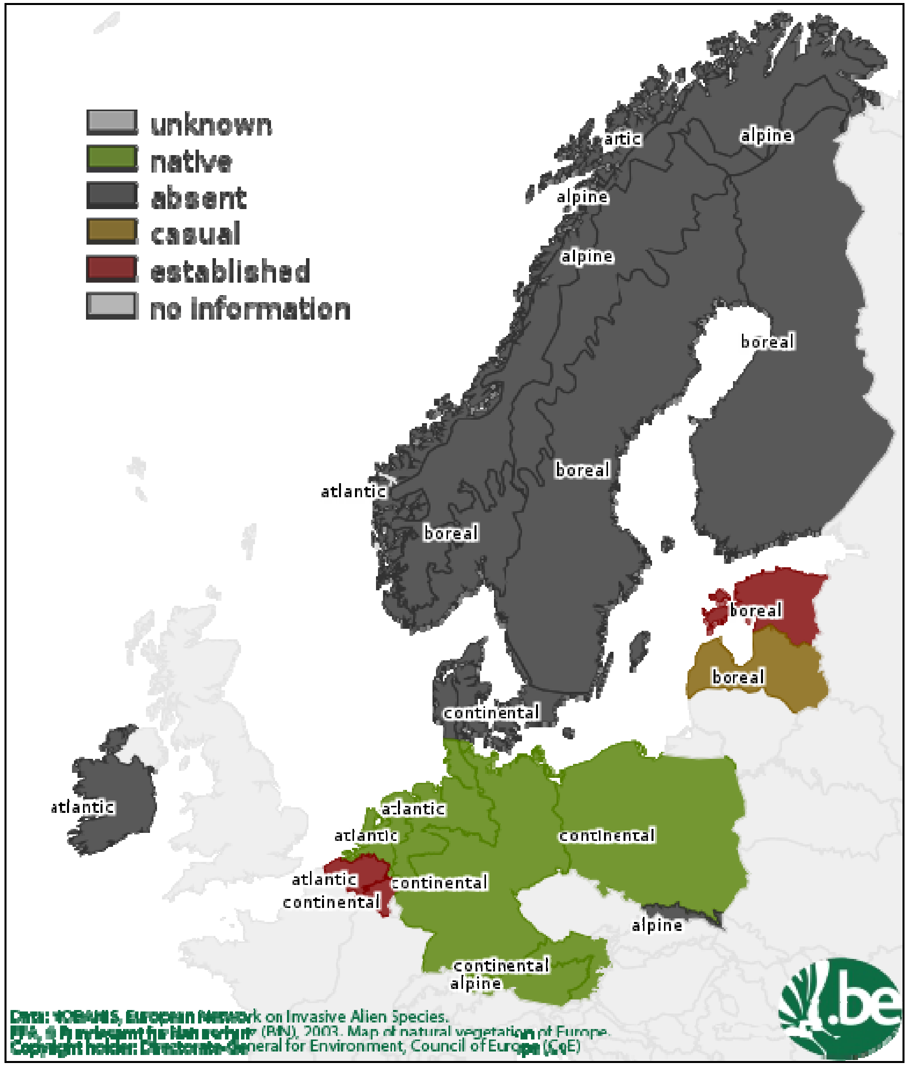


Figure 97: *Pelophylax ridibundus* – EEA. *Pelophylax ridibundus* is established in continental, atlantic and boreal zones It is native to alpine, continental and atlantic zones. First record 1975 in BE. Slow dispersal rate.

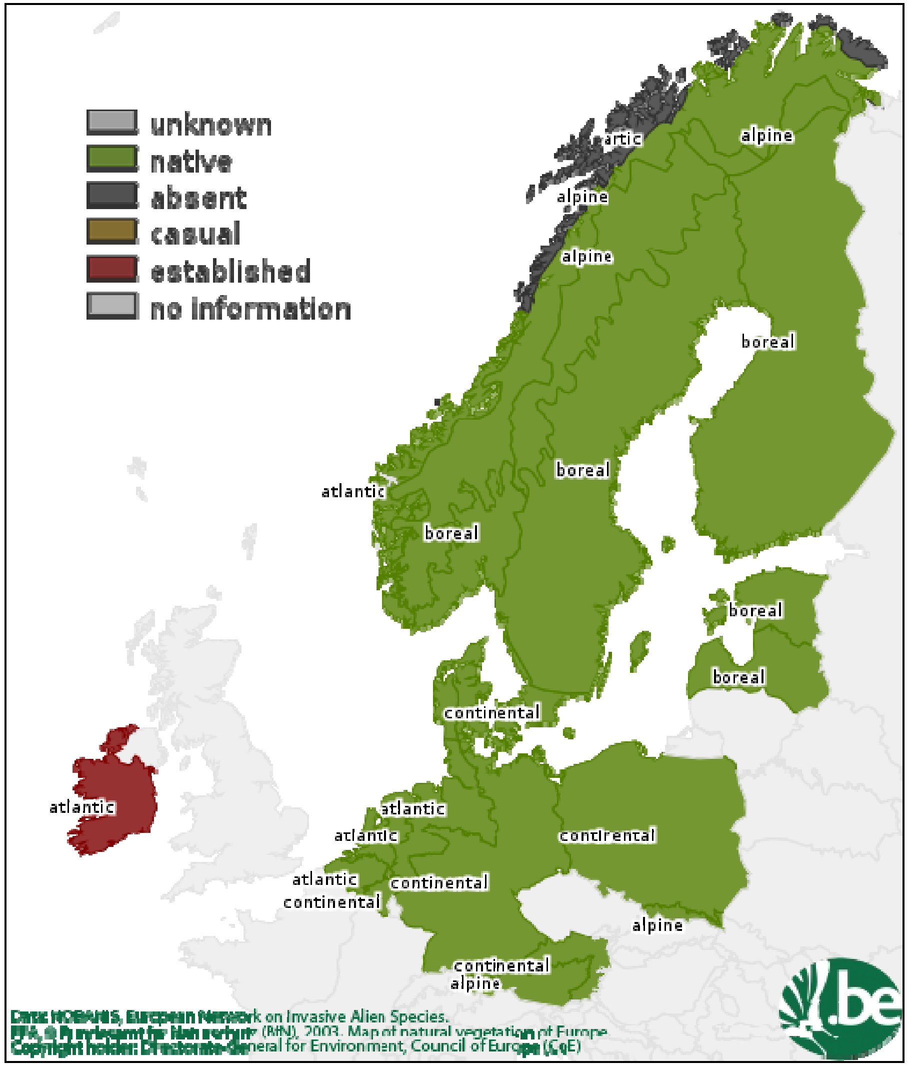


Figure 98: *Phoxinus phoxinus / Phoxinus phoxinux* – EEA. *Phoxinus phoxinus / Phoxinus phoxinux* is not native to Ireland but has established in their atlanic zone. It is native in the alpine, continental, atlantic and boreal zones. Medium dispersal rate.

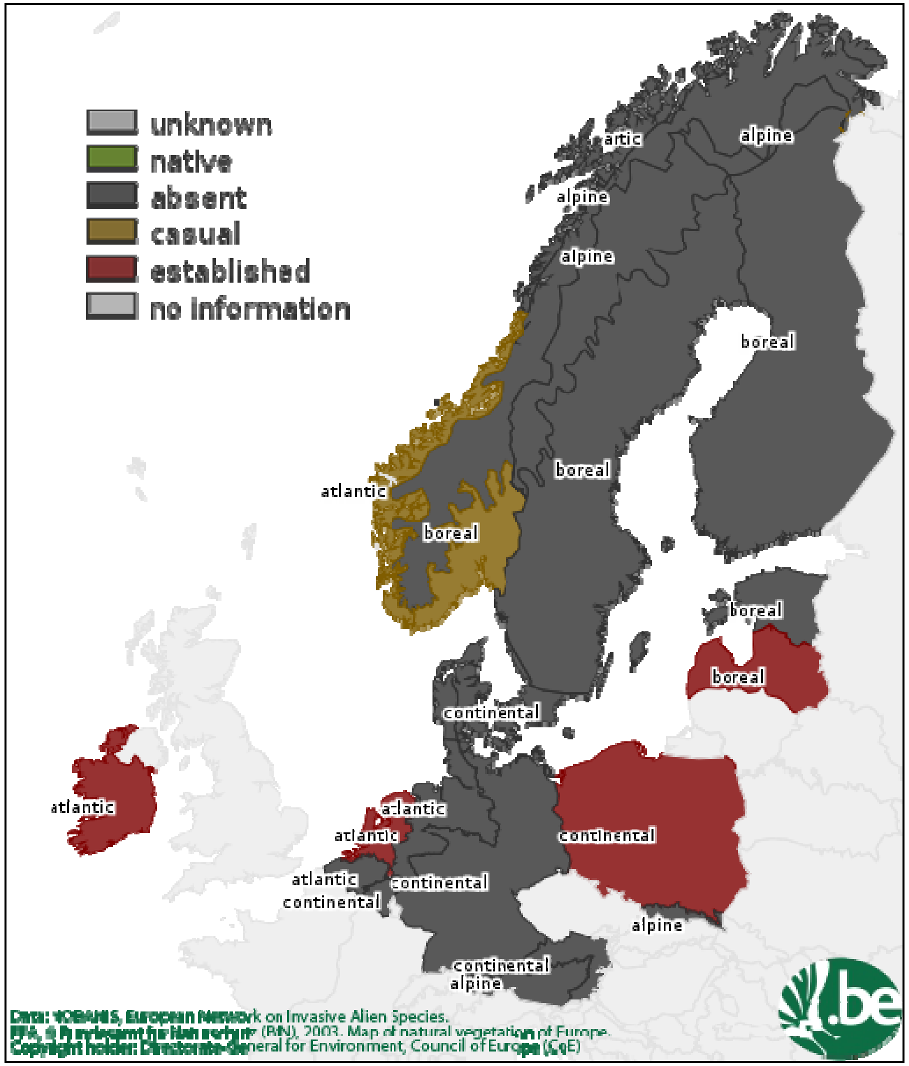


Figure 99: *Phytophthora ramorum* – EEA. *Phytophthora ramorum* is established in continental, atlantic and boreal zones. First record 1990 in SE. Fairly slow distribution range.

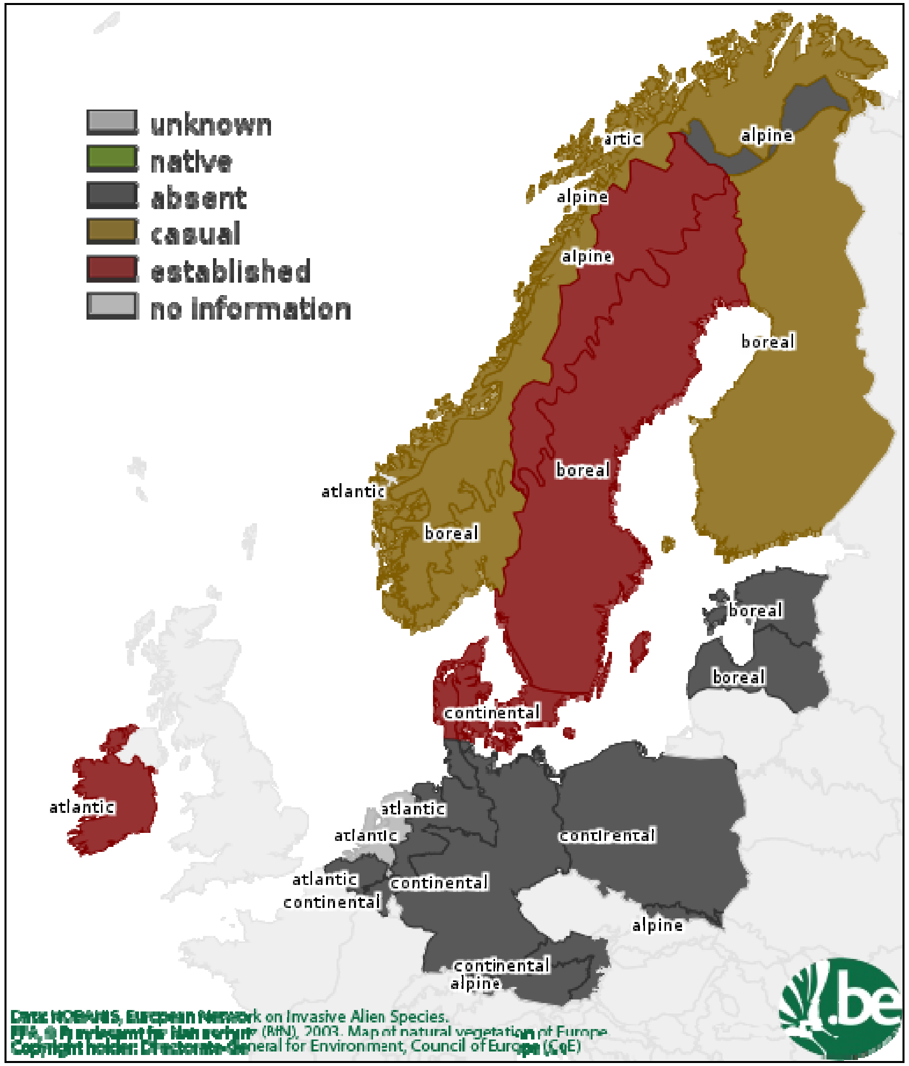


Figure 100: ***Pinus contorta* – EEA.** *Pinus contorta* is established in continental, atlantic and boreal zones. It is casual in alpine and arctic zones. First record 1928 in SE. Slow dispersal rate.

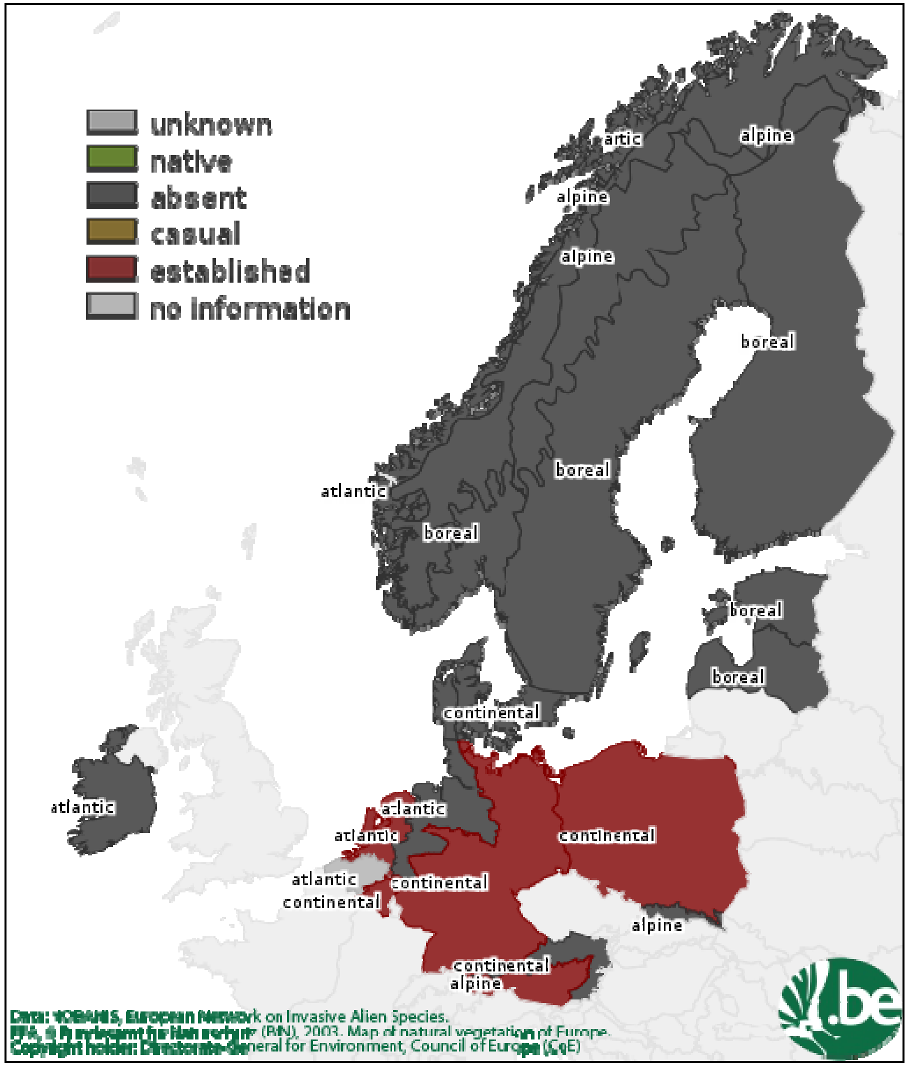


Figure 101: ***Procambarus clarkii* – EEA.** *Procambarus clarkii* is established in alpine, continental and atlantic zones. First record 1988 in DE. Medium dispersal rate.

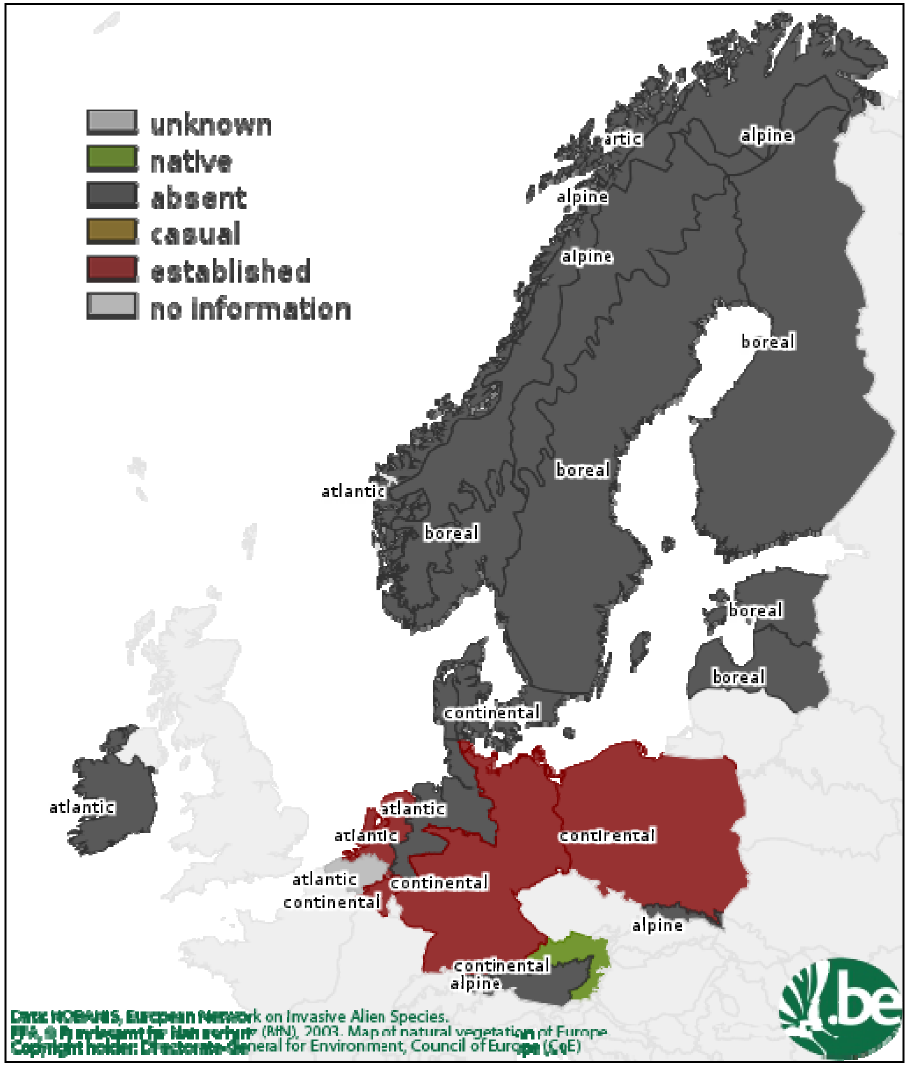


Figure 102: *Proterorhinus marmoratus* – EEA. *Proterorhinus marmoratus* is established in continental and atlantic zones. Medium dispersal rate,

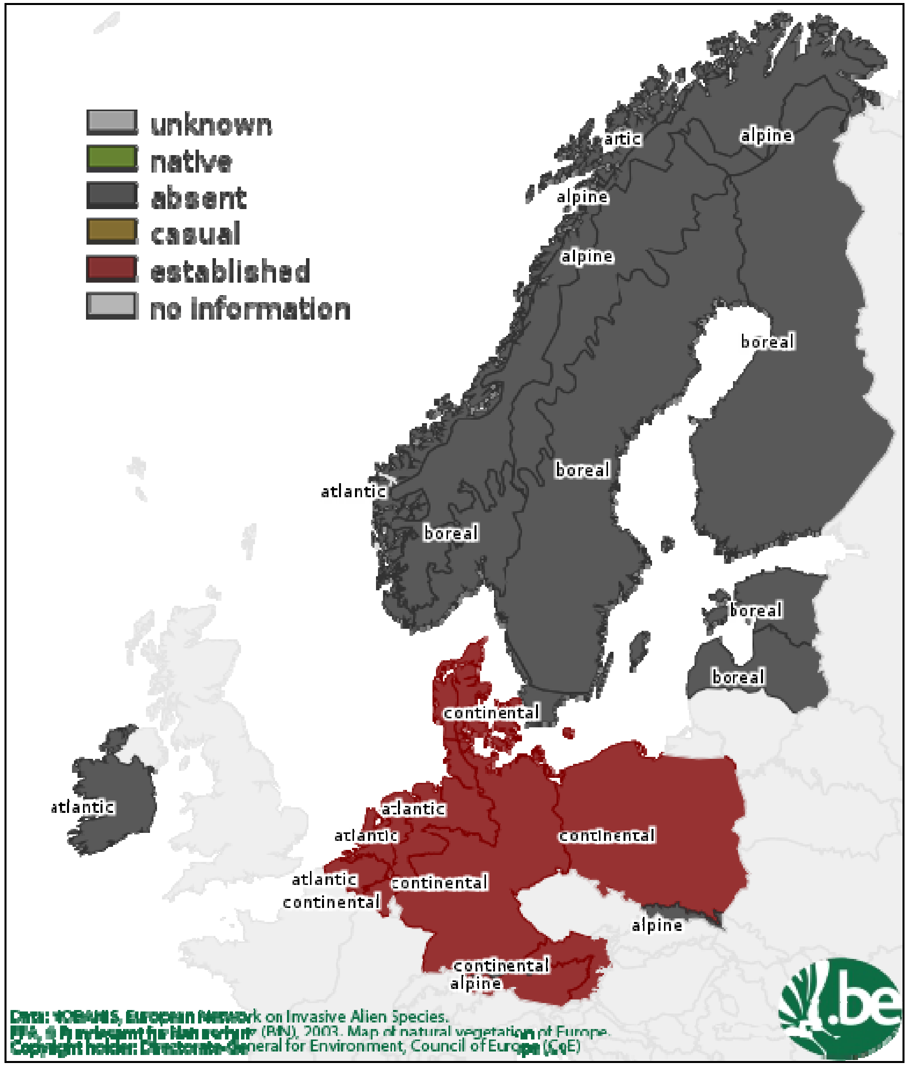


Figure 103: *Pseudorasbora parva* – EEA. *Pseudorasbora parva* is established in alpine, continental and atlantic zones. First record 1982 in AT. Medium dispersal rate.

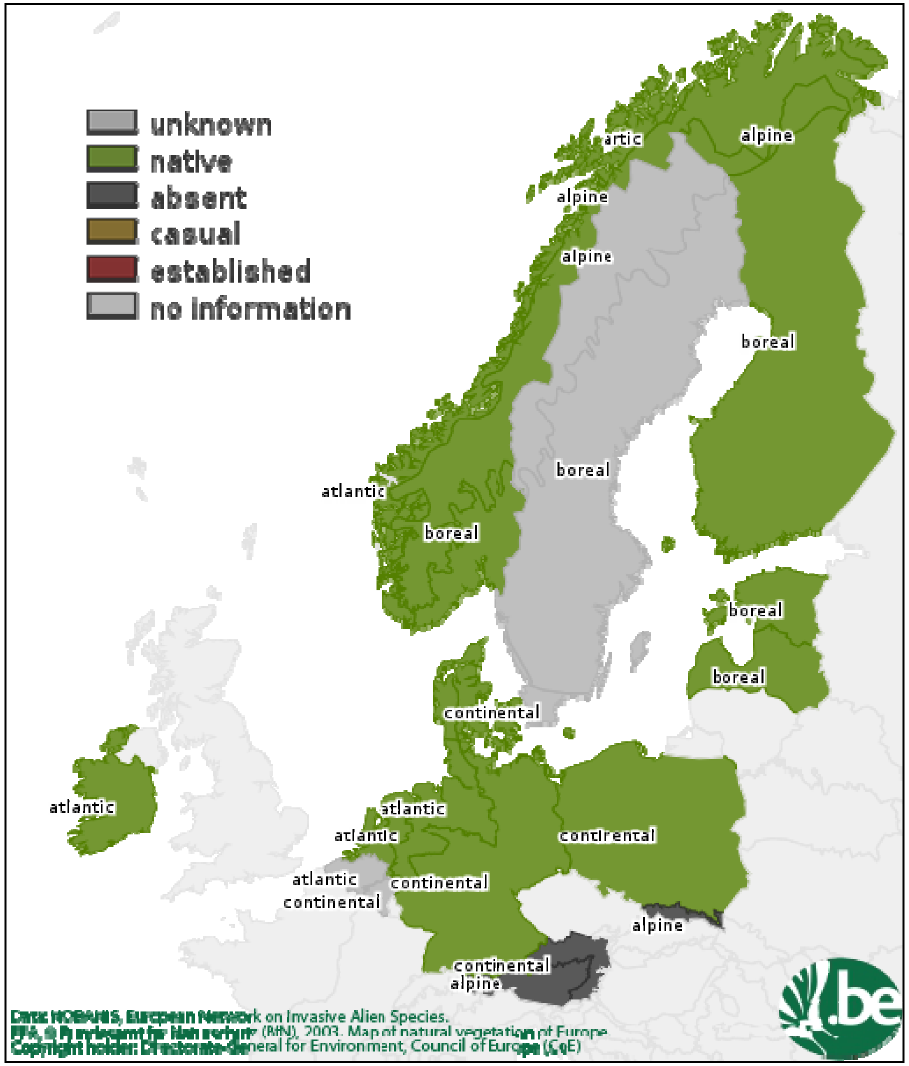


Figure 104: *Salmo salar* – EEA. *Salmo salar* is native to the continental, atlantic, boreal, alpine and arctic zones. Apart from the native stock many countries have a stock of wild farm salmon escaped from pens in the sea (see page XX).

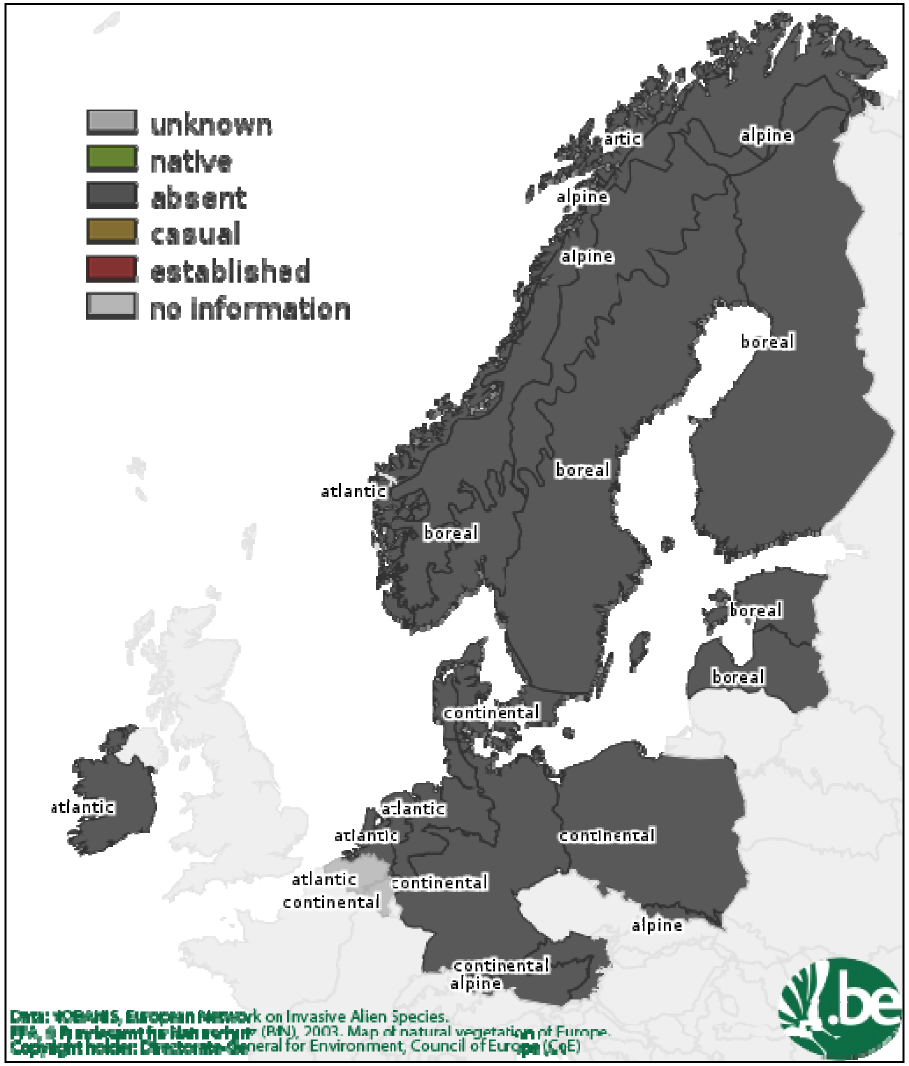


Figure 105: *Selenochlamys ysbryda* – EEA. *Selenochlamys ysbryda* is not established in any zones. Slow dispersal rate.

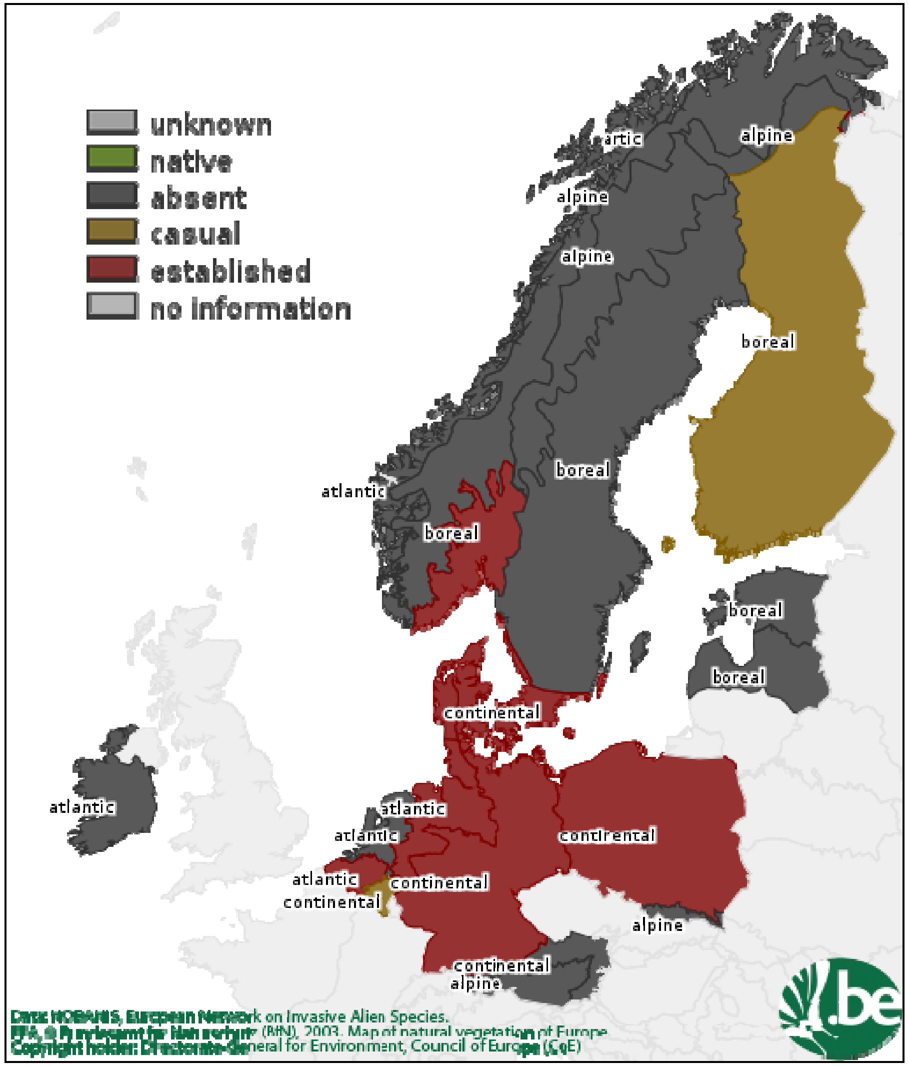


Figure 106: *Spiraea tomentosa* – EEA. *Spiraea tomentosa* is established in continental, atlantic and boreal zones. First record 1935 in SE. Fairly high dispersal rate.

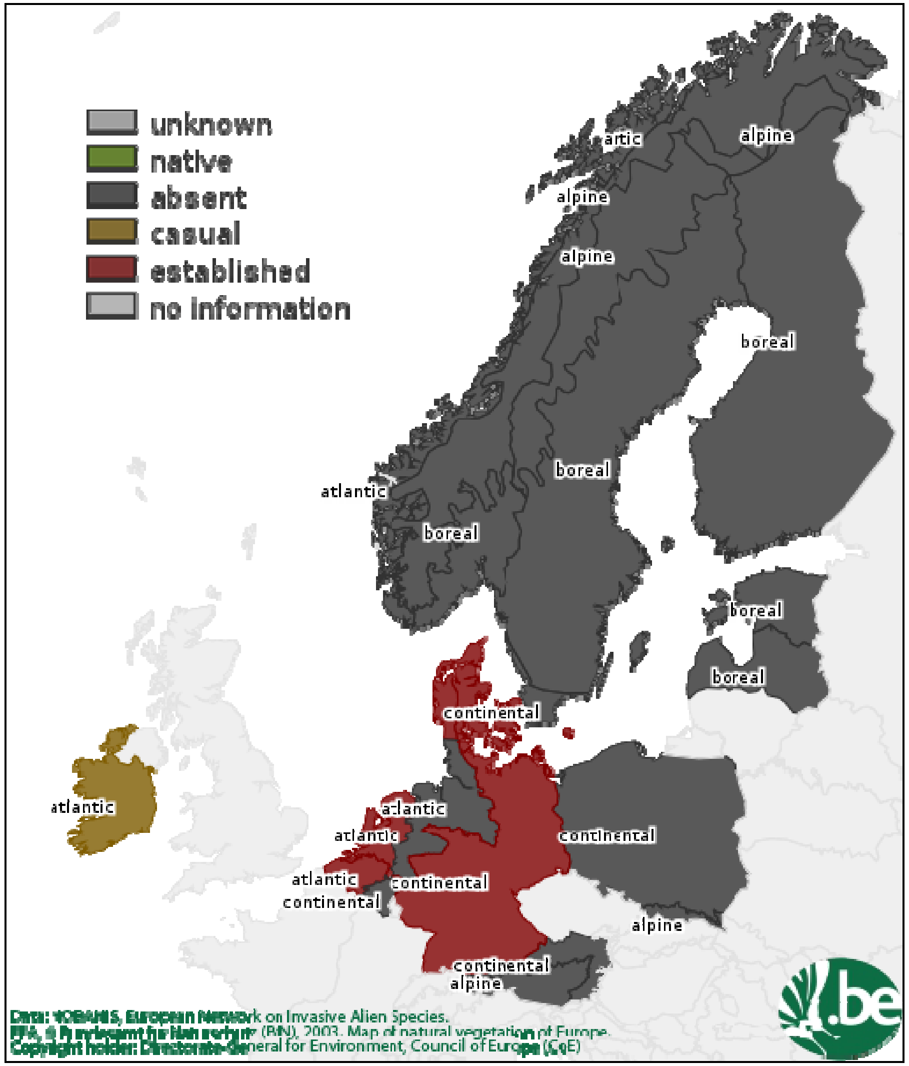


Figure 107: *Tamias sibiricus* – EEA. *Tamias sibiricus* is established in continental and atlantic zones. First record in 1950´s in AT, where it has gone extinct again. Medium dispersal rate.

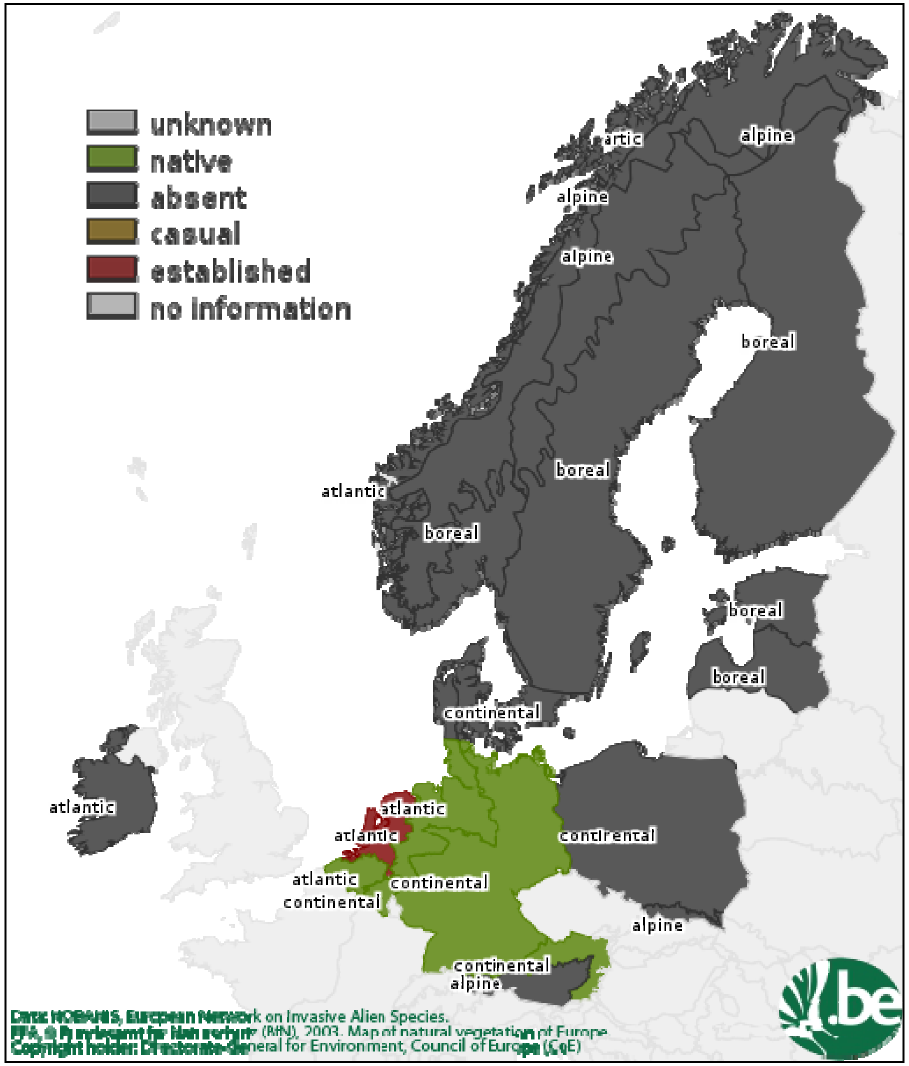


Figure 108: *Thaumetopoea processionea* – EEA. *Thaumetopoea processionea* is established in the atlantic zone. It is native in the continental and atlantic zones. Slow dispersal rate.

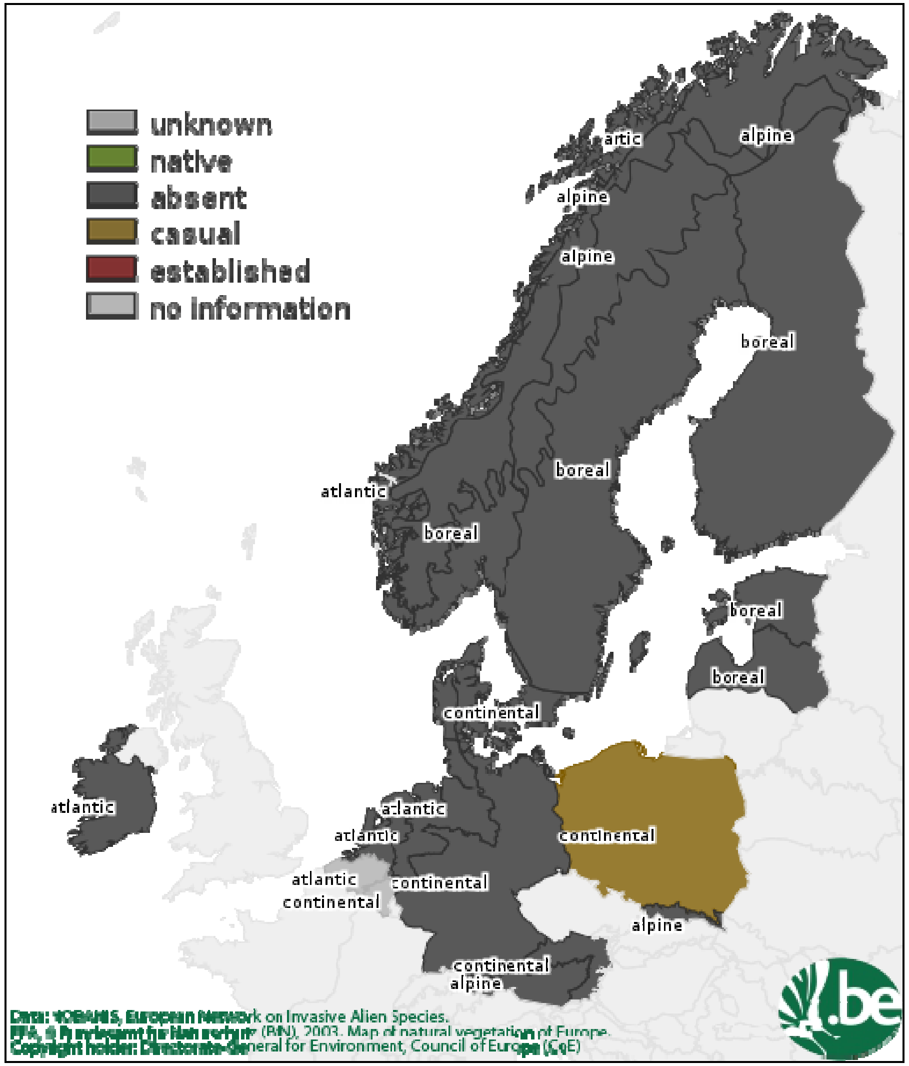


Figure 109: *Threskiornis aethiopicus* – EEA. *Threskiornis aethiopicus* is casual in the continental zone. High dispersal rate.

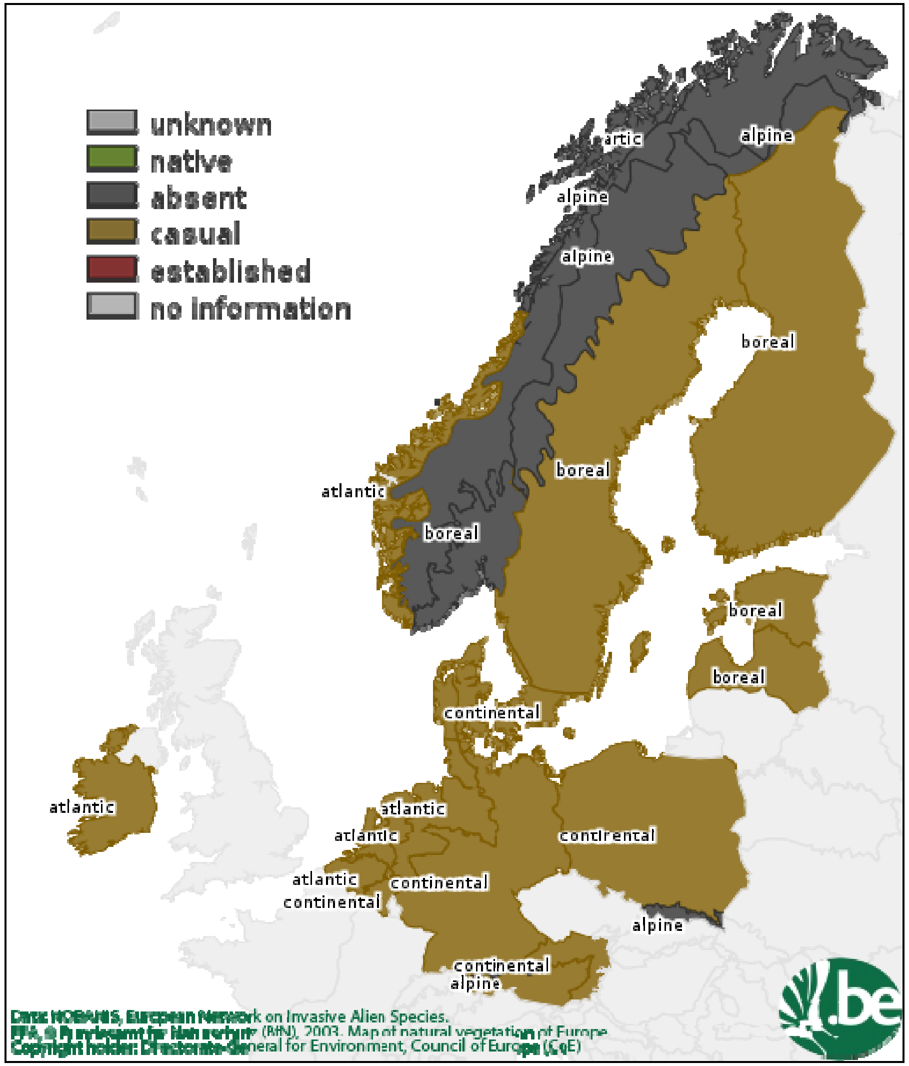


Figure 110: ***Trachemys scripta* – EEA.** *Trachemys scripta* is casual in the alpine, continental, atlantic and boreal zones. First record 1964 in DK. Slow dispersal rate.

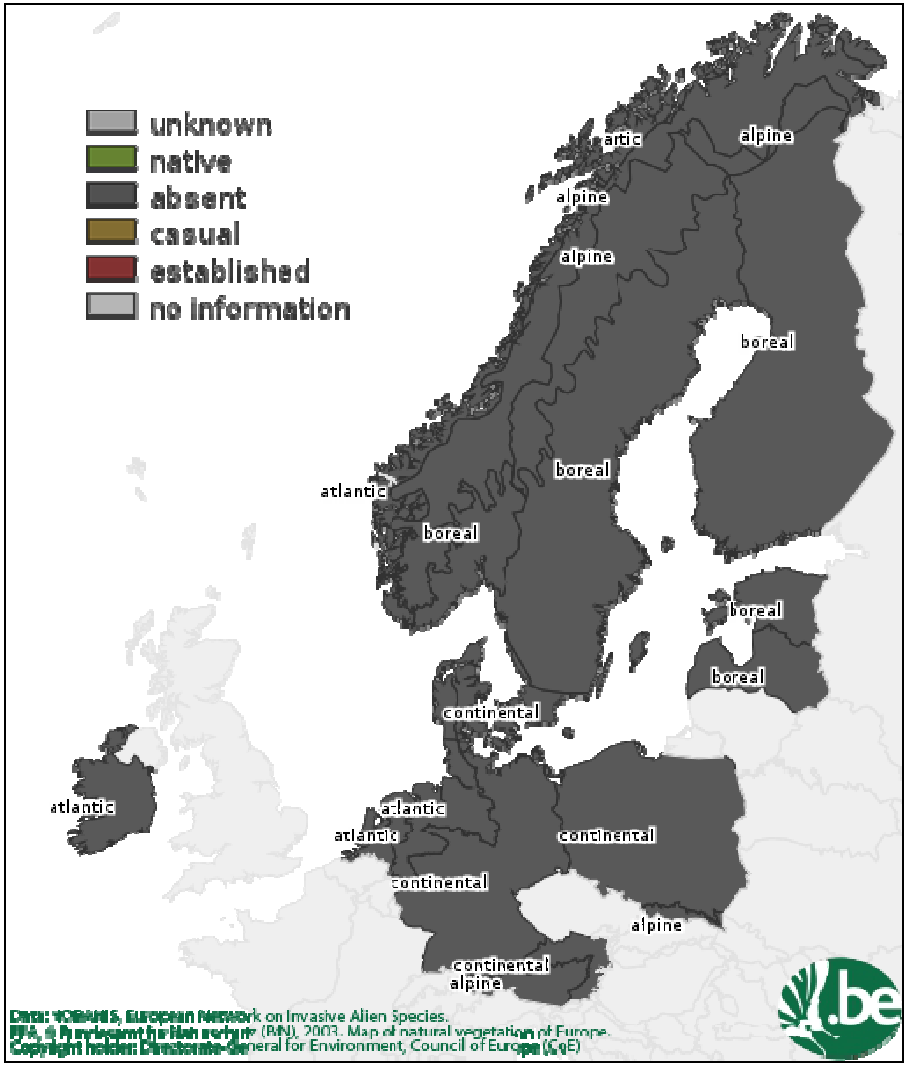


Figure 111: *Xenopus laevis* – EEA. *Xenopus laevis* is not established in any zones. Slow dispersal rate.

Discussion

The use of biogeographical zones help countries to obtain an overview of which species will have the potential to establish a population and perhaps become invasive and what regions are at greatest risk.

However this tool for risk mapping faces a few limitations and hence should be used along with other existing methods. The limitations in general concern:

- lack of sufficient information on distribution of IAS and potentials for their establishment and becoming invasive,
- problems with the risk mapping methodology, *i.e*. the complexity of assessing the potential of an IAS to become invasive using the biogeographic approach.

Lack of information

A basic, major challenge in developing this risk mapping tool based on EEA's biogeographical regions, was to obtain information on species distribution. For all of the participating countries, it has been a challenge to gather the detailed information on the distribution of the 100 species. For some of the countries participating in the NOBANIS network, it has been impossible. Monitoring of alien species is very deficient and virtually non-existent in the greatest part of the region. When information exists, it is often extremely patchy in time and area, even for the most well-known of the IAS. Some national data is available in Citizen Science reporting projects in *i.e.* Denmark, Norway, Sweden, Ireland and Estonia, but has not been incorporated into national databases on IAS. It has proven to be very time consuming and expensive to convert the existing species distribution data from the level of detail it has at present, to the level of detail needed to provide information on all species in all biogeographical regions. This is not a critique of Risk mapping as a tool, but simply an observation of an obstacle to creating more risk maps. These obstacles can be overcome with only if additional resources for the work are allocated and technical advances are made in information gathering.

Despite the serious problem with lack of data, the biogeographical approach will nonetheless, provide a good overview of what species would be relevant for the countries to seek out more information on.

Eye on Earth and Nature Watch

In the future it may become easier to obtain the detailed distribution information needed to make use of biogeographic zones for risk mapping from the European Environment Agency's Eye on Earth Nature Watch program[2]. Eye on Earth is an online, global mapping and information service on environmental issues (www.eyeonearth.org). It is developed by EEA along with partners. Subsequently organisations across the globe have been invited to join the network and add their data to the range of datasets. Eye on Earth aims at crowd sourcing data from contributors ranging from governments to lay people (the so called "citizen science"). The result is a web service of online maps, which can be manipulated to show the layers relevant for the user. The users are expected to be just as diverse including NGOs, governments, scientists and individuals (www.eea.europa.eu). In the future

[2] www.eea.europa.eu/pressroom/newsreleases/new-eye-on-earth-global and www.eyeonearth.org/

when IAS maps, based on data from governments as well as individuals, are accessible online, it will create easier access to data with sufficient distribution details needed for creating risk maps. Hence risk mapping could become less time consuming, since in this project collecting the necessary data proved to be the greatest challenge.

Nature Watch is an Eye on Earth service, which is being developed to enable citizen science reporting for selected invasive alien species. 15 of the most invasive alien species in the European terrestrial and freshwater environments have been selected for the reporting scheme in the initial stages of the Nature Watch Program, which will become operational in the summer of 2012. Information from Citizen Science Reporting projects from seven pilot countries[3] will initially be fed into NatureWatch. It is hoped that eventually Nature Watch will encompass the entire pan-European region and greatly contribute to our knowledge of the distribution of at least the easiest identifiable IAS Nonetheless, some methodological problems with using information from Citizen Science reporting projects will remain and should be further addressed.

The use of biogeographical zones for creating national alarm lists

Central to these limitations is it that species which are relatively newly introduced, may not yet have spread to all the different biogeographical zones in which they can potentially thrive. Hence the maps for recently introduced species should be interpreted mainly as showing which biogeographical regions it is known that the species can establish in bearing in mind that the maps are not necessarily able to show where the species cannot establish. For the countries with e.g. a boreal zone this means that they should be particularly aware of species, which have established in a boreal zone in another country. Contrary, for species that are recently introduced it will not be safe to interpret the map in the sense that the species will not be able to establish in a boreal zone even if it is not registered in a boreal zone on the map in this report.

Using the biogeographical approach it must also be taken into account that the climatic zones are a construction and naturally there can be great variations in local climatic conditions within the biographic zone, as well as gradual changes or gradients in climatic conditions within the zone and towards the boundaries to other zones. Hence a concern is that a species which is known to be able to establish in e.g. the continental zone but not in the Atlantic zone might be capable of establishing in the Atlantic zone close to the “boundary” between the two zones. Based on previous experiences showing that the species cannot establish in the Atlantic zone, the focus might not be on that particular species in that zone and the chance of rapid response to its arrival might be missed.

In relation to the biogeographical zones it should also be taken into account that these zones presumably will be dynamic due to climate change. This is not an argument for not using the approach for alarm lists, but only a reminder that in time, focus should be on revising the partitions.

The maps in this report are snapshots and reflect the situation at the time of the making of the report. Hence the alarm lists constructed from the maps cannot be seen as final lists, since the dispersal range of invasive alien species is dynamic and species may spread to new areas and die out in other areas.

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[3] Denmark, Estonia, Hungary, Norway, Slovenia, Sweden, UK,

Climatic conditions alone are not always a good indicator of the potential invasiveness of alien species. Some species live all or part of their life in habitats that to some extent are not completely affected by the surrounding climate. This could for instance be burrowed in the soil, in tree trunks or in man-modified habitats. Hence these organisms may not behave as expected in relation to the use of bioclimatic zones.

From a biological perspective it should also be noted that all kinds of living organisms will be affected by the biotic factors in their surroundings. This means that the presence of suitable food items, predators, pathogens etc. will play a crucial role in the species ability to establish a viable population in any given area. If these criteria are not met even in a suitable climatic zone the species will not be capable of living there. This does not however, alter the situation that according to climate, the conditions are right for the species. If biotic factors in time should change, the species potentially can establish in the area.

Nevertheless, this quite simple alarm system can provide European countries with a reasonable overview of the spread of alien species to preliminarily screen what species may be of concern and as a basis for further risk assessment. It provides a means to a more systematic approach for the early detection of IAS, which has been requested by EU (http://ec.europa.eu/environment/nature/invasivealien/docs/ias_discussion_paper.pdf). The limitations discussed above do not make risk mapping a useless tool, but as with any other method, it is of course important to bear in mind the weaknesses of the method.

To meet the critique of the maps being snapshots taken on a quite dynamic situation, the next step could be to provide online access to the maps, in which case they could be updated regularly as is the case with the species database on the NOBANIS website. This way the maps will be more useful and trustworthy continually compared to the ones in a report that in time will be obsolete.

EEA's biogeographical zones vs. Metzger's environmental stratification

In general, the Metzger partition divides the European countries into more regions than the EEA partition (see appendix III). Along with the better scientifically foundations for the partition of the zones, this indicates that the use of Metzger's stratification system should provide a more accurate view of how the species are distributed.

In this report an area of focus was to make a small-scale assessment of the two methods when compared to each other. Hence EEA maps and Metzger maps were made for ten alien species known to be well-established in large parts of Northern Europe. These species are referred to as Category 1 species (for species list see appendix I and II and for maps see figure 4-23). Since the assessment is based on a fairly small amount of data it will only be possible to notice tendencies.

Looking at the maps of the ten Category 1 species, nine species show a difference between the EEA map and Metzger map. Only *Sciurus carolinensis* does not show any variation in dispersal range since it is located in all of Ireland but nowhere else on both maps (see maps 22 and 23). For the other species, generally there is a tendency towards a more nuanced view in the Metzger maps that in the EEA maps which was also expected. Several species e.g. *Branta Canadensis* (figure 4 and 5), *Bunias orientalis* (figure 6 and 7) and *Mustela vison* (figure 16 and 17) do not occur in the *alpine south* in Germany, even though they apparently have established populations in the adjacent areas. This indicates that the climatic conditions in these areas may be inhibiting the species from establishing. On the EEA maps this zone is not differentiated and therefore on the map it looks as if the species also inhabit this area.

In some areas the species occur as casual on the Metzger map, in contrast to on the EEA map where it is shown as established. This is for instance the case for *Bunias orientalis* and *Lupinus nootkatensis* (figure 12 and 13)*. For Bunias orientalis* this means that on the Metzger map it has not established in the alpine north zone and hence the interpretation could be that it will not be able to establish in this zone. When looking at the EEA map it shows that *B. orientalis* can establish in a much larger area and also in the area covering what is equal to the alpine north zone on the Metzger map.

The inverse situation is also seen e.g. for *Branta canadensis* and *Mustela vison*. For *Branta canadensis* the area of establishment covers most of Norway on the Metzger map, whereas on the EEA map there is a rather large alpine zone where it is absent and another area where it is casual.

The maps for *Harmonia axyridis* (figure 10 and 11) show that the species occurs casually in the southern part of Sweden. On the EEA map it is shown as occurring only in the continental zone and not in the boreal zone. On the Metzger map it is casual in the nemoral zone, which covers the boreal zone, and a bit of the continental zone. This results in two quite different dispersal ranges for *Harmonia axyridis* in the southern part of Sweden.

No clear advantages for use of either the EEA biogeographical zones or the Metzger Stratification system could be seen from the results of this study. As stated above, it has been a great challenge for the countries to obtain the necessary data for mapping the distribution range of the 100 species. Making use of Metzger's environmental stratifications instead of the EEA biogeographical zones increases this challenge since the degree of detail for the data needed is even higher. It becomes obvious in some of the Metzger maps in this report e.g. for *Lupinus nootkatensis* where Norway has a large area without information. Again in the future, when national and regional Citizen Science projects such as Eye on Earth may be able to contribute to the data, this will presumably no longer be a major obstacle.

Case studies examining the results of the Risk maps

The accuracy and validity of the results of the risk maps was tested by comparing the results for Sweden with reports of occurrence from the Swedish Species Gateway www.artportalen.se (extracted 2021-03-13) and references within NOBANIS.

Case Study 1. *Bunias orientalis*

– Results of risk mapping by biogeographical region can give an exaggerated picture of the present distribution of the IAS.

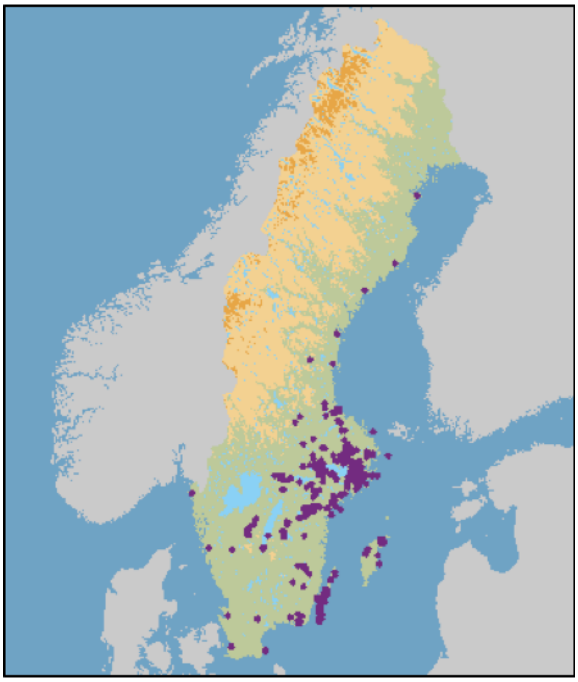

Figure 113. Swedish Species Reporting System

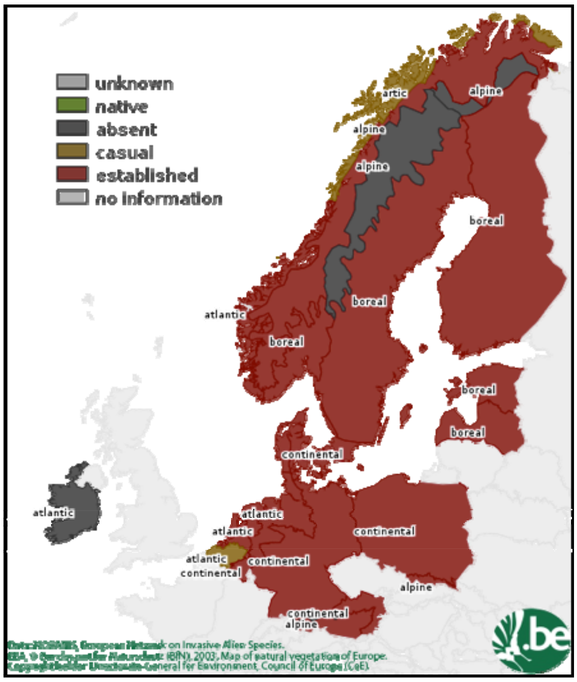

Figure 112. Biogeographic regions EEA system

Comparison of distribution of *Bunias orientalis* in Sweden according to:

Figure 112: Reports of Distribution of Bunias orientalis in Sweden 2000-2012 in the Swedish Species Information Reporting System [http://www.artportalen.se/plants/default.asp Date of access 2012-03-13](http://www.artportalen.se/plants/default.asp).

Figure 113: NOBANIS risk mapping according to the EEA Stratification System

Conclusion: Mapping on a large biogeographic region scale can give an exaggerated picture of the present distribution of the species. This effect is most evident for countries with large areas within a biogeographic zone and more negligible for small areas. The advantage is that one has a clear picture that the species could probably establish in a much larger area. This is especially true along the coast of northeastern Sweden, where although there are only a few observations and localities reported, *Bunias orientalis* is considered established within the entire region, from the coast and west to the alpine region. This could be adjusted by considering the frequency of the species, which could include number of individuals and number of localities, when mapping distribution. A system of overlays with reported observations, when available, with biogeographic regions would enable managers to see actual present distribution and potential for spread.

Lack of data could however, make this adjustment very difficult to do for more than a very few IAS. In addition, one must consider the methodological problems with Citizen Science reporting schemes, which include that reports from the reporting system may reflect more the effort and bias of the reporters rather than actual distribution.

The major disadvantage of this exaggerated picture of IAS distribution could be that one may get the mistaken impression that it is too late in the invasion process to take measures to prevent further spread of the IAS.

Case Study 2. *Harmonia axyridis*

- Risk mapping becomes more difficult as the IAS is less frequent

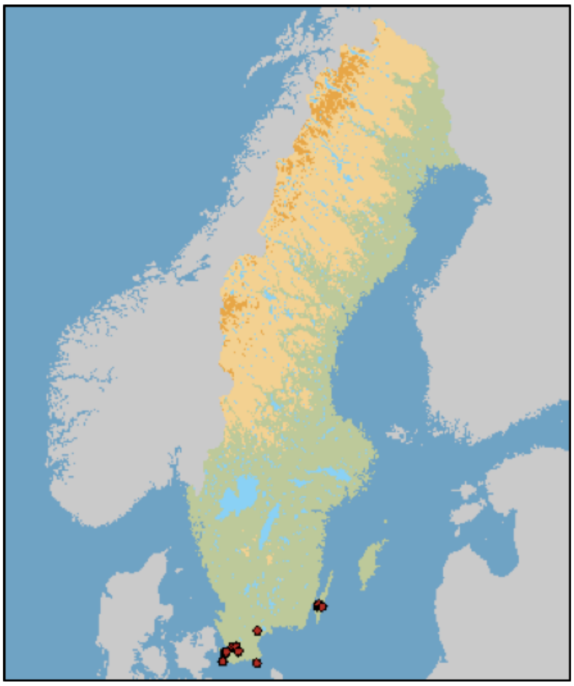

Figure 114. Swedish Species Reporting System

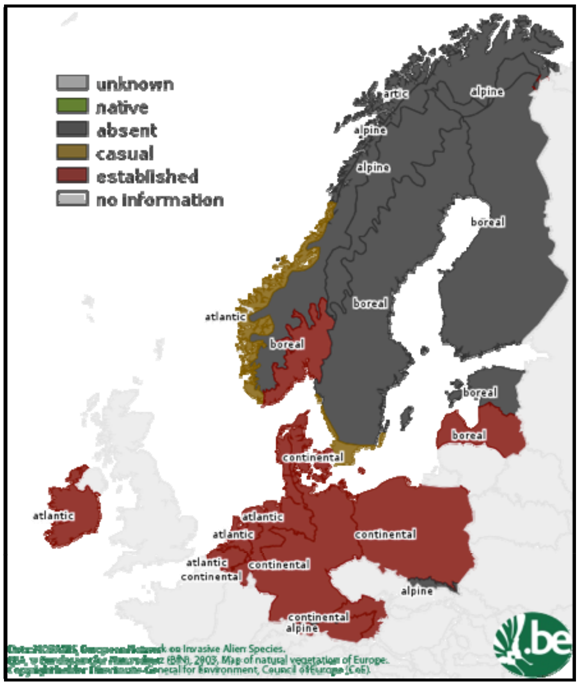

Figure 115. Biogeographic regions EEA system

Comparison of *Harmonia axyridis* distribution in Sweden according to:

Figure 114: Reports of Distribution of *Bunias orientalis* in Sweden 2000-2012 in the Swedish Species Information Reporting System [http://www.artportalen.se/plants/default.asp Date of access 2012-03-13](http://www.artportalen.se/plants/default.asp).

Figure 115: NOBANIS risk mapping according to the EEA Stratification System

Figure 116: NOBANIS risk mapping according to the Metzger System

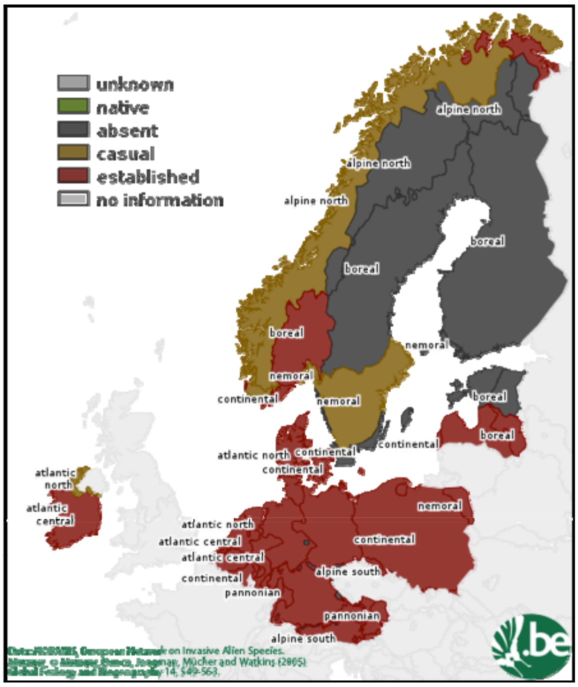

Figure 116. Biogeographic regions Metzger system

Conclusion: The accuracy of the risk maps become more fragile as the IAS is less frequent. The accuracy of the reports received for the species and the system for the biogeographic regions, are crucial for the usefulness of the map. According to published literature, reports of *Harmonia* were confined to the Gothenburg area on the Swedish West Coast. The EEA system reflected more accurately than the Metzger system the climatic zone where Harmonia has later been reported from according to the Swedish Species Gateway – along the southern and southeastern coasts of Sweden including the island of Öland. This example also illustrates that Citizen Science Reporting schemes, such as the Swedish Species Reporting System does not necessarily include all observations of species, as the verified report from Gothenburg is not recorded in the system.

Conclusion

The Risk mapping project has identified 100 species introduced to the project region, causing concern that they may potentially spread and hence expand their current distribution range. Data on occurrence in every EEA bioclimatic zone in the 12 participating countries were gathered and used for making a risk map for each of these species.

The species were selected amongst terrestrial, freshwater and brackish water species, aiming to achieve a maximum diversity within taxa, establishment dates and biogeographic affinities. The species were divided into three categories according to certain criteria such as availability of detailed distribution data and continuous expanding of distribution range.

- The Category 1-species are species with a detailed distribution map available and with well-established populations in the project area. The 10 Category 1-species were used to make an assessment of EEA biogeographical stratification vs. the Metzger environmental stratification. The aim was to see if the use of Metzger's stratification offered a more accurate result than the EEA biogeographical zones.
- The Category 2-species are species without a detailed distribution map. They are expected to expand their distribution range in the future and hence the maps for Category 2-species can be used by the countries to make their alarm lists.
- The Category 3-species are species with isolated local populations. They are also expected to expand their distribution range in the future and the maps for Category 2-species can be used by the countries to make their alarm lists. To create a tool for early warning and rapid response these 100 species were depicted on risk maps. The risk maps in this report are maps showing the degree of presence of a species in the biogeographical zones according to EEA partitions. Based on these maps, countries can obtain knowledge of which introduced species that have proven to be able to establish in the different biogeographical zones and hence which species they with reasonable suspicion can assume will have the ability to establish viable populations in their country and hence have the potential of becoming invasive.

This method of risk mapping, based on occurrence of an invasive alien species in biogeographic zones is a valuable, easily accessible tool for Early Warning and Rapid Response. Risk mapping can be used for rapidly identifying risks and prioritizing measures to meet these risks. The simplicity of the method, using available information on NOBANIS and in the literature, makes it very useful for identifying species that are invasive in a biogeographic zone and may spread to new areas in the zone or to adjacent zones. This enables a quick, preliminary screening assessment of the nature and scope of the potential risk of an IAS. This is invaluable in coordinating measures both nationally and regionally to prevent introduction and spread of IAS identified as high risk species. If it is too late in the invasion process for prevention, the method is also useful for coordinating eradication or control measures.

Risk mapping is also useful for identifying invasion “hot spots”, that is core areas where an IAS is established and spreading from. This is important for development of policies and measures at the regional and European scale to prevent further spread and harm by the IAS. Risk mapping could be a valuable tool for prioritizing preventative or eradication measures for IAS that for example, are not yet widely spread, but have the potential to further spread in one or several biogeographic zones.

Risk mapping has a high potential value in communication to policy makers, environmental managers and the general public of the importance of preventative measures to prevent the introduction and spread of IAS.

However, some methodological difficulties with risk mapping remain to be solved. These include:

- Lack of information on distribution and impacts. This critical problem is especially acute for IAS that have recently arrived in Europe. An IAS could be present in a biogeographic region, but if not reported, would result in an inaccurate risk map. Likewise, lack of a report of an IAS in a region is difficult to interpret if it cannot establish there or if it has only not yet done so.
- Scale of the biogeographic zones and mapping. The biogeographic zones used are perhaps too large and undifferentiated for producing accurate assessments of the areas of risk. The zone classifications as used in this project for both the EEA and Metzger Methods are too general to be of great value for planning more local measures on the national level for large countries. Statistical analysis of the results of the risk mapping projects could be helpful in assessing the next steps of developing the method. As access to more detailed distribution improves in the future, it would be valuable to use sub-levels in the classification systems in order to achieve more accuracy.
- Sources of information for risk mapping need to be improved in order to fully realize the potential of the method. Monitoring of IAS in Europe needs to be greatly improved in order to have the data to include in primary data sources like NOBANIS. Overlays with monitoring programs and citizen science reporting schemes with the risk maps would give the potential to greatly improve the accuracy of the risk maps.
- If the species was recently introduced it may not be possible to see on the map all the biogeographical zones it is able to establish viable populations in since it may not have had the time to spread into these zones yet. This is not the same as saying that it will not have the potential to do so in time. Some method for incorporating information from other areas outside of the region with similar biogeographic zones and experience of the particular invasive alien species, needs to be considered in development of the risk maps.

Despite these limitations to the method it is still believed that risk mapping is a useful tool, because it offers an excellent overview of the distribution of the species shown on maps and the potential for their spread. Risk mapping offers a foundation for countries to prioritize their efforts against introduced alien species.

This Risk mapping project has also compared two different climatic stratifications of Europe; EEA biogeographical stratification and the Metzger environmental stratification. The aim was to see if the use of Metzger's stratification offered a more accurate result than the EEA biogeographical zones. Although Metzger's environmental stratification provides more detailed information on biogeographical zones it is not possible for this study to state that distribution depicted on Metzger maps provide a better foundation to predict possible new areas of distribution.

It was difficult for the participating countries to obtain the detailed information on distribution and impacts of IAS needed for the risk mapping. In the future, the advent of improved environmental monitoring programs, which include IAS as well as Citizen Science reporting projects such as Eye on Earth's Nature Watch, may be able to contribute to the data. This will presumably mean that lack of data will no longer be a major obstacle. But until then, the conclusion is that the methodology of using risk mapping according to biogeographic zones for early warning systems for such a large area as the NOBANIS region is sound and promising , but it is too time consuming and expensive to be operational. It is however, clear from the results of the project that the biogeographic method of presenting data would be of great value for NOBANIS. This approach should be strived after in future development of the NOBANIS gateway.

Acknowledgements

This project would not have been possible without the generous help and high competence of Sonia Vanderhoeven and Etienne Branquart of the Invasive Species Unit, General Directorate of Agriculture, Natural Resources and Environment, Belgium, who with their IT team produced the risk maps from the data gathered by NOBANIS. Thank you also to the NOBANIS national focal points who gathered data on the distribution of IAS and commented the results. This project was funded by the Nordic Council of Ministers.

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Appendix I

Species list in alphabetic order

Species	Common name	Habitat	Group	Category
Acer negundo	Box elder	Terrestrial	Angiosperms	2
Acer rufinerve	Redvein maple	Terrestrial	Angiosperms	3
Acridotheres tristis	Common mynah	Terrestrial	Birds	2
Agrilus planipennis	Emerald ash borer	Terrestrial	Arthropods	3
Ailanthus altissima	Chinese sumac	Terrestrial	Angiosperms	2
Ambrosia artemisifolia	Common ragweed	Terrestrial	Angiosperms	3
Ameiurus melas	Black bullhead	Freshwater	Fish	2
Ameiurus nebulosos	Brown bullhead	Freshwater	Fish	2
Amelanchier spicata	Dwarf serviceberry	Terrestrial	Angiosperms	2
Anguillicola crassus	Eel swimbladder nematode	Freshwater	Nematodes	3
Anoplophora glabripennis	Asian long-horn beetle	Terrestrial	Arthropods	3
Aphanomyces astaci	Crayfish plague	Freshwater	Fungi	2
Arion lusitanicus	Iberian slug/ Spanish slug	Terrestrial	Molluscs	3
Arthurdendyrus triangulatus	New Zealand flatworm	Terrestrial	Flatworms	3
Astacus leptodactylus	Narrow clawed crayfish	Freshwater	Crayfish	3
Azolla filiculoides	Large mosquito fern, water fern	Freshwater	Ferns	3
Branta canadensis	Canada goose	Terrestrial	Birds	1
Bufo marinus	Bullfrog, cane toad	Freshwater	Reptilia & amphibia	3
Bunias orientalis	Turkish wartycabbage	Terrestrial	Angiosperms	1
Bursaphelenchus xylophilus	Pine wood nematode	Terrestrial	Nematodes	3
Cameraria ohridella	Horse-chestnut leafminer	Terrestrial	Arthropods	3
Campylopus introflexus	Heath star-moss	Terrestrial	Bryophyta	2
Castor canadensis	American beaver	Freshwater, terrestrial	Mammals	1
Cercopagis pengoi	Fish-hook waterflea	Freshwater	Arthropods	3
Cervus nippon	Sika deer	Terrestrial	Mammals	2
Chelydra serpentina	Snapping turtle	Freshwater	Reptilia & amphibia	3
Corbicula fluminea	Asian clam	Freshwater	Mollusks	3
Cornus sericea	Red-osier dogwood	Terrestrial	Angiosperms	3
Corvus splendens	House crow	Terrestrial	Birds	3
Cotoneaster horizontalis	Wall cotoneaster	Terrrestrial	Angiosperms	3
Craspedacusta sowerbyi	Fresh water jellyfish	Freshwater	Cnidarians	3
Crassula helmsii	New Zealand pigmyweed	Freshwater	Angiosperms	3
Dreissena polymorpha	Zebra mussel,	Freshwater	Molluscs	2
Elodea canadensis and nuttallii	Canadian waterweed	Freshwater	Angiosperms	2
Eriocheir sinensis	Chinese mitten crab	Freshwater	Arthropods	2
Fallopia japonica	Japanese knotweed,	Terrestrial	Angiosperms	2
Galinsoga quadriradiata	Hairy galinsoga/shaggy soldier	Terrestrial	Angiosperms	2
Gambusia holbrooki	Eastern mosquitofish	Freshwater	Fish	3
Gunnera tinctoria	Giant rhubarb	Terrestrial	Angiosperms	3
Gyrodactylus salaris	Salmon fluke	Freshwater	Flatworms	3
Harmonia axyridis	Harlequin ladybird	Terrestrial	Arthropods	1
Heracleum mantegazzianum	Giant hogweed	Terrestrial	Angiosperms	2
Heracleum persicum	Persian hogweed	Terrestrial	Angiosperms	3
Heracleum sosnowskyi	Sosnowski's hogweed	Terrestrial	Angiosperms	3
Hydrocotyle ranunculoides	Floating pennywort	Terrestrial/ freshwater	Angiosperms	3
Hydropotes inermis	Chinese water deer	Terrestrial	Mammals	3
Impatiens glandulifera	Himalayan balsam	Terrestrial	Angiosperms	2
Lepomis gibbosus	pumpkinseed	Freshwater	Fish	3
Linepithema humile	Argentine ant	Terrestrial	Arthropods	3

Lithobates catesbeiana	Bullfrog	Freshwater	Reptilia & amphibia	3
Ludwigia peploides and L. uruguayensis (=L. grandiflora)	Floating primrose-willow and Uruguayan primrose	Freshwater and terrestrial	Angiosperms	2
Lupinus nootkatensis	Nootka lupin	Terrestrial	Angiosperms	1
Lupinus polyphyllus	Large-leaved lupine	Terrestrial	Angiosperms	1
Lymantria dispar	Gypsy moth	Terrestrial	Arthropods	3
Lysichiton americanus	American skunk cabbage	Terrestrial	Angiosperms	3
Marenzelleria neglecta	Red-gilled mud worm	Brakish and freshwater	Annelids	3
Melampsoridium hiratsukanum	Alder rust	Terrestrial	Fungi	3
Mimulus guttatus	Monkeyflower	Terrestrial	Angiosperms	2
Mustela vison	American mink	Freshwater, terrestrial	Mammals	1
Myocastor coypus	Coypu	Freshwater, terrestrial	Mammals	2
Mytilopsis leucophaeata	False dark mussel	Freshwater	Molluscs	3
Neogobius melanostomus	Round goby	Brackish and freshwater	Fish	3
Nyctereutes procyonoides	Raccoon dog	Terrestrial	Mammals	3
Ocinebrellus inornatus	Japanese oyster drill	Freshwater	Molluscs	3
Odiellus spinosus	Harvestman spider	Terrestrial	Arthropods	3
Ondatra zibethicus	Muskrat	Terrestrial	Mammals	2
Opilio canestrinii	Harvestman spider	Terrestrial	Arthropods	3
Orchonectes limosus	Spiny-cheek crayfish	Freshwater	Crayfish	2
Pacifastacus leniusculus	Signal crayfish	Freshwater	Crayfish	1
Pelophylax ridibundus	Marsh frog	Freshwater	Reptilia & amphibia	3
Phoxinus phoxinus / Phoxinus phoxinux	Common minnow	Freshwater	Fish	3
Phytophthora ramorum	Sudden oak death	Terrestrial	Fungi	3
Pinus contorta	Coast pine	Terrestrial	Angiosperms	3
Pinus mugo	Mountain pine / mugo pine	Terrestrial	Angiosperms	2
Procambarus clarkii	Red swamp crayfish	Lakes, Watercourses	Crayfish	3
Procyon lotor	Raccoon	Terrestrial	Mammals	2
Proterorhinus marmoratus	Tubenose goby	Freshwater	Fish	3
Prunus serotina	Black cherry	Terrestrial	Angiosperms	2
Pseudorasbora parva	Stone moroko, toupmouth gudgeon	Freshwater	Fish	3
Psittacula krameri	Ringnecked parakeet	Terrestrial	Birds	2
Rhododendron ponticum	Common rhododendron	Terrestrial	Angiosperms	1
Robinia pseudoacacia	Robinia	Terrestrial	Angiosperms	2
Rosa rugosa	Japanese rose	Terrestrial	Angiosperms	2
Salmo salar	Atlantic salmon	Freshwater	Fish	3
Salvelinus fontinalis	Brook trout	Freshwater	Fish	2
Sambucus nigra	Black elder	Terrestrial	Angiosperms	2
Sander lucioperca	Pikeperch	Freshwater	Fish	2
Sciurus carolinensis	Grey squirrel	Terrestrial	Mammals	1
Selonochlamys ysbryda	Ghost slug	Terrestrial	Molluscs	3
Senecio inaequidens	Narrow-leaved ragwort	Terrestrial	Angiosperms	2
Solidago canadensis	Canada goldenrod	Terrestrial	Angiosperms	2
Spartina anglica	Common cord grass, rice grass	Terrestrial	Angiosperms	2
Spiraea tomentosa	Steeplebush	Terrestrial	Angiosperms	3
Tamias sibiricus	Siberian chipmunk	Terrestrial	Mammals	3
Thaumetopoea processionea	Oak processionary moth	Terrestrial	Arthropods	3
Threskionis aethiopicus	Sacred ibis	Terrestrial	Birds	3
Trachemys scripta	Common slider	Freshwater	Reptilia & amphibia	3
Xenopus laevis	African clawed frog	Freshwater	Reptilia & amphibia	3

Appendix II

Species list devided into categories

Category 1			
Animals	**Plants**	**Fungi**	**Bryophytes**
Branta canadensis	*Bunias orientalis*		
Castor canadensis	*Lupinus nootkatensis*		
Harmonia axyridis	*Lupinus polyphyllus*		
Mustela vison	*Rhododendron ponticum*		
Pacifastacus leniusculus			
Sciurus carolinensis			
Category 2			
Acridotheres tristis	*Acer negundo*	*Aphanomyces astaci*	*Campylopus introflexus*
Ameiurus melas	*Ailanthus altissima*		
Ameiurus nebulosos	*Amelanchier spicata*		
Cervus nippon	*Elodea canadensis, Elodea nuttallii*		
Dreissena polymorpha	*Fallopia japonica*		
Eriocheir sinensis	*Galinsoga quadriradiata*		
Myocastor coypus	*Heracleum mantegazzianum*		
Ondatra zibethicus	*Impatiens glandulifera*		
Orchonectes limosus	*Ludwigia peploides, Ludwigia grandiflora (= L. uruguayensis)*		
Procyon lotor	*Mimulus guttatus*		
Psittacula krameri	*Pinus mugo*		
Salvelinus fontinalis	*Prunus serotina*		
Sander lucioperca	*Robinia pseudoacacia*		
	Rosa rugosa		
	Sambucus nigra		
	Senecio inaequidens		
	Solidago canadensis		
	Spartina anglica		
Category 3			
Agrilus planipennis	*Acer rufinerve*	*Melampsoridium hiratsukanum*	
Anguillicola crassus	*Ambrosia artemisifolia*	*Phytophthora ramorum*	
Anoplophora glabripennis	*Azolla filiculoides*		
Arion lusitanicus	*Cornus cericea*		
Arthurdendyrus triangulatus	*Cotoneaster horizontalis*		
Astacus leptodactylus	*Crassula helmsii*		
Bufo marinus	*Gunnera tinctoria*		
Bursaphelenchus xylophilus	*Heracleum persicum*		
Cameraria ohridella	*Heracleum sosnowskyi*		
Cercopagis pengoi	*Hydrocotyle ranunculoides*		
Chelydra serpentina	*Lysichiton americanus*		
Corbicula fluminea	*Pinus contorta*		
Corvus splendens	*Spiraea tomentosa*		
Craspedacusta sowerbyi			
Gambusia holbrooki			

Gyrodactylus salaris			
Hydropotes inermis			
Lepomis gibbosus			
Linepithema humile			
Lithobates catesbeiana			
Lymantria dispar			
Marenzelleria neglecta			
Mytilopsis leucophaeata			
Neogobius melanostomus			
Nyctereutes procyonoides			
Ocinebrellus inornatus			
Odiellus spinosus			
Opilio canestrinii			
Pelophylax ridibundus			
Phoxinus phoxinus / Phoxinus phoxinux			
Procambarus clarkii			
Proterorhinus marmoratus			
Pseudorasbora parva			
Salmo salar			
Selonochlamys ysbryda			
Tamias sibiricus			
Thaumetopoea processionea			
Threskionis aethiopicus			
Trachemys scripta			
Xenopus laevis			

Appendix III

Country code	Country	Zones	Number of zones
AT	Austria	Continental, Alpine	2
BE	Belgium	Continental, Atlantic	2
BY	Belarus	Continental, Boreal	2
CZ	Czech republic	Continental, Pannonian	1
DE	Germany	Continental, Atlantic, Alpine	3
DK	Denmark	Atlantic, Continental	2
EE	Estonia	Boreal	1
FA	Faroe islands	Atlantic	1
FI	Finland	Boreal, Alpine	2
GL	Greenland	-	0
IE	Ireland	Atlantic	1
IS	Iceland	Arctic	1
LT	Lituania	Boreal	1
LV	Latvia	Boreal	1
NL	Netherlands	Atlantic	1
NO	Norway	Atlantic, Boreal, Alpine, Arctic	4
PL	Poland	Continental, Alpine	2
RU	Russia	Con., Boreal, Alpine, Arctic, Steppic	5
SE	Sweden	Continental, Boreal, Alpine	3
SK	Slovakia	Alpine, Pannonian	2

Table 2: List of EEA zones for countries participating in the NOBANIS network (EEA report no. 1, 2002).

Country code	Country	Zones	Number of zones
AT	Austria	ALS, CON, PAN	3
BE	Belgium	ATC, CON	2
BY	Belarus	CON, NEM	2
CZ	Czech republic	ALS, CON, PAN	3
DE	Germany	ALS, ATC, ATN, CON, PAN	5
DK	Denmark	ATN, CON	2
EE	Estonia	BOR, NEM	2
FO	Faroe islands	ATN	1
FI	Finland	ALN, BOR, NEM	3
GL	Greenland	-	0
IE	Ireland	ATC, ATN	2
IS	Iceland	-	0
LT	Lituania	CON, NEM	2
LV	Latvia	BOR, CON, NEM	3
NL	Netherlands	ATC, ATN, CON	3
NO	Norway	ALN, ATN, BOR, CON	4
PL	Poland	ALS, CON, NEM	3
RU	Russia	BOR, NEM	2
SE	Sweden	ALN, BOR, CON, NEM	4
SK	Slovakia	ALS, CON, PAN	3

Table 3: List of Metzger zones for countries participating in the NOBANIS network

Country	Number of EEA partitions	Number of Metzger et al. partitions	Comment
AT	2	3	
BE	2	2	Different partitions
BY	2	2	Different partitions
CZ	1	3	
DE	3	5	
DK	2	2	Different partitions
EE	1	2	
FO	1	1	Same partition
FI	2	3	
GL	0	0	
IE	1	2	
IS	1	0	
LT	1	2	
LV	1	3	
NL	1	3	
NO	4	4	Different partitions
PL	2	3	
RU	5	2	Outside data coverage in Metzger et al zones
SE	3	4	
SK	2	3	

Table 4: Number of biogeographic regions per country (for countries participating in the NOBANIS network). In general European countries are divided into more areas with the Metzger zones than with the EEA zones.

Zone	N	Countries	Comment
Alpine	7	AT, CH, DE, FI, NO, PL, SE	Includes both Alpine North (Scandinavia) and South (Alps sensu stricto)
Atlantic	8	BE, DE, DK, IE, NL, NO	
Arctic	1	NO	
Boreal	4	FI, LV, NO, SE	
Continental	7	AT, BE, CZ, DE, DK, PL, SE	

Table 5: Number of countries per EEA bioclimatic zone (only countries participating in the Risk mapping project are included)

Zone	N	Countries	Comment
Alpine North (ALN)	3	FI, NO, SE	
Alpine South (ALS)	4	AT, CZ, DE, PL	
Atlantic Central (ATC)	4	BE, DE, IE, NL	
Atlantic North (ATN)	5	DE, DK, IE, NL, NO	
Boreal (BOR)	5	FI, EE, LV, NO, SE	
Continental (CON)	10	AT, BE, CZ, DE, DK, LV, PL, NL, NO, SE	
Nemoral (NEM)	6	EE, LV, FI, NO, PL, SE	
Pannonia (PAN)	3	AT, CZ, DE	

Table 6: Number of countries per Metzger et al. environmental zone (only countries participating in the Risk mapping project are included).