NINA Report 468

Alien species and climate change in Norway

An assessment of the risk of spread due to global warming

Jan Ove Gjershaug
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Norwegian Institute for Nature Research

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Norwegian Institute for Nature Research

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Abstract

Gjershaug, J.O., Rusch, G.M., Öberg, S. & Qvenild, M. 2009. Alien species and climate change in Norway: An assessment of the risk of spread due to global warming - NINA Report 468. 55 pp.

Climate changes predicted for Norway as a result from global warming are in general higher precipitation, longer growing seasons and shorter, milder winters. These changes may have important consequences for the opportunities for alien species to expand their range, particularly those with origin in southern latitudes. It is expected that species which are nowadays prevented from becoming established due to a relatively severe climate will have more opportunities to do so, and some of these may become invasive. This report aims to make an assessment of the risk that alien species already established in Norway will expand their current ranges, and that new aliens species become established. Specifically, the assessment deals with a comparison of the projected climates for Norway with those in the areas where alien species have their current distribution range in Europe. The bases for the species analysis was the Directorate for Nature Management's "high priority list" of alien species and species in the '100 worst European aliens" assembled in the DAISIE database. 65 species (41 aquatic and 24 terrestrial) were examined. Of these, 18 already occur in Norway, and their distributions are predicted to increase as a consequence of global warming. The potential distribution of another 23 species not yet found in Norway was assessed. Of these, it is predicted that for 22 species there would be suitable temperatures in Norway in the future. Another 24 species were examined, but not included in the climate scenario assessment, either because it is unlikely that their distributions in Norway are limited by temperature, or because they are of unknown origin and therefore it is uncertain whether it can be considered to be an alien species (cryptogenic species).

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Sammendrag

Gjershaug, J.O., Rusch, G.M., Öberg, S. & Qvenild, M. 2009. Fremmede arter og klimaendring i Norge: en vurdering av risikoen for spredning som en følge av global oppvarming – NINA Rapport 468. 55 s.

Som en følge av klimaforandringer predikert for Norge som et resultat av global oppvarming vil det bli mer nedbør, lengre vekstsesonger og kortere, mildere vintrer. Disse forandringer kan ha viktige konsekvenser for muligheten fremmede arter har til å utvide utbredelsen sin, særlig de fra sørlige breddegrader. Det er forventet at arter som i dag er forhindret i å etablere seg på grunn av et relativt hardt klima, vil ha større muligheter for spredning, og at noen av disse kan bli invasjonsarter. Denne rapporten har som formål å gi en vurdering av risikoen for at fremmede arter som allerede er etablert i Norge vil øke sitt nåværende utbredelsesområde, og at nye fremmede arter blir etablert.

Spesifikt omhandler vurderingen en sammenligning mellom predikert fremtidig klima i Norge og klimaet i de områder hvor fremmede arter har sin nåværende utbredelse i Europa. Grunnlaget for utvelgelsen av arter har vært DN notat over prioriterte arter samt listen over ”de 100 verste fremmede europeiske arter” beskrevet i DAISIE databasen.

65 arter (41 akvatiske og 24 terrestriske) ble evaluert. 18 av disse forekommer allerede i Norge og deres utbredelse er forventet å øke som en konsekvens av global oppvarming. Den potensielle temperatur-baserte utbredelsen ble prediktert for 23 arter som enda ikke er funnet i Norge (“door knockers”). Av disse ble 22 arter vurdert å finne egnete temperaturforhold i Norge i fremtiden. Ytterligere 24 arter ble evaluert, men ikke inkludert i klimascenariovurderingen, enten fordi det er lite sannsynlig at deres utbredelse i Norge er begrenset av temperatur, eller at de har ukjent opprinnelse hvor en ikke vet om de er fremmede eller naturlig forekommende arter (cryptogenic species).

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Contents

Foreword

Alien species and organisms are, globally, one of the largest threats to biodiversity and ecosystem functions. They are intentionally or unintentionally spread from their natural geographical ranges by the help of man, being the main reasons international trade and travelling. Although not all alien species pose dangers, some can cause large environmental, health and economic problems. It is particularly invasive species that may out-compete native species and species that transmit diseases and parasites, which pose problems for natural ecosystem. The environment authorities in Norway have expressed concern about the damage that many alien species cause to nature and to the native species that occur in the country. They have prepared a cross-sectoral national strategy and action plan to mitigate and reduce the effects of alien species. (Miljøverndepartementet 2007).

The control of alien species introductions in Norway is principally developed to hinder the introduction of diseases, virus, bacteria, fungi, and other pests important for agriculture, fisheries, and other economic sectors, but any species which are known to produce damage in natural systems in other countries can potentially be a problem in Norway if introduced.

A large number of the alien species in Norway originate from areas with a climate which is warmer than the present climate in the country, and it can be expected that current alien species distribution ranges are in part limited due to the unsuitability for these species to thrive of today's climate. However, the projections about climate change indicate increases in temperature in Norway, both on land and in the sea. There is therefore a concern that the number of alien species that can potentially establish in the country and their geographical extent may increase as a consequence of climate warming, (DN 2008a). This report deals with an assessment of this risk.

We are most thankful to colleagues from various organizations for their responsiveness and cooperation in facilitating the search and acquisition of climate data and related literature. Particular thanks to K. Bevanger, Norwegian Institute for Nature Research, I. Hanssen-Bauer, Norwegian Meteorological Institute; V. Husa and J. Aure, Marine Research Institute; F. Flatøy, Bjerknes Centre for Climate Research, W. Cramer, Postdam Institute for Climate Impact Research and E. Juul Green, the International Council for the Exploration of the Sea.

April 24th 2009, J. O. Gjershaug, G. M. Rusch, S. Öberg and M. Qvenild.

Introduction

1.1 Background

Alien species means a species, subspecies, or lower taxon occurring outside of its natural range and dispersal potential (i.e. outside the range it occupies naturally or could not occupy without direct or indirect introduction or care by humans) and include any part, gametes or propagule of such species that might survive and subsequently reproduce (DN 2001).

Regional distributions of species are principally determined by macroclimate (Huntley *et al.* 2007). Further, simulated distributions in future climate scenarios show that species are likely to experience major shifts in their range if such climatic changes take place. (Huntley *et al.*1995, Vetaas 2002). These predictions generally refer to species distributions in their natural ranges, but are equally applicable to the geographical ranges of alien species (Beerling *et al.* 1995).

Changes in the climate in Norway that are predicted as a consequence of global warming are in general: higher precipitation, longer growing seasons, and shorter, milder winters. These may have important consequences for the opportunities for alien species to expand their range, particularly those with origin in southern latitudes (e.g. Beerling *et al*. 1995)). It is expected that species which are nowadays prevented from becoming established due to a relatively severe climate will have more opportunities to do so, and some of these may become invasive (Stachowicz *et al*. 2002). For example, alien species in Norway that at present are only able to survive in microclimates in urban areas such invertebrate species that exploit compost heaps during the winter could be able to become established elsewhere outdoors (Ødegaard & Tømmerås 2000). Alien plants that have so far only survived or thrived in southern Norway will likely be able to expand northwards and to higher altitudes provided that there are suitable habitats where they can establish (Beerling *et al*. 1995). Many species of plants are already spreading in Norway (Fremstad & Elven 1997) and according to current climate scenarios it is likely that several of these will not only expand northwards and further inland, but also become increasingly common in areas where they are already established.

Not all expansion of the distribution or invasive ranges can be ascribed to climate change. Land use change and other human interventions associated with the facilitation of species dispersal will promote the spread of alien species. It should therefore be expected that changes in climate and in land use acting in combination will increase the risk of expansion of species (e.g. Rosvold & Andersen 2008). An already important group of alien species that will likely become more prominent are garden plants and plantation trees that have become naturalized (Fremstad 2000). Many of the numerous species that are grown in Norwegian gardens and green spaces or in forestry are well adapted to Norwegian conditions and are found in the wild. Some have been grown for a long time and have had good opportunities to spread. Other introductions are comparatively recent, but are basically well adapted to Norwegian conditions. They orginate from areas in Asia and North America where the environment is comparatively similar to that in Norway as regards to the climate. New ornamental plants are continually being imported and it is likely that some of these will join the flora of alien species.

1.2 Objectives

This report aims to make an assessment of the risk that alien species already established in Norway will expand their current ranges, and that new aliens species will become established. Specifically, the assessment deals with:

1) A review of current predictions about climate change for terrestrial and aquatic environments.

2) A selection of alien species including organisms in all main habitats: aquatic marine, aquatic inland, and terrestrial occurring in Norway and consisting of a set of high

priority species selected by the Directorate of Nature Management (DN 2008b) (ca 57 species) and a list of potentially invaders (“door knockers”), species not occurring in Norway today but present in neighboring countries (in the North European and Baltic network on invasive alien species - NOBANIS Data Base).

3) An assessment of the risk for expansion in new areas by comparing climate change scenarios for Norway with the climate in current distribution ranges of alien species in Norway and in Europe using the CLIMEX software.

2. Climate scenarios

2.1 Global

The range for predicted global average warming (relative to pre-industrial values) is 1.1ºC to 4.6ºC for the end of the 21st century depending on the future emissions of climate gasses (IPCC 2007). As a consequence of higher air temperature, it is also expected warmer temperatures in the oceans. In the latest IPCC report (2007) climate model atmospheric components had a typical distance of 150 kilometer or more between the calculating points. This resolution is probably sufficient for modeling large-scale features, but it is in general still too coarse to reproduce the climate on a regional or local scale (Hanssen-Bauer *et al.* 2003). In order to produce regional scenarios, downscaling and regional modeling (dynamical downscaling), statistical methods (empirical downscaling) or combinations of these techniques have been applied in Scandinavia (Hanssen-Bauer *et al.* 2003, 2005).

2.2 In Norway

The RegClim programme (Regional Climate Development under Global Warming) (Hanssen -Bauer *et al.* 2005) has produced a series of climate change scenarios for Scandinavia through regional downscaling of global climate change predictions. The predictions on warming rates appear to be robust regarding the type of climate model, the emission scenario and the downscaling strategy. They show that warming rates during the 21st century will increase with distance from the coast and with latitude (Fig. 1). Also, in most of Scandinavia, higher warming rates are projected in winter than in summer.

In contrast, predictions about changes in precipitation are less reliable, being the spread between different scenarios larger than for temperature. A substantial part of the projected precipitation change is connected to projected changes in atmospheric circulation, which differ considerably from one model integration to another (Hanssen-Bauer *et al.* 2005). A tendency for increased large-scale humidity over Scandinavia typically indicates increasing annual precipitation for the 21st century. This tendency is most significant during winter.

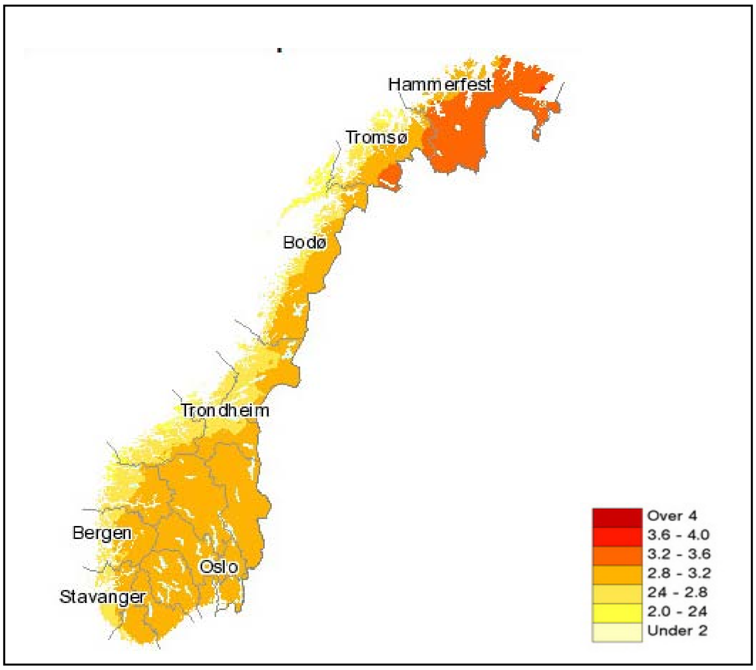


Figure 1. Change in mean temperature from current (1961-1990) to future (2071-2100). Source: se Norge.no.

Predicted changes from the current climate (baseline 1961-1990) to the period 2071-2100 are that maximum temperature in summer will increase most in the south-east, with 3ºC and about 2ºC in rest of the country. The number of hot summer days will also increase (mostly in the south-east) and the winters will be milder with minimum temperatures between 2.5 and 4ºC above present values. The largest increase is expected in the region of Finnmark. (http://regclim.met.no/presse/download/regclim_brosjyre2005.pdf).

Further, the predicted climate change will most likely lead to a reduction in the number of days with snow cover in Fennoscandia (IPCC 2007). In Norway, the largest change in snow season duration is projected along the coast, and especially in the innermost parts of the coastal areas in West-Norway, Mid -Norway and North -Norway (Fig. 2). The HBV model projects a reduction of more than 80 days in these areas from current (1961-1990) to future climate (2071-2100) (Vikhamar-Schuler & Førland 2006).

Temperatures in the oceans are also increasing. Over the period 1961 to 2003, global ocean temperature has risen by 0.10ºC from the surface to a depth of 700 m. although lower temperatures have been recorded since 2003 (Bindoff *et al.* 2007). However, an acceleration of the rates at which the sea surface temperature has increased has been observed in Europe in recent decades and projections suggest that sea surface temperature could rise more than the global average (EEA 2008, ICES www.ices.dk/iceswork/bulletin/ICES%20CLIM.pdf). Along the Norwegian coast, the coldest winter mean temperature is observed in the Skagerrak area (2^{o}C). Temperatures increase along the coast of western Norway and the county of Nordland due to the influence of the Gulf Stream (winter temperatures of 4-5ºC), and decrease slightly towards the north (Asplin *et al.* 2008). How large the temperature increase will be in the ocean is uncertain, but an increase of 1-2ºC in the water layers with highest biological activity has been predicted as fairly likely (http://www.imr.no/aktuelt/nyhetsarkiv/2004/mai/ hva_vil_klimaendringer_bety_for_livet_i_havet). Changes in the timing of seasonal biological phenomena (phenology) and in the distribution of marine species have been observed, including earlier seasonal cycles (by 4-6 weeks) and northward movements, of up to 1100 km over the past 40 years, and it seems that these changes have accelerated since 2000. Fur-

ther, sub-tropical species are occurring with increasing frequency in European waters (EEA 2008).
Increased temperatures of lakes and rivers (by 1-3ºC during the 20th century) have resulted in decreases in the ice cover by 12 days in average in the last century in Europe. These changes can be at least partly attributed to climate change, and partly to other causes such as freshwater use for cooling processes (e.g. power plants). Lake and river surface water temperatures are projected to increase further with increasing air temperatures (EEA 2008).

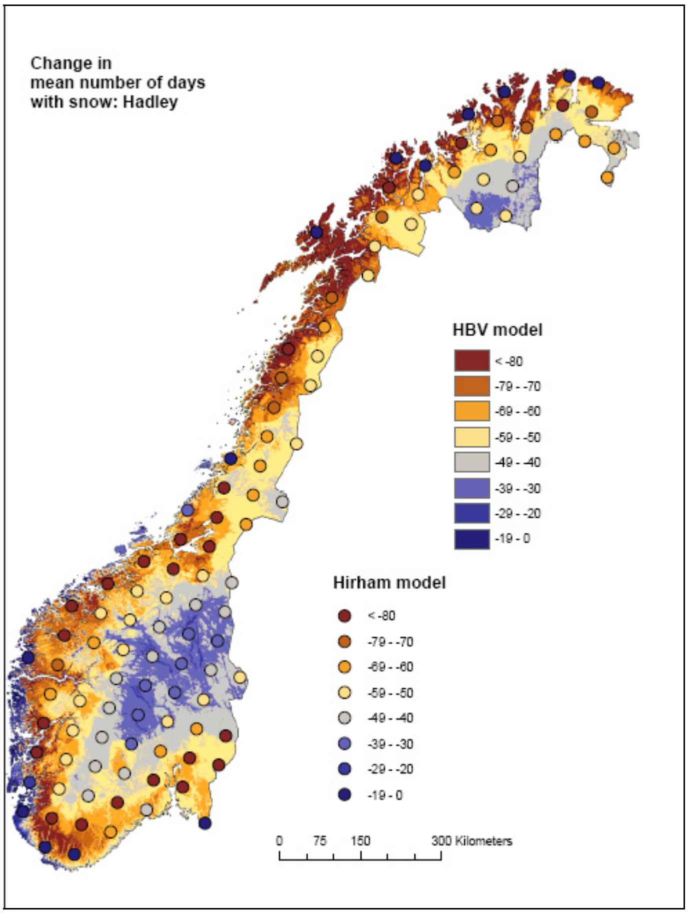


Figure 2. Change in mean number of days with snow derived from both the HIRHAM and the HBV models for the Hadley AOGCM (from Vikhamar-Schuler & Førland 2006).

3 Tools to predict distribution ranges

Various modeling tools have been used for predicting species distributions according with regional climates (Huntley *et al.* 1995, review by Elith *et al.* 2006, Stokland *et al.* 2008). However, robust predictions depend on extensive and accurate data on geographical distributions and of corresponding climate data. This kind of data is generally scarce for most species which makes the use of these approaches unrealistic in view of the number of alien (or potential alien) species to be considered in the assessment, and within the resources and time available for this evaluation.

3.1 Models

CLIMEX is one of several software tools developed for bioclimatic analysis. It was originally designed (CSIRO Entomologist) to predict where foreign species of plants and animals (mostly agricultural pests) would be able to survive if they were introduced into Australia. The ability to predict the risk is vital in the effort to prevent establishment of introduced species, and the aim to develop CLIMEX has been to know which introduced species are adapted to the climate in the recipient country in order to establish priorities for their control or eradication. CLIMEX is now used widely around the world by agricultural, quarantine, and conservation agencies to look at a range of species from insects to weeds, and plant diseases to earthworms.

The CLIMEX software (CLIMEX Version 3) contains two different climatic-matching tools (Sutherst *et al.* 2007). One is a generic model of organism's response to climate ("CLIMEX model"), while the other is for comparing meteorological data of different places without reference to any particular species ("Match Climates" function). The CLIMEX model is of the kind used for predictions of species distribution ranges and requires accurate data on climate and ecological requirements, and good knowledge of the species distribution ranges and of the corresponding climates.

Since the number of species to be evaluated in this assessment was large and data about the distribution of the species varied largely in quality, the use of the CLIMEX model was not a feasible alternative. The climate -matching function in CLIMEX, however, allows the user to directly compare the temperature, rainfall, rainfall pattern and relative humidity of a given location with any number of other locations. It provides a method of identifying sites with similar climates for targeting collection and release sites, or for assessing risks from exotic species. The results are presented as a series of 'match indices' indicating the goodness of fit for the selected climatic variable. The function has often been used most often to determine areas at risk from exotic species. (http://www.climatemodel.com/climFunc.htm)

In this assessment, we used the Match Climates function, to compare climate change scenarios for various locations in Norway with the climate in the current distribution ranges of terrestrial and freshwater organisms. The fit between the climate change scenarios and the climate in Europe, and distribution ranges of each of the individual species were later compared visually to assess the likelihood of spread into new areas.

The meteorological database in CLIMEX does not include marine temperatures; therefore for marine organisms we compared water surface temperatures in the species current distribution ranges in Europe with the projected temperatures along the Norwegian coast (current mean temperatures and an increase of $1^{o}C$ and $2^{o}C$) to assess the potential ranges of spread.

3.2 Climate databases and climate matches

The CLIMEX software is equipped with a database of records from about 2400 meteorological stations worldwide. It includes monthly long term average maximum and minimum temperatures, rainfall, and relative humidity.

We restricted the analyses in this report to changes in temperature since first, predictions about changes in rainfall are considerably more uncertain than those about temperature (Hanssen-Bauer *et al.* 2005). A complicating factor is that increases in rainfall are more likely to occur during the winter (Hanssen-Bauer *et al.* 2005), so factors such as snow depth may be more important in determining the habitat availability for certain species than the amount of water available. Secondly, the general prediction for Scandinavia is that rainfall will increase, except for possibly in the south-eastern areas in the region; therefore it is unlikely that the availability of water will constrain the spread of species.

Climate scenarios for Norway were therefore based only on projected temperature changes in the regions defined in Hanssen-Bauer & Førland (1998), and we set the variables rainfall and relative humidity as constants in the CLIMEX climate-matching analyses.

Norway has been divided into six temperature regions based on a combination of principal component analysis and cluster analysis of series of long-term temperature variations and trends (Hanssen-Bauer & Nordli 1998) (Fig. 3). Regions are fairly homogenous concerning temperature variations and typical temperature series (updated to 1997) and the defined temperature regions have been used for the statistical downscaling of temperature scenarios in the project “RegClim”. For each region, there are different annual and seasonal temperature change scenarios (projected warming) from the years 1980-1999 to 2030-2049 (Hanssen-Bauer *et al.* 2003) (Table 1).

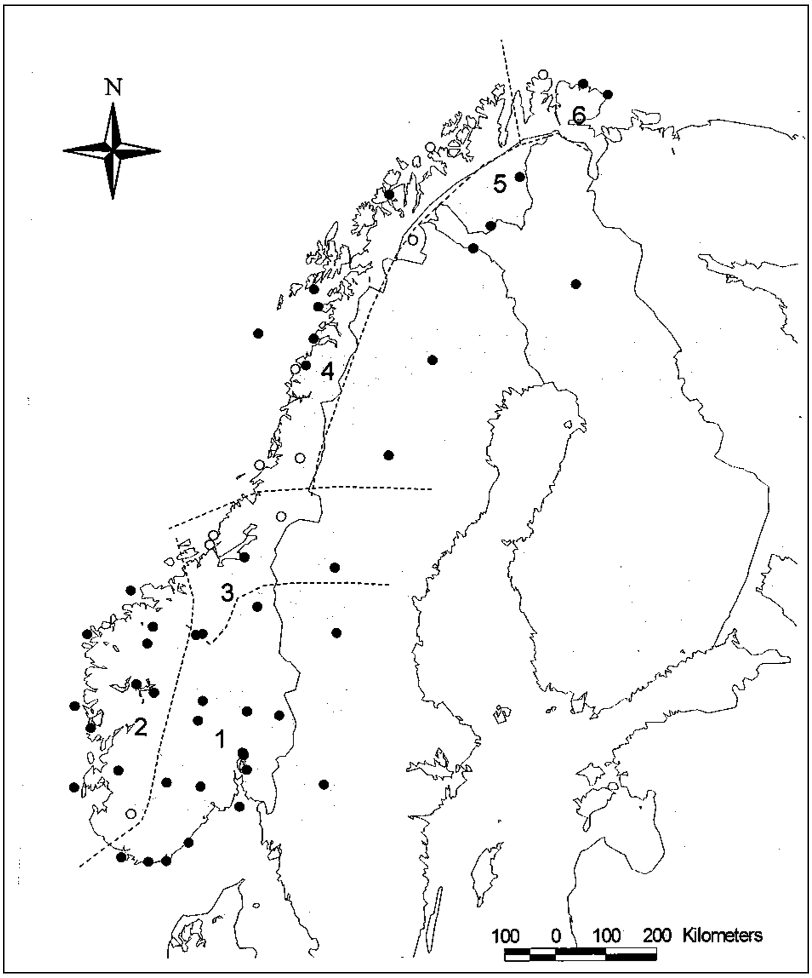


Figure 3. Temperature regions defined in Hanssen-Bauer & Nordli (1998). Dots indicate stations in the network included in the regionalization analysis.

For each region, one or two key stations with data available in the CLIMEX meteorological database were chosen to represent the individual regions' projected climate change scenarios (table 1). For larger regions, two stations were chosen to reveal typical features in different parts of the region. There was only one station from Region 4 and no stations from Regions 5 and 6 in the CLIMEX database. The northern location in region 4 (Tromsø) and the key stations in region 5 and 6 were neither represented nor had any closely located locations in the CLIMEX meteorological database. Data for particular locations can normally be imported and added to the CLIMEX meteorological database (Sutherst *et al.* 2007), but this function was faulty in CLIMEX version 3 during the preparation of this report and the stations where therefore not included in the analyses. However, the included locations cover an extensive range from south to north in Norway to be able to make predictions about spreading of alien species northwards and inland.

Table 1. Projected warming from 1980-1999 to 2030-2049 in the four Norwegian temperature regions (Hanssen-Bauer *et al.* 2003). Key station(s) for each region are stated. Key stations/regions in shade were not included in the present study.

Region	Key station	Temp. change annual	Temp. change winter	Temp. change summer
1	Oslo	+1,35	+1,96	+0,86
1	Lillehammer	+1,35	+1,96	+0,86
2	Stavanger	+1,28	+1,65	+0,96
2	Lærdal	+1,28	+1,65	+0,96
3	Trondheim	+1,19	+1,67	+0,83
4	Brønnøysund	+1,58	+1,94	+1,24
4	Tromsø	+1,58	+1,94	+1,24
5	Sihccajavri	+2,20	+2,78	+1,67
6	Vardø	+2,30	+2,92	+1,58

3.3 Marine water temperatures

Maps of seasonal sea surface (< 10 m) temperatures for summer (July-September) and winter (January-March) were retrieved from National Oceanographic Data Center (NODC) (World Ocean Atlas 2005, http://www.nodc.noaa.gov) (Fig. 4). Climate change projections for sea temperatures that were used in the analyses were increases of 1ºC and 2ºC (http://www.imr.no, Nr. 4-2003: Klima og fisk – med fokus på Barentshavet) for both summer and winter temperatures.

Summer Winter

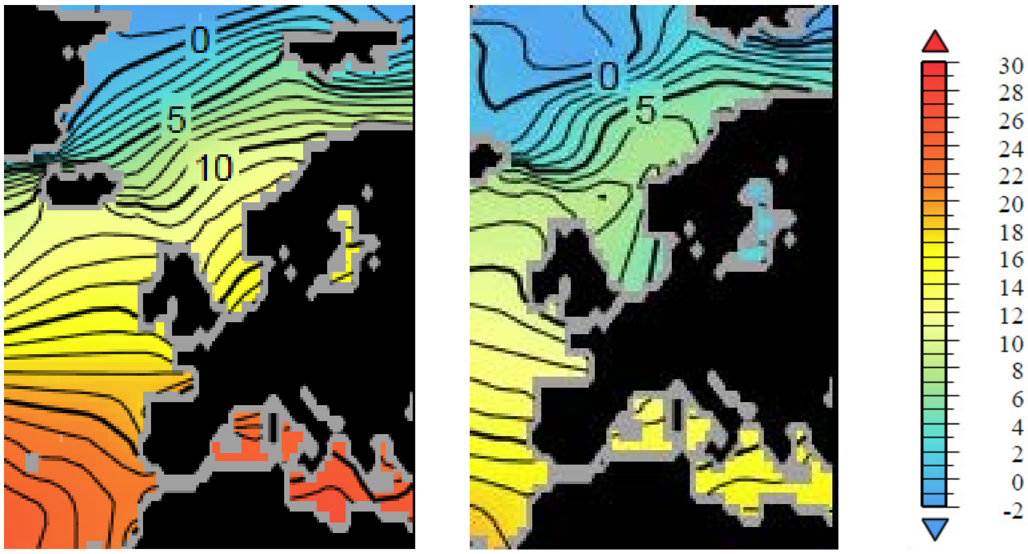


Figure 4. Surface sea temperatures for the winter season (January-March) and the summer season (July-September). Source: National Oceanographic Data Center (NODC). Contour interval= 1°C.

3.4 Alien species ranges

Species distribution maps were retrieved from the DAISIE (Delivering Alien Invasive Species in Europe) database (http://www.europe-aliens.org). This database has information of 8996 alien species occurring in Europe, including a set of "100 of the worst" invasive aliens in the region. Data include information about the species' biology and ecology, habitat and distributions (including maps) and invasion trends. Data were also retrieved from NOBANIS (North European and Baltic Network on Invasive Alien Species) database (http://www.nobanis.org). This database contains information about the invasiveness and frequency of the alien species found in northern Europe. For some species for which distribution maps were not available in these bases, maps in the Norwegian Biodiversity Information Centre (Artsdatabanken) (http://www.biodiversity.no), GBIF (Global Biodiversity Information Facility) (http://www.gbif.org) and Norges Dyr (Semb-Johansson 1990) were consulted. The information in the databases is comprehensive and generally up to date. However, when available, literature sources were used to obtain more accurate assessments of the likelihood of the individual species to spread.

4 Selection of species

4.1 Species data sources

We based the selection and evaluation of species primarily on the three available databases described above; The Alien Species Database developed by The Norwegian Biodiversity Information Centre (NIBC), The North European and Baltic Network on Invasive Alien Species (NOBANIS) and the Delivering Alien Invasive Species In Europe (DAISIE) project.

- The Alien Species Database of NIBC contains documentation on 2483 species recorded in Norway by 2006.
- NOBANIS has developed a network of common databases containing 3770 alien and invasive species of the region as well as 57 fact sheets on selected species. The NOBANIS network consists of the following countries; Austria, Belgium, Denmark, Estonia, Finland, Faroe Islands, Germany, Greenland, Iceland, Ireland, Latvia, Lithuania, the Netherlands, Norway, Poland, Slovakia, Sweden, and the European part of Russia, but not the British Iles.
- DAISIE has developed a public domain database and fact sheets of the 100 most widespread invasive species in Europe. Information has been selected from 63 countries and the database consists of 8996 alien species occurring in Europe. The list of the 100 worst alien species has been selected in terms of their impact on biodiversity, economy, and health.

4.2 Criteria for the selection of species

From these data sources we used the following criteria to select a set of alien species for further evaluation:

- Species from all types of habitats; aquatic marine, aquatic inland and terrestrial.
- Species classed as “high priority” by the Directorate for Nature Management (DN 2008b).
- Species that have been classified as ‘100 worst alien species in Europe’ (DAISIE database).
- Species that have rapidly spread in neighboring countries (Sweden, Denmark, Finland and European part of Russia) as well as the other countries in the NOBANIS region (NOBANIS database).
- Species for which according to the distribution maps and other documentation their distribution appeared to be limited by climate.

4.3 Selected species

The set of species that was evaluated is presented in 3 tables (Appendices I-III, in total 62 species). Each table contains information for each taxon on climate related habitat requirements with special focus on sensitivity to air and water temperatures, the current distribution in Norway and in neighboring countries, the general trends of distribution in the NOBANIS region, the status and trends about distributions, and the source from where the information was retrieved. For some species the information available in any of the three databases was very scarce. We complemented the information in these bases with literature sources when available.

Species in Norway

The overview of alien species in Norway currently includes 2500 taxa. In this survey, we concentrated on a set of 57 species which have been classed as “high priority” by the Directorate for Nature Management (DN). Based on this list we revised available information on each taxon in the three databases mentioned above and made a preliminary evaluation from current distribution ranges and ecological requirements about whether the species spread could be limited by temperature. This set consisted of 41 species (18 species in Appendix I and 23 species in Appendix III) (Table 2). The 18 species in Appendix I already occur in Norway and it was considered that their distribution could potentially expand due to climate warming. Species in Appendix III were evaluated but not included in the climate scenarios – species range assessment. The reasons for excluding these species were 1) that their distributions do not appear to be limited by temperature, or 2) they have unknown origin which cannot be ascribed as being native or alien (cryptogenic species).

The 18 species already occurring in Norway (Appendix I) are predominantly from aquatic marine and terrestrial habitats (Table 2). Five of the species from terrestrial habitats are plants that have been introduced as ornamental, but there is no predominant group of organisms in the marine habitat.

Door knockers

Species registered or established in neighbouring countries, but that have not been observed in Norway, as well as species that today are found on southern latitudes are expected to spread and expand northwards due to climate changes (Bevanger *et al.* 2007). Such species (hereon “door knockers”) are numerous and the lack of data about the species ecological requirements (both physical and in interaction with other organisms) make predictions about which species may become problematic, challenging. Out of the 57 species in the NOBANIS area with fact sheet information, only 13 species have not yet been recorded in Norway (DN 2008b). We assessed the potential spread of these 13 species due to changes in temperature. In addition, we revised the DAISIE list of the “100 worst invasive alien species in Europe”, and preliminarily selected species we considered to be potential door knockers in face of projected warming of the climate. In total, we evaluated 25 door knocker species (Appendix II) which are predominantly from aquatic habitats (Table 2).

Table 2. Summary of species evaluated in the report.

Species occurring in Norway (see Appendix I).

[1]Two of these species occur also in aquatic inland habitats.

Habitat	Number of species
Aquatic marine	8[1]
Aquatic inland	3
Terrestrial	7

Door knockers (see Appendix II)

[2] Six of these species occur also in aquatic marine habitats.

Habitat	Number of species
Aquatic marine	10
Aquatic inland	9 [2]
Terrestrial	4

Species examined but not included in the climate scenario assessment (see Appendix III)

[3] Two of these species occur also in aquatic inland habitats.

[4] These species occur also in aquatic marine habitats.

Habitat	Number of species
Aquatic marine	9[3]
Aquatic inland	2[4]
Terrestrial	13

5 Climate match: Scenarios in Norway and current climate in Europe

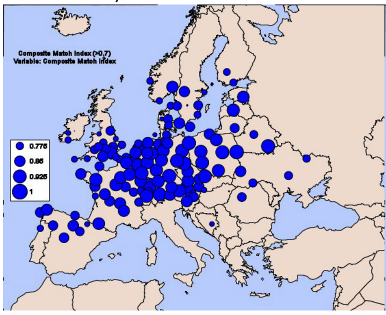
The “Match Climates” routine in CLIMEX was used to compare the climate change scenarios (temperature rise, see Table 1) of key stations (“Home” locations) in the different regions in Norway (see section 3.2) with the present day (1961-1990) climate of all the locations in Europe with data the CLIMEX meteorological database (“Away” locations). When key stations in Hanssen-Bauer & Nordli (1998) were not included the CLIMEX meteorological database, a closely located location was used.

The comparisons were made using mean annual, winter and summer temperatures. Separate analyses were conducted for each season in order to assess whether there could be seasonal differences in the potential constraints to the species distribution. In CLIMEX, the similarity of the climate between the “Home” and the “Away” locations is measured by the Composite Match Index (CMI), a value between zero and one, with higher values corresponding to a greater match between locations. CMI > 0.7 is good matching, and if CMI = 1, climates are exactly the same.

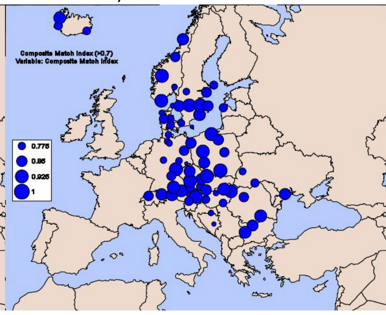
The resulting climate matches were used to make general predictions on whether terrestrial and aquatic inland alien species could spread to any of the different regions in Norway in a future climate change scenario. More specifically, the predictions were made by comparing present species distributions maps (see section 6) and the resultant “Match Climates” maps from CLIMEX (see below). The “Match Climates” maps show the degree of similarity (CMI) as circles where only locations with CMI > 0.7 have been displayed. The larger size of the circles corresponds with larger CMI. Thus, the more the distribution of a species equals the distribution and size of CMI circles on “Match Climates” maps of a certain location (or key station), the higher is the likelihood that the species could spread there, based on temperature. The comparisons were made for both terrestrial and fresh water alien species established in Norway (Appendix I) and for door knockers (Appendix II) for which distribution maps were available.

The following maps resulted from the climate-matching analyses between projected changes in mean annual, winter, and summer temperatures for the 6 locations analyzed and the climate in European locations. R numbers indicate temperature regions in Hanssen-Bauer & Førland (1998).

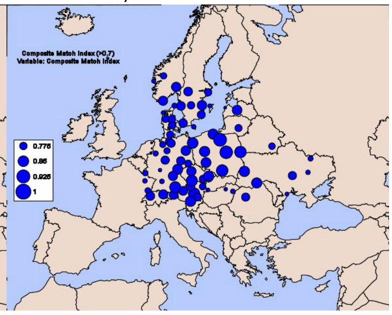
R1. Oslo, annual

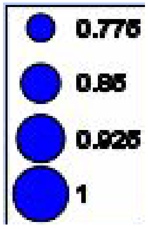


R1. Oslo, winter

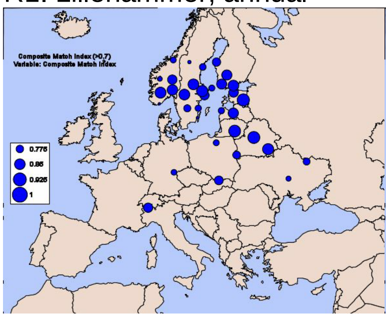


R1. Oslo, summer

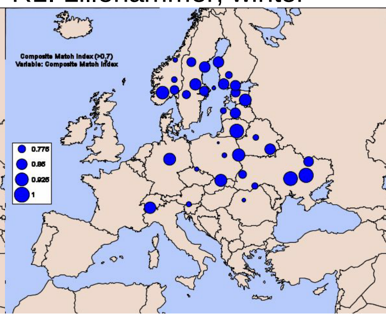




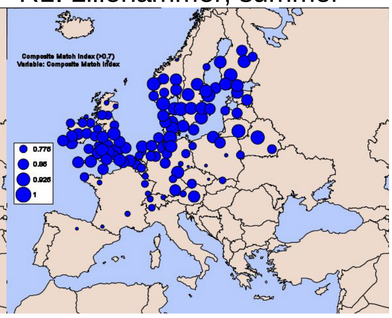
R1. Lillehammer, annual



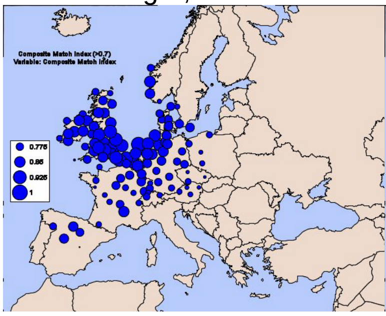
R1. Lillehammer, winter



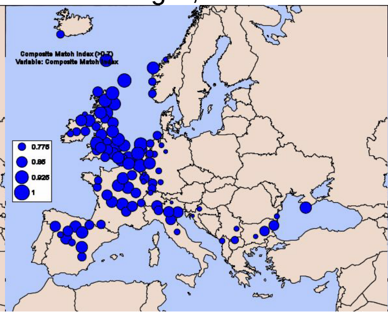
R1. Lillehammer, summer



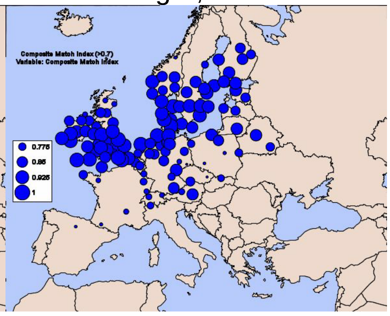
R2. Stavanger, annual



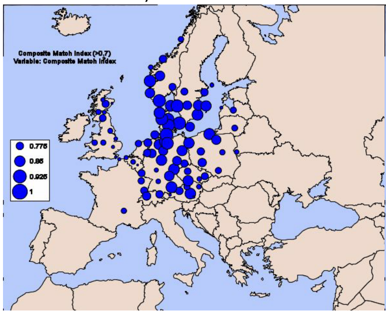
R2. Stavanger, winter



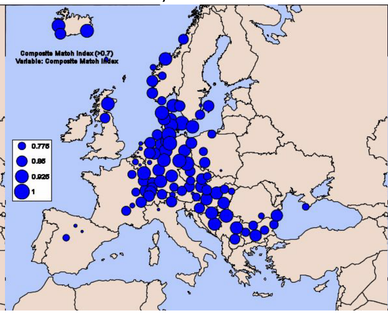
R2. Stavanger, summer



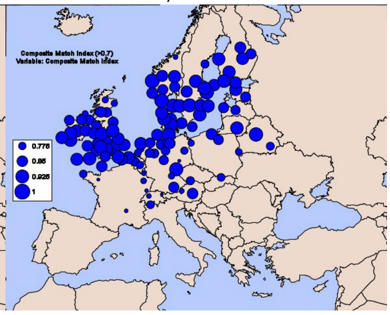
R2. Lærdal, annual



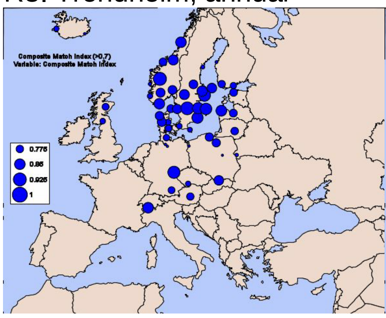
R2. Lærdal, winter



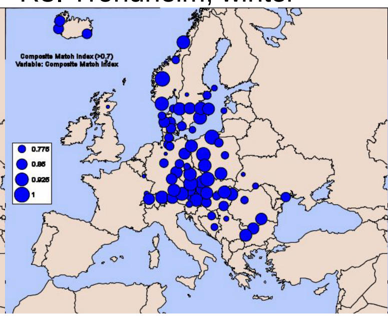
R2. Lærdal, summer



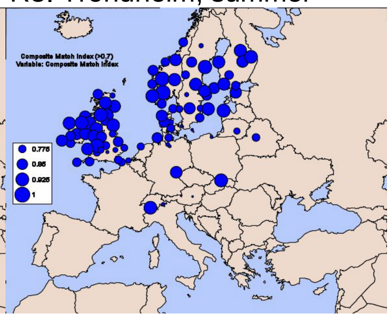
R3. Trondheim, annual



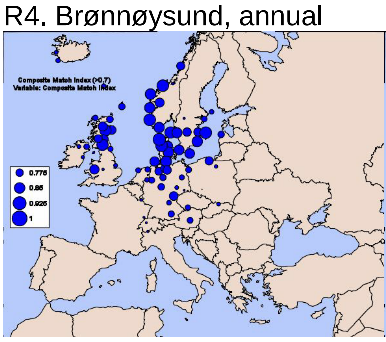
R3. Trondheim, winter



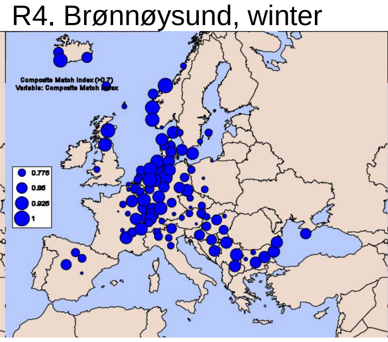
R3. Trondheim, summer



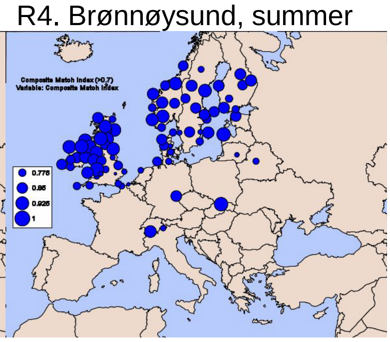
R4. Brønnøysund, annual



R4. Brønnøysund, winter



R4. Brønnøysund, summer



6 Predictions of future distribution ranges

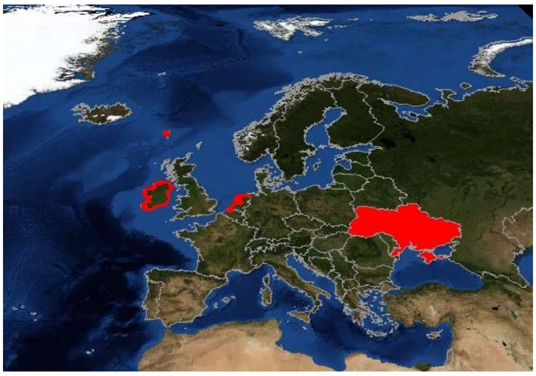
6.1 Species occurring in southern Norway. Source of species distribution maps: DAISIE

Legend

Known in country	Known in CGRS square	Known in sea
Native in country	Native in CGRS square	Assumed native range

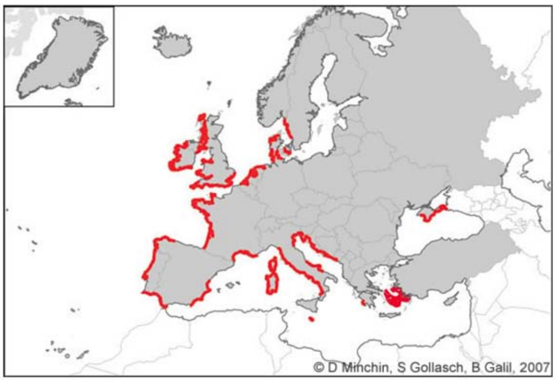
Aquatic marine

(Dinoflagellat) *Alexandrium tamarense*



This dinoflagellate is established but rare in Norway. With a temperature increase of 1°C, this species is supposed to increase the range in the Oslofjord area and with an increase of 2°C, to spread to the southern west coast of Norway.

Stillehavsøsters *Crassostrea gigas*, Pacific oyster

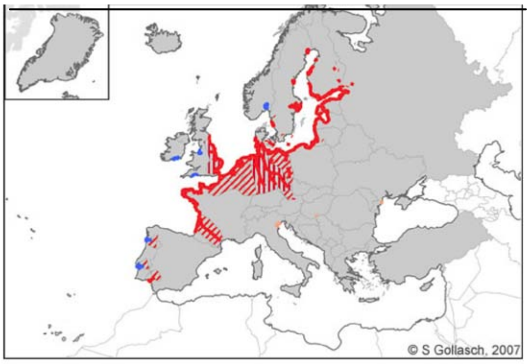


This oyster is found north to Scotland with a summer sea surface temperature of about 13°C. It has been found along the Norwegian coast up to Nordland, introduced for aquaculture purpose. It has been found from Østfold to Kragerø and near Bergen. It is supposed to spread further north with an increased sea temperature. It needs 15-30°C for successful reproduction and can therefore breed only in hot summers in Norway.

Amerikansk knivskjell *Ensis americanus,* American razor clam

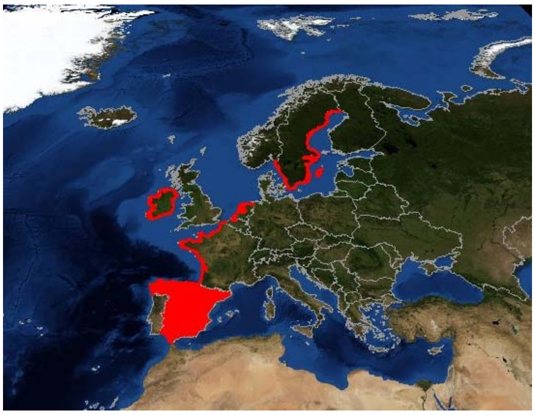
This razor clam appears to have summer temperature requirements of about 15° C. It is supposed to spread up to the south-west coast of Norway with an increase of 1°C and to the whole west coast of southern Norway with an increase of 2°C.

Ullhåndskrabbe *Eriocheir sinensis*, Chinese mitten crab



This crab is found in waters with summer temperature of about 14°C. If the northern border of its distribution were determined by temperature, it should occur up to the southern west-coast of Norway. So far it is only found in the Oslofjord area. With a temperature increase of 1°C it could spread to the whole west-coast of Norway, and with an increase to 2°C to the Trøndelag coast. Blue colour on the map indicates uncertain establishment.

Japansk sjølyng *Heterosiphonia japonica*



This species is found in areas with a summer sea surface temperature of 15° C. With a summer sea surface temperature increase of 1° C it will probably reach the southern part of Norway, and with an increase of 2° C it will reach the west coast of Norway.

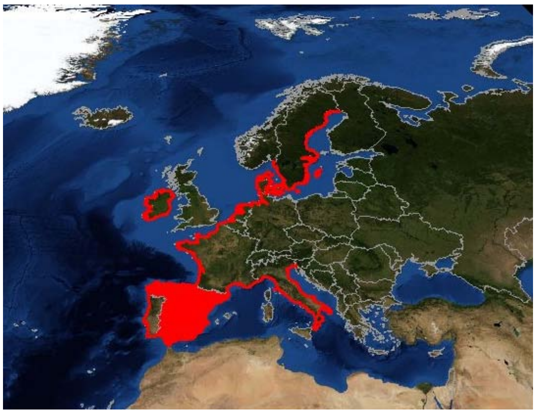
(Marin flerbørsteorm) *Marenzelleria neglecta*, Red-gilled mud worm

This species is found in areas with a summer sea surface temperature of 15° C. With a summer sea surface temperature increase of 1° C it will probably reach the southern part of Norway, and with an increase of 2° C it will reach the west coast of Norway.

(Ribbemanet) *Mnemiopsis leidyi*, American comb jellyfish

The species is found in Skagerrak with a summer sea temperature of 15° C. With a summer sea surface temperature increase of 1° C it will probably reach the southern part of Norway, and with an increase of 2° C it will reach the west coast of Norway.

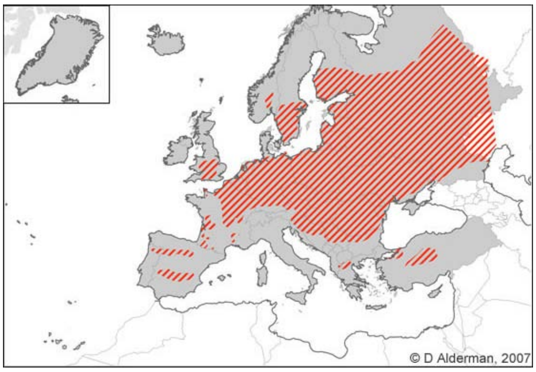
Japansk drivtang *Sargassum muticum*



This species is in Skagerrak and is found up to Sognefjorden. It is found in areas with a summer sea surface temperature of 13° C. With a summer sea surface temperature increase of 1° C it will probably reach the the coast of Trøndelag, and with an increase of 2° C it will reach the coast of Nordland county.

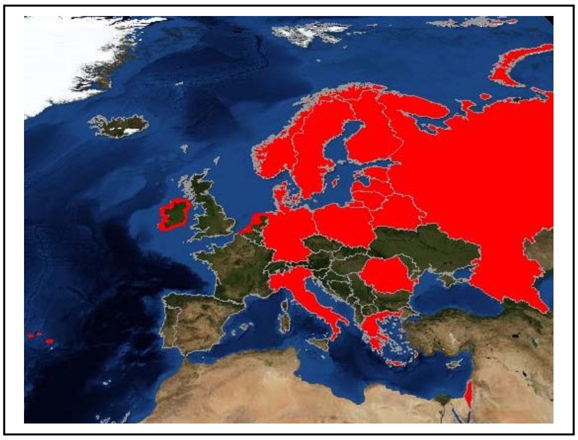
Aquatic inland

Krepsepest *Aphanomyces astaci*, Crayfish plague



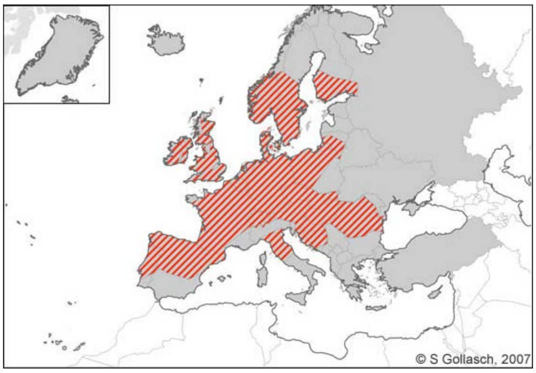
The species has the potential to spread northwards, at least up to Nordland. The climate in its present range matches generally well with predicted climate scenarios for all stations. There is comparatively less fit for Trondheim (annual), Brønnøysund (annual and summer) and Lillehammer (annual and winter) predicted temperatures.

Karpe *Cyprinus carpio*, Carp



Has been introduced to lakes in southern Norway up to Mjøsa and Bergen. Due to winter temperatures, it is unlikely that the Carp can establish north of 60°N today. With a warmer winter temperature it will have potential to spread further north.

Vasspest *Elodea canadensis*, Pondweed



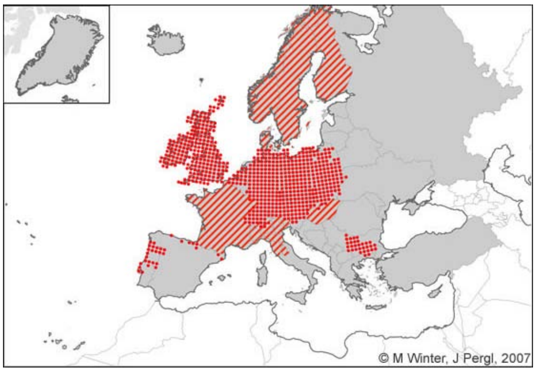
The species has the potential to spread northwards, at least up to Nordland. The climate in its present range matches well the predicted climate scenarios for Oslo, Stavanger, Lærdal and Trondheim, and for Brønnøysund (summer and winter). For Lillehammer there is good match for summer temperatures.

Terrestrial

Iberiaskogsnegl *Arion lusitanicus*, Spanish slug

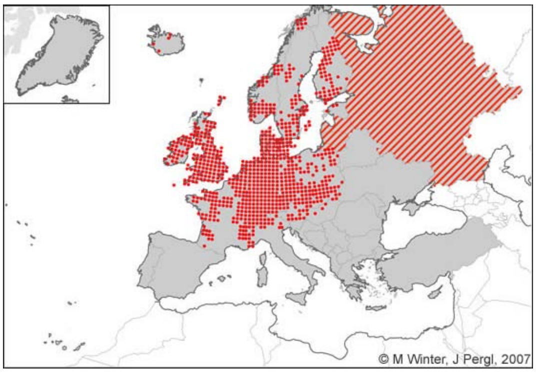
There is a potential of expansion of the range into areas with broadleaf deciduous woodland along the west coast of Norway. Current distribution appears to be limited to microclimate conditions in urban areas (compost). Winter temperature is probably the limiting factor for the distribution and the species will likely spread further north with a milder climate.

Parkslirekne *Fallopia japonica*, Japanese knotweed



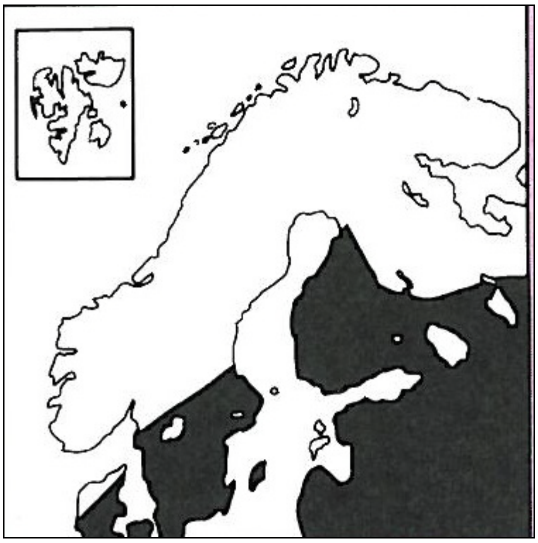
The species has the potential to spread northwards, particularly along the coast, at least up to Nordland. The climate in present range matches well the predicted climate scenarios for Oslo, Stavanger, Lærdal and Trondheim, and for Brønnøysund (summer and winter). For Lillehammer there is good match for summer temperatures..

Kjempebjørnekjeks *Heracleum mantegazzianum*, Giant hogweed



The species has the potential to spread northwards, likely both along the coast and inland, The climate in the present range matches well the predicted climate scenarios for Oslo, Stavanger, Lærdal and Brønnøysund, and for Trondheim (winter and summer). For Lillehammer there is good match with predicted summer temperatures.

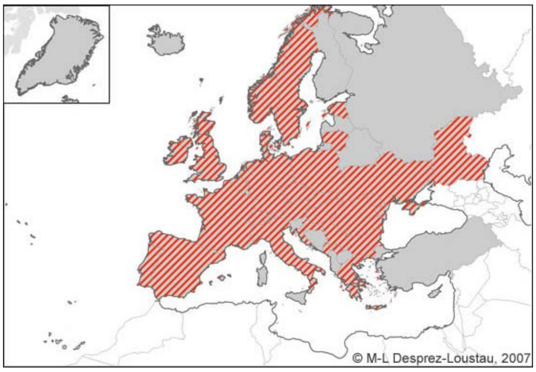
Sørhare *Lepus europaeus,* Brown hare



This species is found in Østfold. It will probably spread northwards with a warmer climate. The climate in the present range fits the predicted climate scenarios for Oslo, Stavanger and Lærdal. Based on the temperature requirements, the species appears to have the potential to spread northwards, along the coast up to Vestlandet.

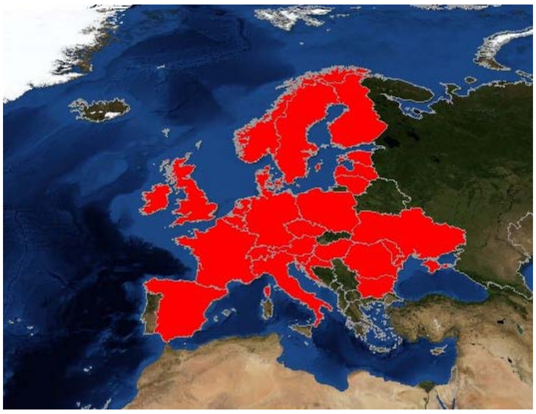
Map from Norges Dyr (Semb-Johansson 1990).

Almesyke *Ophiostoma novo-ulmi*, Elm disease



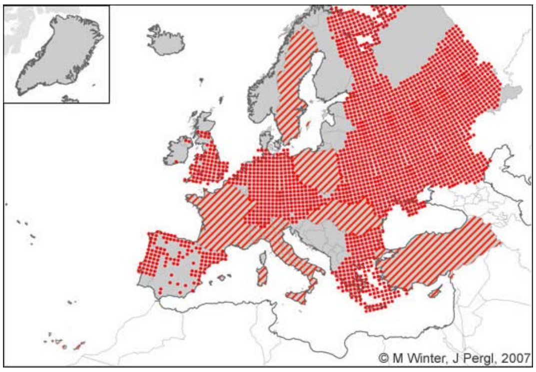
The northernmost distribution range lies south of the northern limit of the *Ulmus* spp. range in Scandinavia (Medelpad, Sweden and Nordland's coast in Norway). It is l ikely that the distribution range will expand to the northern *Ulmus* spp. range limit..

Kanadagullris *Solidago canadensis*



This species has been found once in Nordland county (about 65,50°N). It is, however, common only in the southern part of SE Norway where it is spreading rapidly. The spreading is predicted to continue northwards with a warmer climate.

Robinia *Robinia pseudacacia* L., Black locust



The species has the potential to spread northwards, at least up to Nordland. Climate in present range matches well predicted climate scenarios for Oslo, Stavanger and Lærdal. For Trondheim, it matches well predicted winter and summer temperatures. For Lillehammer and Brønnøysund there is good match for summer and winter temperatures, respectively.

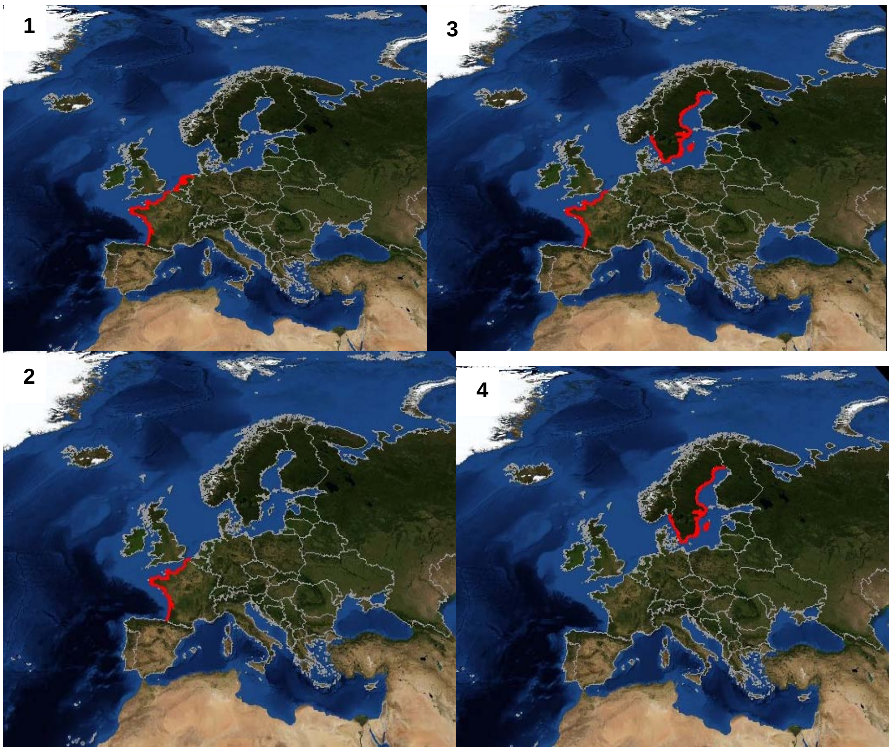
6.2 Door knockers

Legend

	Known in country		Known in CGRS square		Known in sea
	Native in country		Native in CGRS square		Assumed native range

Aquatic marine

(Dinoflagellat) *Alexandrium spp*, Dinoflagellata



1. ***Alexandrium leei***
2. ***Alexandrium angustitabulatum***
3. ***Alexandrium minutum***
4. ***Alexandrium taylori***

All these five marine, planktonic dinoflagellate are associated with toxic paralytic shellfish blooms. With an temperature increase of 1° C, these species are supposed to spread to the Oslofjord area and with an increase of 2° C to the southern west coast of Norway.

(Grønnalge) *Caulerpa taxifolia*, Green tropical seaweed

This species will not reach Norway with a temperature increase of 2° C.

Australsk kalkrørsorm *Ficopomatus enigmaticus*, Australian tubeworm

This species is found in areas with a summer sea surface temperature of 15° C. With an summer sea surface temperature increase of 1° C it will probably reach the southern part of Norway, and with an increase of 2° C it will reach the west coast of Norway.

Engelsk marskgras *Spartina anglica*, Rice gras

This species is found north to Scotland with a summer surface temperature of 14° C. It has not been found in Norway (NOBANIS). If the northern border of its distribution is determined by temperature, it should be found up to the southern west coast of Norway. With a temperature increase of 1° C it could spread to the whole west coast of Norway, and with an increase to 2° C to the Trøndelag coast.

(Kappedyr) *Styela clava*, Stalked sea squirt

This species is found north to Scotland with a summer surface temperature of 14° C. It has not been found in Norway (NOBANIS). If the northern border of its distribution is determined by temperature, it should be found up to the southern west coast of Norway. With a temperature increase of 1° C it could spread to the whole west coast of Norway, and with an increase to 2° C to the Trøndelag coast.

(Mosedyr) *Tricellaria inopinata*, Bryozoa

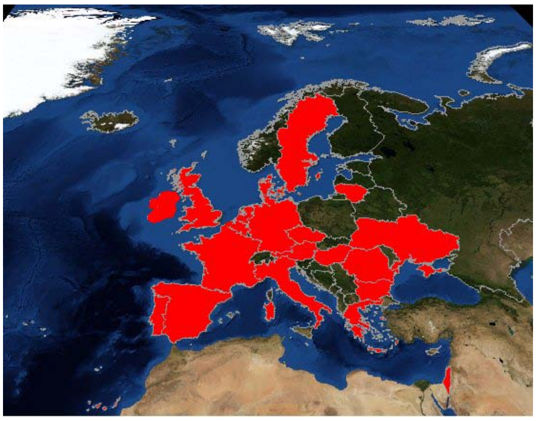
This species is found north to southern England with a summer surface sea temperature of 16° C. It is supposed to spread to the Oslofjord area with a temperature increase of 1° C and to the southern west-coast of Norway with an increase of 2° C.

(Brunalge) *Undaria pinnatifida*, Asian kelp

This species is found north to southern England with a summer surface sea temperature of 16° C. It is supposed to spread to the Oslofjord area with a temperature increase of 1° C and to the southern west coast of Norway with an increase of 2° C.

Aquatic inland

Andematbregne *Azolla filiculoides*, water fern.



The species has the potential to spread northwards, particularly along the coast, at least up to Nordland. The climate in the present range matches well the predicted climate scenarios for Oslo, Stavanger, Lærdal and Brønnøysund. For Trondheim ranges match well predicted summer and winter temperatures. For Lillehammer there is good match for summer temperatures.

(Vannloppe) *Cercopagis pengoi*, Fishhook water flea

This species is distributed in the Baltic Sea with summer temperature of about 14° C. Probably difficult to spread because of to high salinity on the west coast of Sweden, but could be spread to Norway by humans. Mean temperatures in southern Norway are already within the species tolerance range. If spread by humans, it would have the potential to spread to rivers in Vestlandet.

(Musling) *Corbicula fluminea*

The species has the potential to spread northwards, particularly along the coast, at least up to Nordland. The climate in the present range matches well the predicted climate scenarios for Oslo, Stavanger and Lærdal, and relatively good for Brønnøysund. For Trondheim, and Lillehammer there is poor match with predicted annual and annual and winter predicted temperatures, respectively.

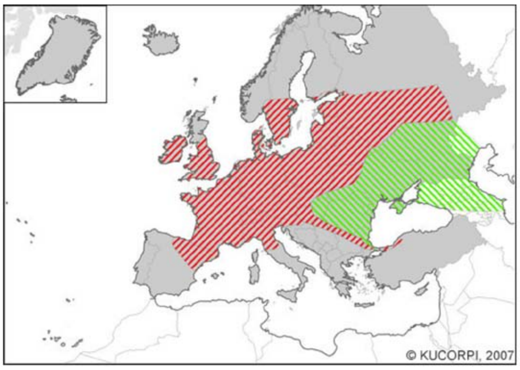
(Vannplante) *Crassula helmsii*, Swamp stone crop.

The species has the potential to spread northwards, particularly along the coast, at least up to Nordland. The climate in the present range matches well the predicted climate scenarios for Oslo, and Stavanger and generally well the predicted climates for Lærdal, Trondheim and Brønnøysund, particularly regarding summer and winter means. For Lillehammer there is good match for summer temperatures.

(Tangloppe) *Dikerogammarus villosus*, Amphipoda

The species has the potential to spread northwards, particularly along the coast, at least up to Trøndelag. The climate in the present range matches well with predicted climate scenarios for Oslo, Stavanger, Lærdal and less well for Trondheim and Brønnøysund.

Vandremusling *Dreissena polymorpha*, Zebra Mussel

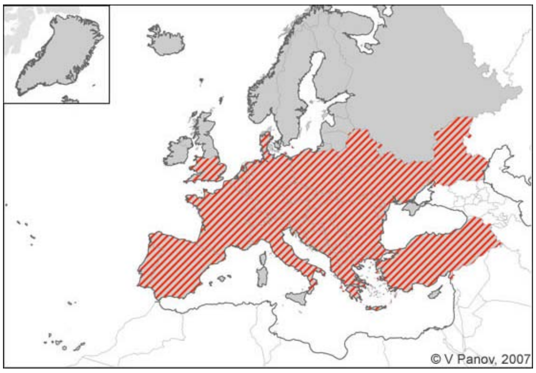


The species has the potential to spread northwards, particularly along the coast, at least up to Nordland. The climate in the present range matches well with predicted climate scenarios for Oslo, Stavanger, Lærdal and Brønnøysund. For Trondheim, the present range climate matches predicted with winter and summer temperatures; and for Lillehammer, only summer temperatures.

(Kutling) *Neogobius melanostomus*, Round goby

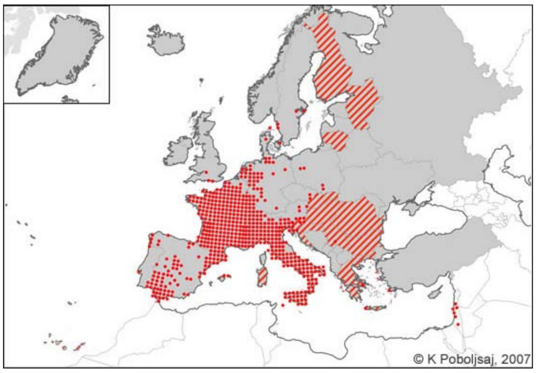
This fish is found in slowly flowing rivers, lagoons, and brackish coastal waters. It is a euryhaline and eurythermic (-1° C to +30° C), so its distribution in Europe today is not determined by temperature. It has the potential of reaching the southern parts of Norway.

(Karpefisk) *Pseudorasbora parva*, Top mouth gudgeon



The species has the potential to spread northwards, particularly along the coast, at least up to Nordland.The climate in present range matches well the predicted climate scenarios for Oslo, Stavanger and Lærdal. For Trondheim and Brønnøysund the range match well with predicted winter temperatures. For Lillehammer there is good match for predicted summer temperatures.

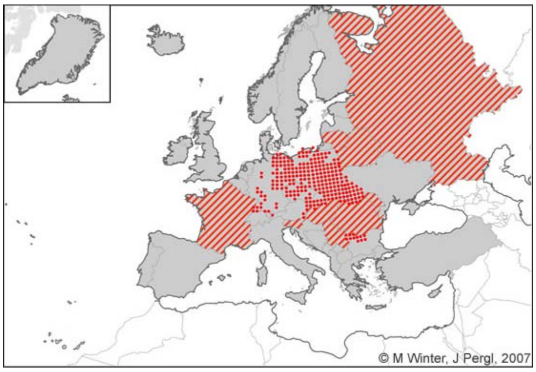
Rødøreterrapin (skilpadde) *Trachemys scripta*, Red-eared slider



The species has the potential to spread (by humans) to the southernmost parts of the country. In general, climate in the present range matches poorly with predicted climate scenarios for all stations. Good matches are for Oslo (annual), Stavanger (annual and winter), and Lærdal and Brønnøysund (winter) predicted temperatures.

Terrestrial

Tagg-gresskar *Echinocystis lobata*, Wild cucumber or Balsam-apple

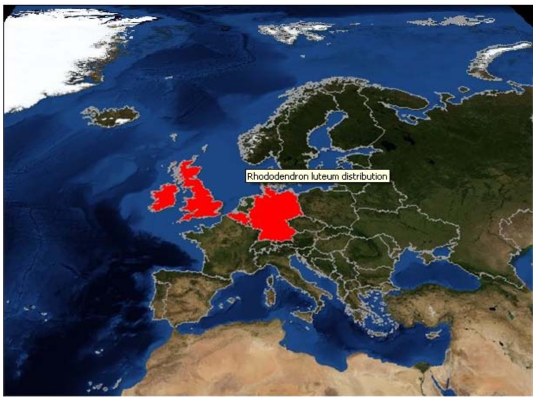


The species has the potential to spread to the sourthernmost parts of Norway. The climate in the present range matches well the predicted climate scenario for Oslo. For Stavanger and Lærdal there is a good match for annual temperatures but relatively poor match for either summer or winter. For Trondheim and Brønnøysund present range climate matches well only with predicted winter temperatures; and for Lillehammer, with summer temperatures.

Argentinamaur *Linepithema humile*, Argentine ant

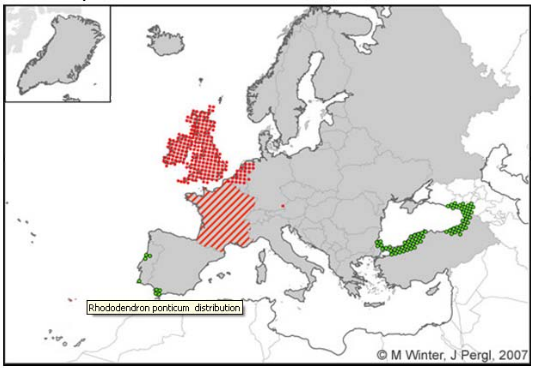
The species has the potential to spread northwards, particularly along the coast, at least up to Nordland. The climate in the present range matches well with predicted climate scenarios for Oslo, Stavanger, Lærdal and Brønnøysund. For Trondheim, the present range climate matches predicted with winter and summer temperatures; and for Lillehammer, only summer temperatures.

Gullasalea *Rhododendron luteum*, Yellow azalea



Climate in present range matches well predicted climate scenarios for Oslo, Stavanger, Lærdal and Brønnøysund, so we predict that the species The species has the potential to spread northwards, particularly along the coast, at least up to Nordland.

Pontisk alperose *Rhododendron ponticum*, Common Rhododendron



The species has the potential to spread northwards along the coast, at least up to Nordland. The climate in the present range matches well with predicted climate scenarios for Oslo and Stavanger, and generally well with predicted climates for Lærdal, Trondheim and Brønnøysund..

The projected increases in temperatures for Oslo show a very good correspondence with the ranges of a large number of species. The good match refers consistently to the three temperature parameters examined, mean annual, winter and summer temperatures. Although not equally good, the correspondence was also high in the case of the climates of Stavanger and Lærdal, and in decreasing order, Trondheim, Brønnøysund and Lillehammer.

For all stations except Oslo, and to a lesser extent Stavanger, there appears to be a mismatch between the areas with current climates in Europe that match the predicted winter and summer temperatures. Predicted summer climates appear to correspond current climate in Central and Eastern Europe, whereas predicted winter climates are more of oceanic type and resemble that of North Western Europe and the British Isles. This mismatch poses an extra challenge to an assessment of potential future distributions since the ability of a species to spread will depend on the season which is the most limiting to the range.

The tendency of the predicted summer climate in most of the stations to resemble the current climate in the British Isles, warns particularly against alien species occurring in this area. The risk of spread appears to be in decreasing order in: Oslo, Stavanger, Lærdal, Trondheim-Brønnøysund, and Lillehammer. The geographical mismatch of predicted climates in winter and summer was most evident for Lillehammer, and this was also the station where the match with current species distributions was lowest.

65 species (41 aquatic and 24 terrestrial) were examined. Of these, 18 are occurring in Norway, and their distributions are predicted to increase as a consequence of global warming. The potential distribution of another 23 species not yet found in Norway were assessed. Of these, 22 species are predicted to find suitable temperatures in Norway in the future. Another 24 species were examined, but not included in the climate scenario assessment, either because their distributions in Norway unlikely are limited by temperature, or they have unknown origin which cannot be ascribed as being native or alien (cryptogenic species).

7 Discussion

This report makes an assessment of the likelihood under climate change of expansion of geographical ranges of a set of alien species in Norway with high priority for national conservation policies and of a series of potential invaders with distribution in Europe but not currently occurring in the country. A series of assumptions made in the assessment set the context under which the results have to be interpreted. First, it is necessary to interpret the results of the “Match Climates” analyses with caution since the highest CMI values between two locations does not necessarily demonstrate biological significance (Sutherst, 2003).

Our first assumption, that macroclimate factors are major determinants of the range, indicates that the predicted distribution would be the potential of the species to establish in areas with a particular climate in the absence of any other constraints to the geographical distribution of the species. For terrestrial organisms, we assumed that only mean temperatures, and not humidity, or other climate related factors such as snow depth, would be the critical factors determining the potential distributions, and we only included average temperatures and not extreme values or climatic variability which are features to which organisms can be highly susceptible (Gaston 2009b). An assumption in the CLIMEX climate match model is that average temperatures adequately describe regional climate differences which are biological relevant and closely correlated with species potential distribution ranges. It assumes therefore that the magnitude of climate variability is comparable for all climates, and therefore, that species occurring in areas with similar climates experience similar extreme temperature events. However, climate variability in Europe does correlate with geographical patterns, e.g. along the oceanic - continental climate gradient (Huntley *et a*l. 2007). Extreme temperature events can be crucial in determining a species ability to establish.

Regarding precipitation, a variable not included in the assessment, apart from possible effects related to the depth and duration of the snow cover (not modeled in CLIMEX), it could be considered that water availability, a critical factor for plants, and probably also for invertebrates, will be of comparatively minor importance in the projected climate scenarios for Norway. However snow cover is probably a factor that can be determinant for the establishment of mammal species (rabbit, raccoon and wild boar in Appendix III), and more important than temperature.

In general, the geographical range of the species which were examined but not included in the climate scenario assessment (Appendix III) appears to be limited by other factors than temperature. Occurrences at high latitudes and/or wide temperature tolerance ranges are indicative of this. In addition to physiological tolerances to the physical environmental, numerous factors contribute to limit the geographic ranges of species. The dispersal capacity of the species appears to be critical (Gaston 2009a). The questions related to dispersal are central to the control of alien species. For example, in the case of the aquatic inland (freshwater) organisms we used the CLIMEX “Match Climates” function in the same way as for the terrestrial organisms, assuming that the summer surface freshwater temperature corresponds closely to the mean summer air temperature. However, freshwater organisms have probably a considerably lower dispersal potential than marine organisms and possibly also lower than terrestrial organisms, but they can be spread by humans. For example, in the case of brook trout, and of other organisms where the dispersal capacity appears to be a limitation to the range (Gaston 2009a), the role of introductions to new areas will be most critical for the expansion of the species.

In a recent review, Gaston (2009a,b) highlights the importance of various factors, acting in interaction, in determining limits of geographical ranges. For example, the tolerance and response to different physiological stress factors can be of importance for the spread of marine organisms. In this case, our assessment was also based only on future temperature scenarios, but the occurrence of most marine organisms are also strongly influenced by water salinity.

Dispersal, migration and source-sink process maintaining population beyond the reproductive ranges, which alone and/or acting in combination with environmental variability can determine expansion of the geographical range (Gaston 2009b). The Pacific Oyster is an example of an aquatic marine organism which has been found further north (Nordland) (Brattgard & Holte 1997, OSPAR 1997, Bevanger 2005) than the area where it can reproduce successfully. It needs at least a summer temperature of 15°C for successful reproduction (Bevanger 2005) so reproduction can occur in southern Norway in warm summers (Figure 5). The oysters sampled in Espevik, Hordaland verify that the Pacific oyster may reproduce in Norwegian waters as far north as 60°N, but most likely, northern populations depend on immigrants from the south. The oyster stocks in Denmark then act as population sources, releasing larvae drifting with coastal currents to Norway (Mortensen *et al.* 2007).

Also patterns related to environmental variability, which will likely be affected by climate change can interact with processes related to migration. For example, some marine organisms occur only in summers with unusual high sea temperatures (Husa et al. 2007, Figure 5). In the future, such warm summers are predicted to be more common.

2005 1997 2002 2006

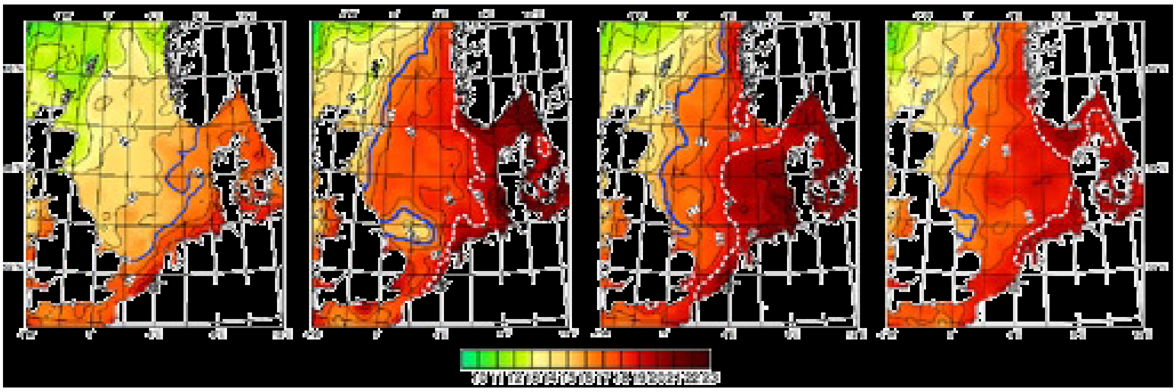


Figure 5. Mean sea surface temperature in a normal summer (august 2005) and three unusually warm summers. The blue line indicates the border for the water masses with normal temperature of 16° C. The white line indicates the border of water masses with normal temperature of 19° C. (after Husa *et al.* 2007).

Trophic interactions are also important determinants of geographical ranges (Gaston 2009b). In our assessment, trophic interactions are evident in the case of parasitic species and diseases. In the case of the species causing elm disease, its current range could potentially occur further north since the host species has at present a higher northern range, so temperature appears to be the limiting factor. This conclusion is strengthened by the fact that the magnitude of the outbreaks appears to be limited by temperature. In contrast, the distribution of *Gyrodactylus* could potentially be distributed at higher latitudes with no limitation of host species or in the dispersal or colonization capacity, but the occurrence of host species appears to be a limitation to the occupation range.

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8 Appendices

Appendix I: Distributions of species already occurring in Norway, which are examined with respect to climate change scenarios. DAISIE: Delivering alien invasive species inventories for Europe database www.europe-aliens.org , NOBANIS: North European and Baltic network on invasive alien species database www.nobanis.org ; NIBC: Norwegian Biodiversity Information Centre www.biodiversity.no .

Taxon	Distribution	Status - Trend	Ecological requirements	Source
Aquatic marine				
Alexandrium tamarense Phylum:Dinophyta. Class: Dinoflagellata **(Dinoflagellat)**	Established, rare in Norway			NOBANIS
Crassostrea gigas. Phyllum: Mollusca Class: Bivalvia **Pacific oyster** (**Stillehavsøsters)**	In northern Europe wild settlements now occur where before their populations were sustained by hatchery production. Found along the coast north to Nordland.	Recent recruitment in the southern North Sea, resulting from increases in summer temperatures, has led to habitat changes.	Tolerant of a wide temperature (3 – 35 °C). Needs 15-30°C for successful reproduction. Therefore reproduction occurs only in hot summers in Norway (Bevanger 2005).	DAISIE
Ensis americanus (Syn. *Ensis directus*). Phylum: Mollusca. Class: Bivalvia **American razor clam (Amerikansk knivskjell)**	Origen North America. In Europe, see distribution map. First record in Germany 1978, spread rapidly in the southern North Sea countries: around the North Sea coast of Denmark and The Netherlands, first record in Norway in 1989. Established, rare.	Increasing	Found in marine and estuarine areas and tolerates relatively low salinities. However low winter temperatures seem to limit the development. Occupy free niche of clean sand in lower intertidal flats.	DAISIE NOBANIS
Eriocheir sinensis. Phylum:	Origen: From Vladivostock to South China.	Continue to spread	Littoral and sub-littoral rock and other hard substrata.	DAISIE

Arthropoda. Class: Malacostraca. **Chinese mitten crab** (**Ullhåndskrabbe**)	In Europe, see distribution map. Found in all North and Baltic Seas countries, and the Atlantic seaboard of Europe. Found in Glomma in Østfold in 1977. Later found 10 km up-stream in the same river. Not established in Norway (NOBANIS)	and new records are reported each year, predominantly in northern Europe	Surface running waters. Littoral zone of inland surface water bodies. Larger estuaries and adjacent waters. Due to its inland migration it colonizes lakes and streams hundreds of kilometers from the sea. Both marine and inland waters.	
Heterosiphonia japonica. Phylum: Rhodophyta **(Rødalger)** (**Japansk sjølyng, japansk strømgarn**)	Origin Asia. In Europe, see distribution map. Found in Norway (Oslofjorden) and other NOBANIS countries.	Rapid spread		Alien Species Database and DAISIE
Marenzelleria neglecta. Phylum: Annelida. Class: Polychaeta **Red-gilled mud worm (Marin flerbørsteorm)**	Found in Sweden and other NOBANIS countries	Competes with native benthic macrofauna for food and space. Increasing	Larval development largely depends on water temperature and lasts about 4 to 12 weeks	DAISIE
Mnemiopsis leidyi. Phylum: Ctenophora (**ribbemaneter**), Class: Tentaculata **American comb jellyfish (Ribbemanet)**	Origen North America. In Europe, see distribution map: Azov, Black, Caspian, North sea and other NOBANIS countries. Found in Oslofjorden in 2005.	Unknown.	Temperature most important limiting factor from 6°C in winter to 31°C (??) in summer. It is invading waters of salinities ranging from 0,3% to 3,9 % in eastern Med.	DAISIE
Sargassum muticum. Phylum: Chromophycota (**Brunalger**), Class: Phaeophyceae **Wireweed (Japansk drivtang)**	In Norway up to Sognefjorden.	Further spread northwards will be limited by low summer temperatures,	Sheltered hard-bottoms, but also hard substrates on soft-bottoms, It tolerates a wide range of abiotic conditions. Low temperature and ice-scour may be inhibiting factor. It can survive long periods with water temperatures of -1.4°C. Hypothetical northern limit for its distribution along the western coast of Norway might be at about 66°N. A further spread northwards will be limited by low summer temperatures, as *S. muticum* requires a temperature of more than 8°C for at least four months to reproduce.	NOBANIS

Aquatic inland				
Aphanomyces astaci. Phylum: Heterokontophyta, Class: Oomycetes (**eggsporesopp**) **Crayfish plague,** (**Krepsepest**)	From North America. In Europe, see distribution map. Found in Norway and other NOBANIS countries.	Increasing	Parasitic, as for host.	DAISIE
Cyprinus carpio. Class: Actinopterygii. Family: Cyprinidae **Carp (Karpe)**	Origen: Eurasia from Black Sea to Manchuria. In Europe: Central and Northern Europe, Italy, Baltic countries, Fennoscandia, see distribution map. In Norway introduced in the 16th century in Agder, Vestfold, Kragerø, Farsund and in the area of Bergen. Later in several water bodies in Østlandet including the Mjøsa lake.		Shallow, warm water bodies with vegetation. Reproduces with water temperatures 17-20^{o}C. Due to winter temperatures, it is unlikely that *C. carpio* can establish north of 60^{o}N.	DAISIE, Jonsson & Semb-Johansson 1992
Elodea Canadensis. Division: Spermatopsida. Family: Hydrocharitaceae (**Froskebitfamilien**) **Pondweed** (**Vasspest**)	In Europe see distribution map. First European record Ireland in 1836, found in Norway and other NOBANIS countries	After a rapid colonization of northern Europe the populations declined Stable	Shallow lakes, ponds, pools, ditches and streams with slow moving water.	DAISIE
Terrestrial				
Arion lusitanicus (syn. *A. lusitanicus*). Phylum: Mollusca. Class: Gastropoda **Spanish slug** (**Iberiasnegl**)	From Spain through Europe, Scandinavia, Iceland. Found in Norway and large parts of central and the southern part of northern Europe.	Increasing in abundance,distributional and altitudinal range	Broadleaf deciduous woodland	DAISIE

Fallopia japonica. (syn: *Polygonum cuspidatum*) Division: Spermatopsida. Family: Polygonaceae (**Skjermplanter**) **Japanese knotweed.** (**Parkslirekne**)	In Europe, see distribution map. Invasive in most European countries, common in Norway	The hybrid variety is competitive and is spreading at a faster rate in Central Europe Simulations of the potential distribution of *F. japonica* under climate change scenarios indicate the likelihood of considerable spread into higher latitudes	Mesic, seasonally wet and wet grasslands, riverine and fen scrubs, hedgerows. Knotweeds invade disturbed habitats and thrive on a wide range of soils, with pH ranging from 3 to 8..	DAISIE and Beerling *et al.* 1995
Heracleum mantegazzianum. Division: Spermatopsida. Family: Apiaceae (**Skjermplanter**) **Giant hogweed** (**Kjempebjørnekjeks**)	In Europe, see distribution map. Found in Norway and other NOBANIS countries.	Unknown	Native to mountain meadows below tree line, alpine and subalpine grasslands, woodland fringes and clearings and tall forb habitats.	DAISIE
Lepus europaeus Class: Mammalia. Family: Leporidae **Brown hare** (**Sørhare**)	Throughout Europe, up to southern Sweden. In Norway in Østfold county.	?	Found in cultural landscape	Alien Species Database
Ophiostoma novo-ulmi. Division: Ascomycota (**Sekksporesopper**). Class: Sordariomycetes (**Kjernesopper**) **Elm disease** (**Almesyke**)	Recorded occurrences throughout Europe, Norway and other NOBANIS countries.In Norway Oslo-fjord and up to Kristiansand. In Sweden, northemnost range in the area of Mälardalen. The northernmost distribution range lies to the south of the north limit of the distribution of *Ulmus* spp.in Scandinavia (Medelpad, Sweden and Norland's coast in Norway).	Climate warming might favour its northwards expansion	Host trees include all the Euro-American native elms. Occurs in woodland, forest and other wooded land, cultivated areas of gardens and parks. Disease expression strongly correlated with temperature and number of sunshine hours, levels of defoliation greatest for mean air temperature above 17°C and 5-7 hours sunshine.	DAISIE

Robinia pseudacacia Family: *Fabaceae* (Ertefamilien) **Black locust, False acacia**	North American species. Found in Sweden and other NOBANIS countries. Found in Østfold, Vestfold, Telemark.	Once introduced in an area, the tree expands rapidly, outcompeting field layer vegetation.	Grows well in full sun and well-drained soils, and it is drought tolerant.	DAISIE NOBANIS
Solidago canadensis. Family: Asteraceae (**Korgplantefamilien**) (**Kanadagullris**)	Origen: North America. From Spain through western Europe, Fennoscandia and NOBANIS countries, the Bristish Isles. In Norwayit has been found once up to about 65,5^{o} N, the species has scattered records at about 63^{o} N. It is common only in the southern part of SE Norway where it is spreading rapidly.	Spreading rapidly in the Southern parts of Norway	Disturbed sites along railways, on roadsides, abandoned fields, as well as in forest edges, open forests, on banks of rivers and natural shore communities. Different soil and moisture conditions.	NOBANIS

Appendix II: Species occurring in neighboring countries but not in Norway (door knockers) examined with respect to climate change scenarios. DAISIE: Delivering alien invasive species inventories for Europe database www.europe-aliens.org , NOBANIS: North European and Baltic network on invasive alien species database www.nobanis.org ; NIBC: Norwegian Biodiversity Information Centre www.biodiversity.no

Taxon	Distribution	Ecological risks	Status - Trend	Ecological requirements	Source
Aquatic marine					
Alexandrium spp. Phylum:Dinophyta. Class: Dinoflage-llata (4 species) **(Dinoflagellat)**	North sea, found near Norway.	Produce paralytic shellfish poisoning (PSP) toxins, can affect humans, other mammals, fish and birds	Increasing abundance in the Mediterranean Sea	Coldwater species seldom found at temperatures over 12°C	DAISIE
Caulerpa taxifolia. Division: Chlorophyta **Green tropical sea-weed (Grønnalge)**	Mediterranean sea.	Outcompete native species	Rapid spread from 1984 to 2000		DAISIE
Ficopomatus enigmaticus Phylum: Anne-lida. Class:Polychaeta **Australian tubeworm (Austr. kalkrørsorm)**	Found in Sweden and other NOBANIS countries	Can impact native communities	May extend further northwards with sea warming.	Requires 18°C to reproduce, warm areas will have prolonged periods of reproduction	DASIE
Spartina anglica. Division:Spermatophyta, Graminae **Rice grass (Engelsk marskgras)**	Found in Sweden, Denmark and other NOBANIS countries	It is recognized as an important environmental modifier	Spreading		DAISIE
Styela clava. Phylum: Chordata. Class: Ascidiacea (**Sekkdyr**) **Stalked sea squirt** (**Kappedyr**)	Found in Sweden and other NOBAnIS countries	Compete with native species	Spreading	Tolerates temp from –2 to 23°C	DAISIE
Tricellaria inopinata. Phylum: Bryozoa (**Mosedyr**).	Found in Belgium , the Netherlands.	Can cause reduction in frequency and abundance of	It seems to form rapidly expanding populations	Tolerates temp from 2-3°C to 34.5°C	DAISIE

Family: Candidae.					
Undaria pinnatifida. Class: Phaeophyceae (**Brunalg-er**) **Asian kelp, Wakame (Brunalge)**	Found in Sweden and other NOBANIS coun-tries	In some regions it is the dominant seaweed and several co-occurring species decrease when it becomes abundant.	Spreading	Optimal growth at 20°C, may survive -1 to 30°C.	DAISIE
Aquatic inland					
Azolla filiculoides. Class: Pteridopsida (**bregner**) **Water fern, Mosquito fern (Andematbregne)**	Found in Sweden and other NOBANIS coun-tries	Forms dense monospecific mats, can affect the water by eliminating submerged plants and algae	Spreading	Optimum growth at 15-20°C, can tolerate field temp of – 10 to – 15°C	NOBANIS
Cercopagis pengoi. Su-perclass:Crustacea. Supe-rorder:Cladocera **Fishhook water flea (Vannloppe)**	Found in Sweden and other NOBANIS coun-tries	Potential competitor with young stages of planktivorous fish for her-bivorous zooplankton	Increasing	Euryhaline species. Summer temperature 15 and 17°C, au-tumn temp above 8°C.	DAISIE
Corbicula fluminea. Phyl-lum: Mollusca Class: Bi-valvia **Asian clam (Musling)**	Found in other NOBANIS countries	Compete with native species	Spreading	Tolerates 2-34°C	DAISIE
Crassula helmsii. Order: Saxifragales. Family: Crassulaceae **Swamp stonecrop, New Zealand pygmyweed (Vannplante)**	Found in several NOBANIS countries	Forms dense marginal and floating mats that can shade-out other water plants and result in oxygen deple-tion of the underlying water causing a decline in invertebrates, frogs, newts and fishes.	Spreading	Tolerates temp from –6 to 30°C	DAISIE
Dikerogammarus villosus. Subphyllum: Crustacea. Order: Amphipoda **(Tangloppe)**	Almost all Western Eu-rope large rivers (Rhône, Loire, Seine,Moselle, Meuse,	It locally eliminates other gammarid species through competition and predation. There have been some observations of the species eating	Spreading	Broad spectrum of temperatures (0 to 30°C)	DAISIE

	Rhine, Main, Danude) and Baltic Sea basin.	fish eggs or attacking small fishes.			
Dreissena polymorpha. Phyllum: Mollusca. Class: Bivalvia **Zebra mussel (Zebra-musling, vandremusling)**	Found in Sweden and other NOBANIS coun-tires	Competes for space and food with native mussels and other filter-feeding organisms	Further range expansions are expected in temperate latitudes of the Northern Hemisphere	Tolerates temperatures from -2 to 40°C, best growth is observed at 18-20°C	DAISIE
Neogobius melanostomus. Phylum: Chordata. Class: Actinopterygii (strålefinne-fisker). Family: Gobiidae **(kutlinger**) **Round goby (Kutling)**	Found in many NOBANIS countries	Decrease species richness of native fish	It is increasing in the Baltic Sea area	Tolerates temp from -1 to +30°C	DAISIE and NOBANIS
Pseudorasbora parva. Class: actinopterygii*.* Family: Cyprinidae **(karpe-fisker) Topmouth gudgeon (Karpefisk)**	Found in many NOBANIS countries	It competes for food with farmed fish species	Spreading	Minimum tem for reproduction is 15-19°C	DAISIE
Trachemys scripta. Class: Sauropsida. Order: Testu-dines (**Skilpadder**) **Red-eared slider** (**Rødøret terrapin**)	Found in Sweden and other NOBANIS coun-tries	Sliders feed on several species of plants and animals, from insects and other invertebrates to all verte-brates, including amphibians and reptiles, small mammals and birds.	Distribution poorly known, every year new records are reported in most European countries.	For a sound hibernation in win-ter, clean waters with sufficient amounts of oxygen are needed.	DAISIE
Terrestrial					
Echinocystis lobata. Fami-ly: Cucurbitaceae **Wild cucumber, Wild balsam-apple (Tagg-gresskar)**	Found in temperate and continental Europe. Found at Larvik, Vest-fold in 1996, but not established in Norway.	This vine branches very fast, cover-ing large areas and overgrowing native vegetation. Its spatial occu-pation competes with native species	There has been increasing invasion within the last twenty years along the main rivers, in floodplains from Western to Eastern Europe	The plant is often damaged by late and early frosts	DAISIE Lid & Lid (2005)

*Linepithema humile.*Class: Insecta*.*Order. Hymenoptera **Argentine ant (Invasjonsmaur)**	The species occurs throughout the world on all continents, especially in mediterranean-type climates, and many oceanic islands. Has been found indoors in Sweden.	Has displaced, even leading to species extinction in some cases, native ant species in many parts of the world	Ecological niche models predict that with changing climate the species will expand at higher latitudes	Moderate temp	DASIE
Rhododendron luteum. Family Ericaceae. **Yellow azalea (Gullasalea)**	Origen: Southeastern Europe and southwest Asia.	Widely cultivated in western Europe, locally naturalised in western and northern Europe. In Britain it has colonized many wet heaths and bogs.			DAISIE & Wikipedia
Rhododendron ponticum. Family Ericaceae. **Common Rhododendron (Pontisk alperose)**	Origen: Southern Europe and S-W Asia. Native range, a disjunct distribution. Ssp *baeticum* is found in southwest Spain and southern Portugal, ssp *ponticum* found in Turkey, Lebanon, Bulgaria and the Caucassus.	Naturalised in the UK, Ireland, Belgium, France and Netherlands. Present in Austria. There is an increasing invasion in continental Europe.	Mixed deciduous forest. Temperate heaths, raised and banked bogs. Tolerant to a wide range of temperatures but intolerant to drought. It grows best in uniformly damp climates. Establishment of seedlings is best in disturbed areas.		DAISIE

Appendix III: Species examined but not included in the climate scenario assessment. DAISIE: Delivering alien invasive species inventories for Europe database www.europe-aliens.org , NOBANIS: North European and Baltic network on invasive alien species database www.nobanis.org ; NIBC: Norwegian Biodiversity Information Centre www.biodiversity.no ; Cryptogenic species: *Species of unknown origin which can not be ascribed as being native or alien (DAISIE*, Cross-taxon and biome definitions of alien species status and related terms).

Taxon	Distribution	Status - Trend	Ecological requirements	Source	Justification
Aquatic marine					
Balanus improvises. Subphylum: Crustacea. Class: Maxillipoda **Bay barnacle (Brakkvannsrur)**	Most of Norwegian coast line up to Lofoten and NOBANIS area	Spreading	Temp 0 to 30°C Optimal temp 14°C	DAISIE	Distribution in Norway unlikely limited by temperature
Chattonella aff. Verruculosus Class: Raphidophyceae **Planctonalgae** (**Encella alge)**	Found in south eastern Norway, in the Skagerrak region with highest concentrations along the west coast of Sweden, observed in the Kattegat.	Unknown whether it is alien or not. Different species from *C. verrucułosus* occurring in Japan.		DAISIE	Cryptogenic species
Cordylophora caspia. Phylum: Cnidaria. Class: Leptolida **Hydroid**	In Europe, see distribution map. Found along most of Norwegian coast north to Nordland. Introduced into the Baltic Sea in early 1800s; spread rapidly to inland waters and estuaries of Europe	Established	Brackish coastal lagoons. Colonies tolerate 5 to 35°C, and reproduce between 10 to 28°C. It can also survive between 0 to 35 ppt as resistant stages. Usually found in water of 1-2 ppt where tidal influence is considerable, or between 2 – 6 ppt where conditions are constant. It may also occur at full salinities	DAISIE	Distribution in Norway unlikely limited by temperature
Coscinodiscus wailesii Division: Bacillariophyta, class: Coscinodiscophyceae	Observed from the Atlantic coast of France to Norway (Sognefjord). First detected in Europe	Unknown.	Pelagic water column. Occupies the upper water layers in coastal waters and also offshore. Wide tolerance to	DAISIE	Distribution in Norway unlikely limited by temperature..

Diatom (kiselalge)	near Plymouth in 1977, Norway by 1979, all along the Atlantic coast		temperature (0-32 °C), salinity (10 – 35 PSU) and nutrients		
Crepidula fornicate Phylum: Mollusca. Class: Gastrapoda **Common Atlantic Slippersnail (Tøffelsnegl)**	From northern Spain, French Atlantic coast, southern England, North sea Swedish Western Coast and southern Norway (Olsofjorden to Hadeland, common). Also found in other NOBANIS countries.	Gradually expanding.	Sub littoral rock and other hard substrata, also sub littoral sediments. It can survive light frosts and in temperatures up to ~30°C, and can endure turbid and brackish water	DAISIE	Distribution in Norway unlikely limited by temperature.
Fucus evanescens. Division: Phaeophycophyta (**Brunalger**) (**Gjelvtang**)	Found from Skagerrak to Finnmark (Brattgard & Holte 1997).	Considered not invasive in Norway and Germany, potentially in Sweden.		Alien Species Database	Distribution in Norway unlikely limited by temperature.
Neogobius melanostomus. Phylum: Chordata. Class: Actinopterygii **(strålefinnefisker)**. Family: Gobiidae **(kutlinger)** **Round goby**	See distribution map. Black, Caspian and Azov Sea. Baltic and North Sea basins	Increasing in the Baltic Sea area.	It is a euryhaline and eurythermic species. Found in Kaidak and Mertvyi Kultuk bays at salinity 20.0-36.9‰. The water temperature varies from -1°C to +30°C, although the fish is less active at temperatures below 6°C.	DASIE	Distribution in Norway unlikely limited by temperature.
Odontella sinensis. Division: Bacillariophyta, Class:Coscinodiscophyceae **Diatom algae (kiselalge)**	From French Atlantic Coast to Central Norway. Skagerrak and Kattegat First found in Danish waters of the Skagerrak in 1903, spread to the North Sea	Stable.	Pelagic column. Common at water temperatures of 2 to 12 °C and salinities from 27 to 35 ppt. Temperatures of 1 – 27 °C and salinities of 2 – 35 ppt may be tolerated	DAISIE	Distribution in Norway unlikely limited by temperature.

Polysiphonia harveyi. Division: Rhodophyta **Red algae (Rødalger)**	Ireland, established in Sweden. Not reported as alien in other NOBANIS countries, cryptogenic species. Secondary spread from neighbouring countries.			Alien Species Database, DAISIE and NOBANIS	Cryptogenic species.
Aquatic inland					
Gyrodactylus salaries. Phylum: Platyhelminthes (**Flatormer**). Class: Trematoda (**Gyro, lakseparasitten**)	Found in NOBANIS countries. In Norway up to Skibotnelva in the province of Troms.	Spreading.		DAISIE	Distribution in Norway unlikely limited by temperature.
Salvelinus fontinalis. Class: Actinopterygii. Family: Salmonidae **Brook trout** (**Bekkerøye**)	In Europe it is present in 20 countries from Spain in the south to Norway in the North From Spain through Europe, Scandinavia	Increasing its area through reproduction and secondary spread.		DAISIE	Distribution in Norway unlikely limited by temperature.
Terrestrial					
Abies alba. Class: Pinopsida. Family: Pinaceae **European Silver Fir (Edelgran)**	Origen: Central Europe, northern limit southern part of Poland. In Norway, northernmost record at Lofoten			NIBC	Distribution in Norway not likely limited by temperature
Branta canadensis. Class: Aves.	Established in eleven countries in	Increasing in several	Coastal habitats, inland surface	DAISIE and	Distribution in Norway unlikely

Family Anatidae (**Andefugler**) **Canada goose** (**Kanadagås**)	northern Europe, and across north-central Europe from Belgium east to Russia. In Sweden large part of the country except in the North and along the Norwegian border. In Finland along coast. In Norway along the coast up to ca. Bodø.	northern, central, and western European countries.	water habitats, grassland and tall forb habitats, heath land, scrub and tundra habitats, regularly or recently cultivated agricultural, horticultural and domestic habitats.	NIBC	limited by temperature.
Bunias orientalis. Family: Brassicaceae (**Korsblomstfamilien**) **Warty cabbage** (**Russekål**)	From France through central Europe, the Balkans, the Baltic countries Fennoscandia and the British Isles. In Norway northernmost records in Satldal in Nordland.	Spreading.	Woodland, sunny edges of forests and riverbanks In the new range it occurrs on grass fields, roadside verges, ruderal and gardens. It can invade dry grasslands, especially neglected dry meadows. It may also be found along railways, on fallow lands and in floodplain meadows.	NOBANIS and DAISIE	Distribution in Norway unlikely limited by temperature.
Erinacus europaeus. Class: Mammalia, Family: Erinaceidae **European hedgehog (piggsvin)**	Western Europe and west Russia. In Norway north to Bodø.				The distribution in Norway is determined by human introductions. By warmer climate, they could live further north. High mortality by road kill is probably the main regulating factor.
Heracleum persicum. Family: Apiaceae. (**Skjermplantefamilien**) **Golpar,** (**Tromsøpalme**)	Very common in Norway, common in Finland and local in Sweden.	Introduced to the North of Norway in the 19th century, spreading to Nordland and central Norway. Considered invasive in Norway, Sweden and Finland.		NIBC and NOBANIS	Distribution in Norway unlikely limited by temperature.

Impatiens glandulifera. Division: Spermatopsida Family: Balsaminaceae (**Springfrøfamilien**) **Himalayan Balsam** (**Kjempespringfrø**)	Origen: Western Himalaya and India (up to 4000 masl). In Europe, Central Europe & UK, Records from Spain through Norway & Finland. Northernmost range, Tromsø. Found invasive to almost all temperate European countries	Due to climatic changes expected to move its boundaries northwards and to higher elevations Higher temperatures can increase populations, but the species occurs already distributed at northern latitudes.	Usually grows in riparian habitats and in other disturbed places with good water and nutrient supply.	DAISIE	Distribution in Norway unlikely limited by temperature.
Lupinus polyphyllus Family: Fabaceae (**Ertefamilien**) **Lupin**, (**Hagelupin**)	Origen: North America. In Europe, from Spain throughout Europe incl. Fennoscandia, the Baltic countries, and the British Isles. In Norway in the whole country.	Spreading. The species is already distributed in northern latitudes.		NOBANIS and NIBC	Distribution in Norway unlikely limited by temperature.
Oryctolagus cunniculus. Class: Mammalia*.* Family: Leporidae **European rabbit** (**Kanin**)	Throughout Europe, up to southern Sweden. In western Norway, at present feral population on only one island.	Likely limited by climate (snow depth) but not by temperature.		NIBC	Likely limited by climate (snow depth) but not by temperature.
Picea sitchensis. Class: Pinopsida. Family: Pinaceae **Sitka spruce (Sitkagran)**	Origen: West coast of North America, Alaska. In Norway, along the coast, northernmost limit in Troms province.	The species is already distributed in northern latitudes.		NIBC	Distribution in Norway unlikely limited by temperature.
Pinus mugo ssp. *uncinata* and *Pinus mugo* ssp. *Mugo*. Class: Pinopsida. Family: Pinaceae **Mountain pine (Bergfuru and**	Origen: High altitudes in south and central Europe, the Alps and Carpathian. In Norway through-	The species is already distributed in northern latitudes.		NIBC	Distribution in Norway unlikely limited by temperature.

Buskfuru)	out the country.				
Procyon lotor. Order: Carnivora. Family: Procynidae **Northern raccoon (Vaskebjørn)**	Found in many NOBANIS countries. Escaped animals have been established in Germany and some other countries, but not in Denmark and Sweden	Expansion towards South and East Europe, expected to expand its range in the already invaded countries very quickly.	In Europe it is often observed in Oak forests with nuts and hole trees. It can also live in urbane areas.		Its climatic range is very large, surviving harsh winters and desert like conditions. The distribution is therefore perhaps not regulated by temperature
Rosa rugosa. Division: Spermatopsida.Family: Rosaceae (**Rosefamilien**) **Japanese rose** (**Rynkerose**)	Central Europe and British Isles. In Norway, coast and fjords in south and Central region. Northernmost distribution, recorded in Tromsø.	Increasing. Higher temperatures can increase populations, but the species occurs already at northern latitudes.	Coastal dunes and sandy shores, rock cliffs, ledges and shores, including the supralittoral, woodland fringes and clearings and tall forb stands, temperate shrub heathland, hedgerows. It can colonize acidic and basic soil alike, and is able to invade nutrient-poor habitats.	DAISIE and NIBC	Distribution in Norway unlikely limited by temperature.
Sus scrofa. Class: Mammalia. Family: Suidae **Wild Boar** (**Villsvin**)	Several observations close to the Swedish border in Østfold county. Population in Sweden is increasing rapidly.		In forests and cultural landscape	NIBC	Distribution in Norway unlikely limited by temperature.

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