State of biodiversity in the Nordic countries

An assessment of progress towards achieving the target of halting biodiversity loss by 2010

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Authors: Bo Normander, Gregor Levin, National Environmental Research Institute of Denmark. Ari-Pekka Auvinen, Finnish Environment Institute. Harald Bratli, Norwegian Forest and Landscape Institute. Odd Stabbetorp, Norwegian Institute for Nature Research. Marcus Hedblom, Anders Glimskär, Swedish University of Agricultural Sciences. Gudmundur A. Gudmundsson, Icelandic Institute of Natural History.

Nordic Council of Ministers
Store Strandstræde 18
DK-1255 Copenhagen K
Phone (+45) 3396 0200
Fax (+45) 3396 0202

Nordic Council
Store Strandstræde 18
DK-1255 Copenhagen K
Phone (+45) 3396 0400
Fax (+45) 3311 1870

www.norden.org

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Preface

This report presents the main findings of the project Nordic Biodiversity Indicators 2010 (NordBio2010). NordBio2010 aims to evaluate the target of 'halting the loss of biodiversity by 2010' by developing relevant indicators for the state and trends of biodiversity in the Nordic countries. Compared to other countries, the Nordic countries have a relatively good source of biodiversity data. However, lack of uniformity in monitoring programmes, methodologies as well as in temporal and geographical resolution poses challenges for collection and analysis of available data series and their compilation into useful indicators that can be used in all countries.

The importance of the present work is that for the first time a number of important contributions on possibilities and methodologies for developing indicators are brought together to show how the quality and quantity of major Nordic ecosystems develop over time. The project can be seen as an initial step towards a process in which biodiversity data is collected and monitoring programmes targeted in order to quantify the state of biodiversity in the Nordic countries. The report suggests indicators and evaluates trends and developments in biodiversity in relation to the common target of halting biodiversity loss by 2010. It is, however, apparent that more information could be gathered if further research was carried out involving collection and evaluation of already existing data and development of common methodologies for monitoring biodiversity. Moreover, the marine environment has not been covered in this project.

NordBio2010 was supported by grants from the Nordic Council of Ministers and the National Environmental Research Institute in Denmark. The project has been carried out by a project group consisting of researchers from Finland, Sweden, Norway, Iceland and Denmark (lead). The authors wish to thank the following biodiversity researchers and experts for generous contributions to the project:

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The project's website has the address: http://nordbio2010.dmu.dk

In December 2008, the report was sent in consultation to a number of national biodiversity researchers, civil servants and NGOs in the Nordic countries. Final editing of the report was concluded on 3 February 2009.

Summary

The aim of the NordBio2010 project is to evaluate the 2010 biodiversity target by developing indicators that can describe changes in biodiversity over time in the Nordic countries. We have developed a simple concept to clarify the use of biodiversity indicators; a concept that can describe both the *quantity* and *quality* dimensions of biodiversity. Changes in quantity are measured as trends in the area of pre-defined habitats or ecosystems (such as forest, grassland or inland water bodies). Changes in quality are measured as species abundance trends and, when applicable, as other habitat quality parameters, such as trends in the proportion of old trees in forests or grazing pressure on grasslands.

In order to measure changes in biodiversity quantity, we have developed a common Nordic habitat classification system that defines a range of ecosystem types. At the 1st level we have defined 10 major habitat types, which at the 2nd level are divided into 27 sub-types. The classification at the 1st level is based on well-defined criteria, including the type and degree of vegetation cover, the type of underlying substrate as well as human influences, such as agricultural management practice. The division into subtypes at the 2nd level is based on a less stringent evaluation of various criteria relevant in a Nordic context. To measure biodiversity quality we have identified a range of species abundance indicators and other quality indicators for each of the main habitat types, and when data sources were sufficient these indicators have been calculated and presented. Based on the concept of measuring both quantity and quality, a two-dimensional biodiversity index can be computed, and such indices are presented for those of the main habitat types (such as farmland, mire and forest) where adequate data exist.

Key messages

- ☹ Our results show that biodiversity has declined in the Nordic countries since 1990.
- ☹ It is highly unlikely that the target of halting biodiversity loss by 2010 can be met in the Nordic countries.
- ☺ If further efforts are directed towards analysing existing data sources, additional indicators can be constructed and hence a better knowledge base can be achieved.
- ☺ We recommend that future nature and biodiversity monitoring be increasingly coordinated at a Nordic level.

Our results comprise the most comprehensive documentation of land use in the Nordic countries to date. Based on recent and historic data sources we have been able to deduce key trends in land use. The results show that the area of important nature types such as mire, grassland and heathland have decreased significantly over the past one to two decades, whereas the area of constructed habitats, including city areas and transport networks, has grown considerably in all of the Nordic countries. Each of these individual trends will cause the quantity of biodiversity to decline. On the positive side, however, a slight increase in the area of forest may count as the only trend in land use that may have a positive impact on biodiversity.

Looking into the quality aspect of biodiversity, our results reveal that two-thirds of the quality indicators presented show declines and the remaining one-third show improvements (or steady-state). While all of the quality indicators for farmland, mire and grassland show declines in biodiversity, the indicators for constructed and coastal habitats, inland water and forest reveal both positive and negative trends in biodiversity. However, none of the main habitat types exclusively shows improvements. The majority of the species indicators are based on bird populations. Even though birds generally are believed to be highly relevant indictors for biodiversity, they clearly represent only a corner of biodiversity. However, bird species are the best monitored group in the Nordic countries and therefore constitute the best assessment tool for biodiversity. A limited number of population trends also exist for butterflies, mammals and a few plant species, whereas time series are almost non-existent for all remaining species groups. In conjunction with the other indicators, however, the bird indicators selected here represent valuable information on the trend and state of biodiversity in the Nordic countries.

In respect to both the quantity and quality dimensions of biodiversity our results indicate an overall decline in biodiversity in the Nordic countries since 1990. In particular, farmland, mire, grassland and heathland show declines in biodiversity, but also the remaining habitats show negative trends. Therefore, based on the findings from this study, we conclude that it is highly unlikely that the target of halting biodiversity loss by 2010 can be achieved by the Nordic countries.

Our results should be perceived as a first attempt to make an overall assessment of the state of biodiversity in the Nordic countries. We believe that if further efforts were directed towards scrutinising existing and historic monitoring programmes and data sources, additional indicators could be calculated and hence a better knowledge base would be achieved. Also, our experience is that the monitoring programmes in the Nordic countries vary considerably between the individual countries and as a consequence it is often difficult to find matching datasets in all countries. We recommend that nature and biodiversity monitoring in future be coordinated at a Nordic level to a greater degree, and that monitoring be more focused on measuring *temporal* changes in biodiversity.

If the target of halting biodiversity loss in the Nordic countries is to be achieved, major additional efforts will be necessary. It is not the scope of the NordBio2010 project, however, to suggest the policy actions that would be needed. It is simply the conclusion of this first assessment of Nordic biodiversity that further action is required if the Nordic countries are to approach their 2010 target for biodiversity.

Dansk resumé

De nordiske lande har vedtaget et fælles mål om at standse nedgangen i naturens mangfoldighed, biodiversiteten, inden 2010. Formålet med NordBio2010-projektet er at evaluere 2010-målet ved at udvikle et system af indikatorer, der kan beskrive ændringer i biodiversitet. Endvidere er målet at forbedre det fremtidige arbejde med og koordinering af de nationale overvågningsprogrammer. I projektet har vi anvendt et simpelt koncept til at anskueliggøre brugen af biodiversitetsindikatorer; et koncept, der kan beskrive både *kvantitet* og *kvalitet* af biodiversitet. Kvantitet måles som udviklingen i areal af definerede habitattyper eller økosystemer (fx skov, græseng eller vandløb). Kvalitet måles som populationsstørrelser af udvalgte arter, og hvis det er relevant som andre kvalitetsparametre, fx forekomsten af gamle træer i en skov eller græsningsomfang på en eng.

For at måle ændringer i kvantiteten af biodiversitet har vi udviklet et fællesnordisk system til klassificering af habitattyper. Systemet definerer og afgrænser en række natur- og økosystemtyper. På det øverste niveau har vi defineret 10 hoved-habitattyper, og på andet niveau har vi inddelt i 27 under-habitattyper. Inddelingen på øverste niveau er baseret på velkendte kriterier herunder vegetationsdække- og type, substrattype og menneskelig indflydelse som fx landbrugsdrift. Inddelingen på andet niveau er baseret på en mere løs evaluering af forskellige kriterier, der er relevante i en nordisk sammenhæng. For at måle ændringer i kvaliteten af biodiversitet har vi identificeret en række indikatorer for populationsstørrelse af udvalgte arter og andre kvalitetsindikatorer for hver af hoved-habitattyperne, og hvis der findes data af tilstrækkelig kvalitet er disse indikatorer beregnet og præsenteret i rapporten. Baseret på konceptet om at måle både kvantitet og kvalitet, kan et to-dimensionelt biodiversitetsindeks beregnes. Eksempler på sådanne indeks er angivet for de hoved-habitattyper, hvor tilstrækkelig data forefindes.

Hovedbudskaber

☹ Vores resultater viser, at biodiversiteten i de nordiske lande er faldet siden 1990.

☹ Det er højest usandsynligt at de nordiske lande kan nå målet om at stoppe nedgangen i biodiversitet inden 2010.

☺ Hvis eksisterende datakilder analyseres yderligere, vil flere indikatorer kunne beregnes, og derved kan et bedre vidensgrundlag opnås.

☺ Vi anbefaler, at fremtidig overvågning af natur og biodiversitet i højere grad koordineres mellem de nordiske lande.

Vores resultater udgør den hidtil mest omfattende dokumentation af udviklingen i arealanvendelse i de nordiske lande. Baseret på nye og historiske datakilder har vi kunnet beskrive de væsentligste udviklinger i arealanvendelsen. Resultaterne viser, at arealet af vigtige naturtyper som moser, græsenge og hede er faldet betydeligt siden 1990. Hver enkelt af disse udviklingstendenser forårsager et fald i den samlede biodiversitet. En mindre stigning i skovarealet kan derimod tælle på den positive side, idet den som den eneste ændring i arealanvendelse kan have en positiv betydning for biodiversitet.

Hvis man ser på kvalitetsaspektet af biodiversitet, viser vores resultater, at to tredjedele af de beregnede indikatorer angiver et fald i biodiversitet, mens den resterende tredjedel viser forbedringer (eller *status quo*). Mens alle indikatorer for agerland, moser og græsenge viser faldende biodiversitet, viser indikatorerne for bebyggede arealer, kystområder, søer og vandløb og skov både positive og negative tendenser for biodiversitet. Men ingen af hovedhabitattyperne viser udelukkende positive tendenser. En stor del af artsindikatorerne er baseret på populationsdata for fugle. Selvom fugle generelt anses som at være meget relevante indikatorer for biodiversitet, er det klart at de kun repræsenterer et hjørne af den samlede biodiversitet. Men fugle er den artsgruppe, der findes de bedste overvågningsdata for i de nordiske lande, og derfor udgør de det bedste analyseredskab i forhold til biodiversitet. Et mere begrænset omfang af populationsdata findes for sommerfugle, pattedyr og enkelte plantearter, mens tidsserier stort set ikke eksisterer for de resterende artsgrupper. Men sammenholdt med de andre relevante indikatorer udgør de valgte fugleindikatorer værdifuld information om udviklingen i biodiversitet i de nordiske lande.

I forhold til begge aspekter af biodiversitet, kvantitet og kvalitet, påpeger vores resultater en faldende biodiversitet i de nordiske lande siden 1990. Særligt for agerland, moser, græsenge og hede ses fald i biodiversitet, men også de resterende habitattyper viser negative tendenser. Baseret på resultaterne i dette projekt konkluderer vi derfor, at det er højst usandsynligt, at de nordiske lande kan nå målet om at stande faldet i biodiversitet inden 2010.

Vores resultater skal ses som et første forsøg på at lave en overordnet vurdering af tilstanden i biodiversitet i de nordiske lande. Vi mener, at hvis yderligere arbejde lægges i at analysere eksisterende og historiske overvågningsprogrammer og datakilder, vil man kunne beregne yderligere indikatorer og derved opnå et bedre vidensgrundlag. Derudover er det vores erfaring, at overvågningsprogrammerne i de nordiske lande afviger en del fra hinanden, og derved er det ofte svært at finde sammenlignelige datasæt i alle lande. Vi anbefaler, at den fremtidige overvågning af natur og biodiversitet i højere grad koordineres mellem de nordiske lande, og at fokus især rettes mod at dokumentere ændringer i biodiversitet over tid.

Hvis målet om at standse tabet af biodiversitet skal nås i de nordiske lande, vil det kræve en stor indsats. Det er dog ikke formålet med NordBio2010-projektet at foreslå hvilke politiske tiltag, der vil være nødvendige. Vi kan udelukkende konkludere med denne første analyse af nordisk biodiversitet, at yderligere tiltag vil være nødvendige, hvis de nordiske lande vil nærme sig det fælles 2010-mål.

1. Introduction

The Nordic countries have agreed on a common goal to halt the loss of biodiversity by 2010 (Nordic Council of Ministers 2005). To document progress towards this target, the state and trends of biodiversity should be measured and evaluated. In March 2006 a workshop was held in Denmark to discuss how the 2010 target could be evaluated in a Nordic context (Normander et al. 2006). It was agreed that enough biodiversity data exist in the Nordic countries to develop indicators and possibly even a composite index that can describe the present state and historical development of biodiversity. However, aggregation and harmonisation of the various datasets as well as discrepancies in the different nature monitoring programmes would have to be addressed.

Following the workshop, the project Nordic Biodiversity Indicators 2010 (NordBio2010) was launched. NordBio2010 has been commissioned by the Nordic Council of Ministers and led by the National Environmental Research Institute of Denmark. Other national research institutions involved in the work are the Norwegian Institute for Nature Research, the Norwegian Forest and Landscape Institute, the Finnish Environment Institute, the Swedish University of Agricultural Sciences and the Icelandic Institute of Natural History.

The project aims to evaluate the target of 'halting the loss of biodiversity by 2010' by developing relevant indicators for the Nordic countries. It also aims to improve future work involved in national nature monitoring programmes and increase co-operation between the countries involved in the project. Further information about NordBio2010 can be found at http://nordbio2010.dmu.dk.

This report presents the main results and findings of NordBio2010. The concept of using indicators to describe the state and trends of biodiversity is discussed in Chapter 2. An indicator framework for the state of biodiversity in the Nordic countries is presented in Chapter 3, followed by three chapters defining biodiversity quantity indicators (Chapter 4), biodiversity quality indicators (Chapter 5) and a concept for a biodiversity index (Chapter 6). The main results arrived at for each of the eight main habitat types present in the Nordic countries are presented in Chapters 7 to 14. Chapter 15 contains an evaluation summarising the overall trends in biodiversity in the Nordic countries and, in so doing, aims to provide an assessment of the 2010 target.

2. Developing indicators for biodiversity

The importance of protecting biodiversity has been widely acknowledged on the international political arena. Countries participating in The Convention on Biological Diversity (CBD) have committed themselves 'to achieve by 2010 a significant reduction of the current rate of biodiversity loss at the global, regional and national level as a contribution to poverty alleviation and to the benefit of all life on earth' (UNEP 2002). The EU member countries have adopted an even more ambitious target, not only to significantly reduce but to halt the decline in biodiversity by 2010 (European Council 2001). The implementation of all policies affecting biodiversity should contribute towards meeting this goal. The state and trend of biodiversity should also be measured in order to assess the effects of implemented policies.

The Nordic countries have adopted the target of EU to 'halt the loss of biodiversity by 2010' and given it emphasis both in the Nordic Environmental Action Plan 2005–2008 (Nordic Council of Ministers 2005) and in the Nordic Sustainable Development report (Nordic Council of Ministers 2004). The 2010 targets – even if they may seem improbable to be reached – are important milestones for European and global efforts to protect biodiversity. Any significant progress towards these targets would mean a very significant shift in our attitude towards the living environment. However, the way to halting biodiversity loss is riddled with obstacles – the first of which is of a very basic nature: how can we measure the state and change of biodiversity?

2.1 Indicators for measuring biodiversity

Indicators are used to quantify and communicate complex phenomena – in this case the state of biodiversity – in a simple manner (Bibby 1999). However, there is no universal indicator, which can accurately reflect changes in biodiversity in different ecosystems at different spatial and temporal scales because of the inherent complexity of the ecological systems. Subsets of indicators are therefore needed to obtain balanced assessments of the trends in biodiversity. Table 2.1 lists relevant criteria for obtaining good biodiversity indicators. It is not often the case that all criteria may be met but the list comprises an important tool when choosing and developing biodiversity indicators.

The level of available monitoring data varies greatly between different countries and even within countries. Despite these limitations the overall picture of the state and development of biodiversity is clear: biodiversity is declining on a global, European and Nordic level. For example, an analysis conducted in 2000 of the diversity of species in Finland showed that nearly 20% of 15 000 species studied are estimated to be endangered (i.e. red listed) (Rassi et al. 2001). According to the Norwegian red list 21% of all 18 500 evaluated species are red listed (Kålås et al. 2006). At a global level, the Living Planet Index tracks populations of 1 313 vertebrate species on Earth and shows a decline in biodiversity by 29% from 1970 to 2003 (Loh et al. 2006).

Table 2.1: What is required of a good biodiversity indicator?

Quality	Explanation
1. Representative and good coverage	Includes a large enough or representative group of species and has a good spatial coverage
2. Temporal and up-to-date	Shows temporal trends and can be updated routinely, e.g. annually
3. Simplifying information	Summarises a complicated phenomenon into a simple and intelligible form
4. Clear presentation	Possible to display clear messages with eye-catching graphics
5. Quantitative and statistically sound	Based on real quantitative observations and statistically sound data collection methods
6. Relatively independent of sample size	Usable data may be obtained even with relatively small sample sizes
7. Sensitive	Measured qualities are more sensitive to change than their environment (i.e. early warning)
8. Realistic	Based on existing monitoring programmes. Implementation is economically feasible
9. Indicative	Indicates changes in a bigger scale
10. User-driven and acceptable	Responds to the needs of stakeholders and is broadly accepted amongst them
11. Normative and policy relevant	Linked to politically set goals and baselines. Enables assessing progress towards targets
12. Not sensitive to background changes	Buffered from natural fluctuations. Measures changes caused by humans
13. Explainable	The impact and significance of the change measured by the indicator must be known
14. Predictable	May be forecast and linked to socio-economic models
15. Comparable	Enables comparison (e.g. benchmarking of countries)
16. Aggregatable and disaggregatable	Data may be aggregated and disaggregated into different levels (e.g. country vs. community)

The table is constructed by NordBio2010, based on Noss 1990, Delbaere 2003, Gregory et al. 2005 and EEA 2007.

In 2004 the Council of the European Union, the European Environment Agency and a number of other partners launched a project with the aim to develop a common set of biodiversity indicators for Europe. The project Streamlining European 2010 Biodiversity Indicators (SEBI2010) has so far produced a first draft of the set, which contains altogether 26 indicators (EEA 2007, EC 2008a). Some of these indicators, such as the abundance and distribution of selected species, directly track the status of a part of Europe's biodiversity. Others reflect threats to biodiversity, look at sustainable use of biodiversity resources or address the issue of ecosystem integrity.

In Finland a set of 75 biodiversity indicators was composed to evaluate results of the Finnish National Biodiversity Action Plan for 1997–2005 (Auvinen et al. 2007). This set of indicators is currently being expanded and improved upon as a joint effort between national research institutions, ministries and NGOs dealing with biodiversity issues. The collection with over 120 indicators will be published on the Internet in early 2009. A working version of the site can already be found at www.biodiversity.fi.

2.2 Types of biodiversity indicators

Just as there is a multitude of individual biodiversity indicators, there are also many different types of indicators amongst them. One may, for example, choose to use one single species as an indicator of wider ecosystem quality or alternatively try to combine information on as many species and habitats into one index as possible. Indicators may also be indicators of many things: for instance, of pervasive changes in the quality of habitats caused by humans or of changes in human attitudes towards biodiversity. In short, indicators may look at the same issue from several different points of view and convey even contrasting messages.

One helpful and commonly used model for classifying indicators is the DPSIR-framework (Smeets and Weterings 1999). In this model indicators have been divided into five groups:

- D: Driving forces (e.g. socio-economic, lifestyle, large-scale policies)
- P: Pressures (e.g. use of natural resources, harmful emissions)
- S: State (biotic and abiotic conditions; e.g. soil quality, species' population sizes)
- I: Impacts (e.g. ecosystems functions, species becoming endangered)
- R: Responses in order to abate adverse development (e.g. protection, restoration, monitoring)

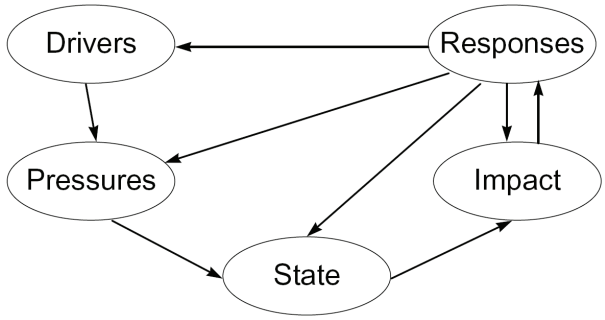

Figure 2.1: The DPSIR framework for reporting on environmental issues.
Source: Smeets and Weterings 1999.

Reducing a complex reality into a model such as the DPSIR-framework is not always easy. For example, classifying indicators may prove difficult (the division between state and impact is often unclear, for example), some indicators may fall entirely outside of the framework and the interconnections between indicators may decrease the feasibility of the DPSIR approach. On the other hand, the framework does provide several advantages. A careful application of the framework generally provides a good starting point for a comprehensive and balanced assessment of biodiversity. Most importantly, however, applying DPSIR directs attention on cause-effect relationships: the DPSIR framework underlines the connections between human actions and changes in biodiversity.

2.3 Aggregation of indicators

Even though many biodiversity indicators aggregate information to a relatively high level, there is a widespread need to simplify their message even further. Some have suggested that economic indices such as the Dow Jones or Nikkei should be taken as models for the development of biodiversity measures (Gregory et al. 2003, Lindström and Svensson 2005, Loh et al. 2005). The hope is that such indices would help getting focus on biodiversity issues in the media and in policy making.

Ideally, indicators should use similar approaches and measure changes at uniform scales. Aggregating indicators according to, for example, habitat, country or biogeographical region would then be possible (e.g. de Heer et al. 2005). Often the available data sources are nevertheless too heterogeneous and time series too patchy for the required uniformity to be reached. In these cases, different visual summaries in the form of arrow and traffic light symbols have been attempted (e.g. Secretariat of the Convention Biological Diversity 2006, Chick et al. 2007).

One recent approach to aggregation of biodiversity data has been to combine measurements of the quantity and quality aspects of biodiversity into a single composite index (ten Brink 2000, Normander et al. 2006, Nybø & Skarpaas 2008). The Natural Capital Index (NCI) was developed in the Netherlands as a highly aggregated, policy relevant index, to measure overall trends in biodiversity (ten Brink 2000). In developing this indicator it was recognised that biodiversity loss consists of two components: i) loss of habitats or 'ecosystem quantity', resulting from the conversion of natural areas to agricultural or urban use and ii) loss of 'ecosystem quality' (in the remaining area) due to factors such as climate change, pollution, habitat fragmentation and over-exploitation. The NCI is defined as the product of ecosystem quantity and ecosystem quality. Ecosystem quantity is the percentage remaining natural area of a country. Ecosystem quality is expressed as the density of species relative to a baseline situation, whereby the average is taken of a set of representative species. The NCI ranges from 0 to 100%. For example, if we assume for a country that presently 60% of the natural areas are remaining and the quality is on average 20%, the natural capital is 12%. To our present knowledge, NCI has not been calculated for other countries than The Netherlands. Recently, however, the development of a Nature Index for Norway based on principles similar to the Dutch work has been initiated (Nybø & Skarpaas 2008). The Nature Index is a composite measure of the condition of given areas of ecosystem types, aggregated from sets of chosen indicators that are direct or indirect measures of species abundances. A Nature Index for Central Norway has been calculated as a pilot for constructing an index at a national level (Nybø & Skarpaas 2008).

3. Nordic biodiversity indicator framework

One of the main goals of the Nordic Environment Action Plan (Nordic Council of Ministers 2005) is to achieve progress towards the conservation of biodiversity. Explicitly, biodiversity loss should be halted by 2010. However, to be able to measure progress towards this goal, one needs to define how the state and changes of biodiversity can be measured. The NordBio2010 project aims at evaluating the 2010 target by developing indicators that can measure changes in biodiversity in the Nordic countries. In order to do so, we have constructed an indicator framework, which sets up the basic principles for selecting and applying indicators. The framework is described below.

3.1 Definition of indicator framework

We have developed a simple concept to clarify the use of biodiversity indicators; a concept that can describe both the *quantity* and *quality* dimensions of biodiversity. Our concept is in parallel to the concept of the Natural Capital Index (ten Brink 2000). Changes in quantity are measured as trends in the area of pre-defined habitats or ecosystems (such as forest, grassland or inland water bodies). Changes in quality are measured as species abundance trends and, when applicable, as other habitat quality parameters, such as trends in the proportion of old trees in forests or grazing pressure on grasslands (Figure 3.1).

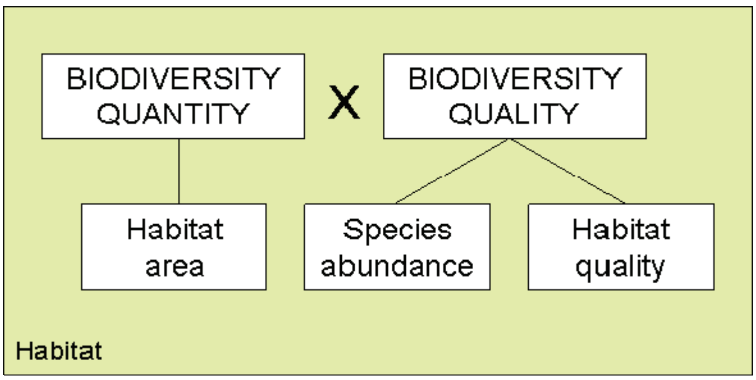

Figure 3.1: Elements in measuring the state of biodiversity. The concept can be applied to a habitat, a sub-habitat, a whole ecosystem, a country or a region.

Species abundance refers to population trends of selected species. Estimating population trends is a central approach to generating summary statistics in the field of biodiversity. The approach is used to produce a wide range of indicators and indices such as the Living Planet Index (Loh et al. 2005) and the indicators for European common bird species (Gregory et al. 2005). When relevant or when data on species abundance is not sufficient, indicators for habitat quality are applied as measures of quality of biodiversity. These include structural indicators such as the amount of dead wood in forest or the type of management of natural grasslands. See Chapter 5 for further description of biodiversity quality indicators.

The indicator framework builds on a habitat classification that covers all major habitat types in the Nordic countries (which will be described in Chapter 4). For each habitat, data series for quantity of biodiversity (i.e. the habitat area) and quality of biodiversity (i.e. species abundances and other quality indicators) are obtained from available data sources, including monitoring programmes, databases and research articles.

3.2 Setting a baseline

A baseline is a starting point for measuring change from a certain date or state. For example, a baseline can be the year 1900 or a 'low-human-impact' state. In Table 3.1 we have defined five different types of baselines. When measuring changes in the state of biodiversity, it would be beneficial to use the natural state – or at least a state before major human interferences – as a baseline situation. However, we are generally not able to define what the natural state would be as we simply lack both quantitative and qualitative information about the state of biodiversity in historical or pre-historical times. The definition of a natural state can also be put under question in the light of the fact that humans have had strong impact on biodiversity even in pre-historic times and that in many cases human impact has also created more biodiversity as in the case of farmland habitats.

Table 3.1: Different types of baselines for measuring changes in biodiversity

Type of baseline	Possible to:	Easy to define?
The natural state	Compare current state to the natural state	No. Basically unknown
Low human-impact or pre-industrial state	Compare current state to the state before major human interferences	No. Controversial
Ecologically safe state	Compare current state to a defined ecologically sustainable state	No. Generally not known
Target state	Compare current state to a defined policy target	Yes, but in the field of biodiversity targets have not been defined or are inaccurately defined
Baseyear (e.g. 1950 or the year the CBD was ratified)	Show progress in a defined time period	Yes.

In NordBio2010 we have decided to use baseyear(s) as a baseline. Depending on the quality and temporal resolution of available data series, the baseyear can be set to 1900, 1950 or 1970 and so forth. As a result of a limited availability of historical biodiversity data in the Nordic countries, we found it unrealistic to define a low human-impact state for biodiversity. Also, safe states or target states basically remain unknown in the area of biodiversity.

4. Definition of quantity indicators

As described previously changes in the quantity of biodiversity is measured as changes in the area of different habitat types. For this purpose we needed an applicable classification of Nordic habitats and nature types. A variety of different classification schemes for habitat and nature types exist. For example, Påhlsson (1998) developed a very detailed classification of Nordic vegetation types. National classification systems have also been developed, e.g. the Norwegian vegetation types (Fremstad 1997) and a nature type system (Norwegian Directorate for Nature Management 2007). Furthermore, at the European scale, several habitat type classifications, such as the European Nature Information System (EUNIS) (Davies et al. 2004), the Corine biotope typology (EC 1991), the Corine Land Cover classification (EEA 2002) and the BioHab habitat type classification (Bunce et al. 2005) have been elaborated.

4.1 Nordic habitat classification

We have elaborated a Nordic habitat type classification, which is the result of numerous discussions among the partners in the NordBio2010 project. In order to guarantee transparency and applicability with respect to data collection, the classification needed to be relatively broad with a limited number of well-defined habitat classes. At the same time the classification had to be detailed enough to distinguish between habitat types, which in respect to nature values are of importance in a Nordic context. Moreover, to make the results from the NordBio2010 project as comparable as possible with other studies, the Nordic habitat classification needed to be compatible with existing habitat classifications.

We have based the habitat classification system on existing definitions from the European Nature Information System (EUNIS), which is a pan-European habitat classification system that was developed between 1996 and 2001 by the European Environment Agency in collaboration with experts from throughout Europe (Davies et al. 2004). It covers all types of natural and artificial habitats, both aquatic and terrestrial, and therefore it provided a good backbone for a Nordic habitat classification.

In general we have applied the EUNIS classification down to the 2nd level. However, in some cases conditions in the Nordic countries differ considerably from the pan-European scale. Therefore, the EUNIS system was adjusted to conditions relevant in the Nordic countries. Figure 4.1

illustrates our classification of the different habitat types. At the 1st level we have defined 10 major habitat types, which at the 2nd level are divided into 27 sub-types. The classification at the 1st level is based on well defined criteria including the type and degree of vegetation cover, the type of underlying substrate and human influences, such as agricultural management and whether the habitat is artificial or constructed. The division into sub-types at the 2nd level is based on a less stringent evaluation of various relevant criteria. To prevent confusion with the EUNIS classification, all habitat codes were given the suffix N for Nordic; e.g. forest was termed N9 Forest. For sub-types the code for the main habitat class was combined with the number of the sub-type. E.g. N9 Forest was divided into the sub-classes: N9.1 Deciduous forest; N9.2 Coniferous forest, N9.3 Mixed deciduous and coniferous forest, N9.4 Mountain birch forest and N9.5 Other forest. Conversions between our Nordic habitat classification and the EUNIS classification can be found in Appendix 1.

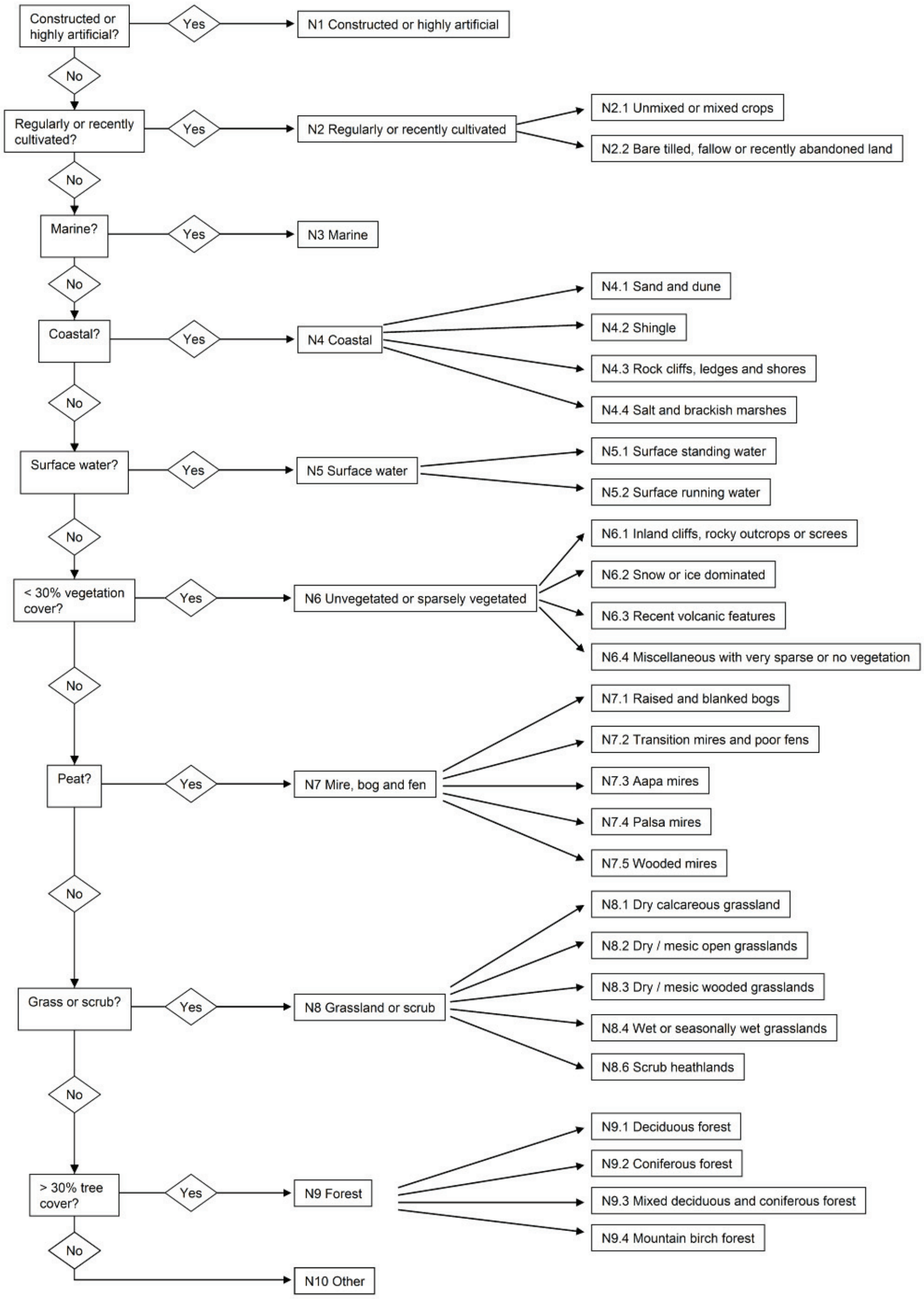

Figure 4.1: NordBio2010 classification tree for Nordic habitat types.

Some habitat types in the EUNIS system, such as E6 Inland salt steppes, do not exist in the Nordic countries. Other habitat types, such as different sub-types of artificial habitats, have not been considered in NordBio2010. Moreover, some habitat types, e.g. wooded grasslands or aapa mires, are very important from a Nordic perspective, but are in the EUNIS system either not included at all or are classified at a lower level. Therefore, we have made a number of changes in relation to the EUNIS system:

- N4.3 Saltmarshes was added as an individual sub-type, consisting of the EUNIS types, A2.5 Coastal saltmarshes and saline reedbeds and D6 Inland saline brackish marshes and reedbeds.
- The EUNIS types, C3 Littoral zone of inland surface waterbodies and D5 Sedge and reedbeds are usually not perceived as individual habitat types in a Nordic context. Therefore, they were included in N5.1 Surface standing waters and N5.2 Surface running waters.
- The EUNIS types, D3.1 Palsa mires and D3.2 Aapa mires, which in EUNIS are classified at the 3rd level, are important habitats in Finland, Norway and Sweden. These classes were therefore added as individual habitat types at the 2nd level in the Nordic habitat classification (N7.4 and N7.3, respectively). EUNIS D3.3 polygon mires was excluded, as this habitat do not exist in any Nordic country. Wooded mire, which in the EUNIS classification is classified under woodlands, is an important habitat type in the Nordic countries and was added as an individual habitat type (N7.5) under N7 Mires.
- Wooded grassland is an important habitat type in the Nordic countries and was included as an individual sub-habitat of N8 Grasslands and shrub heathlands. In EUNIS this habitat type is divided between E7 Sparsely wooded grasslands and various sub-types under G Woodland.
- Mountain birch forest is an important habitat type in the subalpine zones of the Nordic countries. Therefore, N9.4 Mountain birch forest was added as a separate sub-habitat under forest.
- We have decided not to treat intensive and extensive cultivation as different habitat types, because a distinction between those two is usually not made in Nordic statistics. Therefore, the EUNIS types, I1.1 Intensive unmixed crops and I1.3 Arable land with unmixed crops grown by low-intensity agricultural methods have been merged into one class: N2.1 Unmixed and mixed crops.
- The EUNIS class, J Constructed, industrial and other artificial habitats was not divided into sub-habitats in NordBio2010. The EUNIS type, J5 Highly artificial man-made waters and associated structures was included in N5.1 Surface standing waters and N5.2 Surface running waters.

4.2 Description of Nordic habitat classes

N1 Constructed or highly artificial habitats

Any urban and industrial areas, including transport infrastructure, dump sites and areas with surface exploitation (quarries or gravel pits). Regularly or recently cultivated land and artificial lakes are not included. No further sub-classifications are used for this class.

N2 Regularly or recently cultivated habitats

Areas that are cultivated or have been cultivated recently.

N2.1 Unmixed and mixed crops

Cropland, including market gardens and horticulture.

N2.2 Fallow or recently abandoned land

Fields abandoned or left to rest and set aside land.

N3 Marine habitats

Areas below spring high tide limit or below mean water level in non-tidal waters. The marine class is not covered in this project.

N4 Coastal habitats

Areas that occupy coastal features and characterised by their proximity to the sea.

N4.1 Coastal sand and dune

Substrate composed of sand (this class includes inland dunes).

N4.2 Coastal shingle

Substrate composed of shingle.

N4.3 Rock cliffs, ledges and shores

Substrate composed of rock.

N4.4 Coastal and seashore meadows and marshes

Substrate composed of siliceous or decomposing organic material. Often, but not necessarily characterised by saline or brackish water supply and plant species tolerating these conditions. Like grasslands (N8.1 – N8.4) this class is influenced / formed by grazing and / or moving.

N5 Inland surface waters

Inland areas with water surface and the adjoining littoral zone as sedges and reed beds.

N5.1 Surface standing waters

The water body is standing with no perceptible flow as in lakes, ponds or extremely slow-moving parts of rivers. Includes man-made reservoirs.

N5.2 Surface running waters

The water body is running with perceptible flow as in rivers, streams and springs.

N6 Unvegetated or sparsely vegetated habitats

Areas with less than 30% vegetation cover.

N6.1 Inland cliffs, rocky outcrops and screes

Surface dominated by exposed bedrock or mobile rock and rock fragments including screes.

N6.2 Snow or ice dominated habitats

Surface dominated by permanent ice or snow.

N6.3 Recent volcanic features

Surface dominated by substrate of recent volcanic origin.

N6.4 Miscellaneous habitats with very sparse or no vegetation

All other unvegetated or sparsely vegetated areas.

N7 Mires, bogs and fens

Soil substrate dominated by peat. This class includes wooded mires if the soil substrate is peat.

N7.1 Raised and blanket bogs

Surface soil substrate dominated by rain fed peat (ombrogenous). Water table is below surface.

N7.2 Poor fens and valley mires

Water table is at or near the surface and peat forms at water surface (minerogenous).

N7.3 Aapa mires

Patterned frost dependent mires with ice not perpetually present. Patterns characterised by ridges and hummocks.

N7.4 Palsa mires

Frost or ice dependent with ice perpetually present in the solid central cores of raised hummocks.

N7.5 Wooded mires

Forest growing on peat, dominated by Norway spruce (*Picea abies*), Scots pine (*Pinus sylvestris*) or downy birch (*Betula pubescens*) (over 50% of all tree species).

N8 Grasslands and shrub heathlands

Vegetation dominated by grasses and scrubs. Most grasslands are formed by management. Therefore, the influence of grazing and / or moving is decisive for all grassland classes (N8.1 – N8.4). Coastal and seashore meadows are classified under N4 Coastal habitats.

N8.1 Dry calcareous and alvar grasslands
Vegetation dominated by grasses. < 30% trees (canopy cover). Influenced / formed by grazing and / or moving. On calcareous substrate or limestone. Dry conditions.

N8.2 Dry/mesic open grasslands
Vegetation dominated by grasses. < 30% trees (canopy cover). Influenced / formed by grazing and / or moving. On siliceous substrate. Dry/mesic to moist conditions.

N8.3 Dry/mesic wooded grasslands
Vegetation dominated by grasses. > 30% trees (canopy cover). Influenced / formed by grazing and / or moving. On siliceous substrate. Dry/mesic to moist conditions.

N8.4 Wet or seasonally wet grasslands
Vegetation dominated by grasses. Influenced / formed by grazing and / or moving. Primarily on siliceous substrate. Wet or seasonally wet conditions.

N8.5 Scrubs and shrub heathlands
Vegetation dominated by heather and scrubs. < 30% trees (canopy cover).

N9 Forest

Vegetation is dominated by woody vegetation cover (>= 30% crown cover (definition from Nordic Council of Ministers) except mountain birch forest (>= 10% crown cover) and the substrate is other than peat. This threshold does not apply to clearings or recently planted areas, which are likely to have >= 30% woody vegetation cover within a decade.

N9.1 Deciduous forest
>= 70% deciduous tree species (Definition from Nordic Council and CORINE).

N9.2 Coniferous forest
>= 70% coniferous tree species (Definition from Nordic Council and CORINE).

N9.3 Mixed deciduous and coniferous forest
Neither deciduous nor coniferous tree species cover more than 70% (Definition from Nordic Council and CORINE).

N9.4 Mountain birch forest

Areas with >= 10% tree cover (canopy cover) dominated by birch with no or negligible amounts of coniferous trees. Located in the sub-alpine region.

N9.5 Other forest

Forest areas, including transition areas, clear-cut and replanted areas that can not be classified in the other sub-habitats.

N10 Undefined

This covers habitat types and areas that are not defined or not known.

4.3 Bio-geographical regions

For several habitat types it is relevant to know in which bio-geographical region they are located. For example, boreal, boreo-nemoral and nemoral forests differ largely from each other in terms of their climatic and physical conditions and hence in terms of species composition. Figure 4.2 shows the distribution of bio-geographical regions that we have applied in Nord-Bio2010. The map is a revised version of the Nordic Council's physical geographical regionalisation (Nordic Council of Ministers 1984). The regionalisation is mainly based on vegetation and climatic characteristics, such as precipitation and temperature.

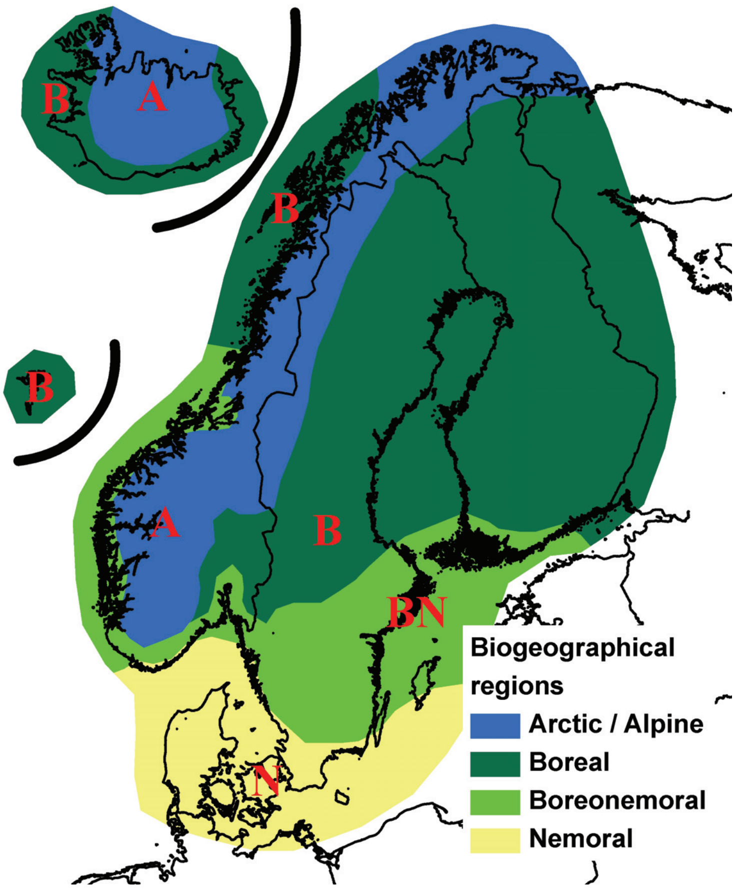

Figure 4.2: Bio-geographical regions in the Nordic countries.
Source: NordBio2010, revised from Nordic Council of Ministers 1984.

The bio-geographical regions can be described as follows:

Arctic / Alpine (suffix **A**)

The arctic and alpine bio-geographic zones constitute the areas above and north of the climatic tree border. Most of the Scandinavian Peninsula is situated south of the Arctic, except for a small area along the coast in northern Norway. In this area the climatic tree line extends down to sea level. Elsewhere the zone is conditioned by high altitudes in mountainous areas. The climate is harsh with cold and long-lasting winters. The alpine zone covers large areas in the Scandinavian mountains (mostly Norway and Sweden) and Iceland. Alpine and arctic plants dominate the vegetation. Heaths dominated by ericaceous species such as bilberry (*Vaccinium myrtillus*), cowberry (*Vaccinium vitis-idaea*) and crowberry (*Empetrum hermaphroditum*) cover large areas. The differences in snow duration in summer gives rise to distinct zonations from wind swept and dry ridges to snow beds dominated by mosses and a few vascular plants.

Boreal (suffix **B**)

The boreal zone in the Nordic countries forms the western fringe of the vast taiga of the Eurasian continent. Coniferous forest dominated by Norway spruce (*Picea abies*) and Scots pine (*Pinus sylvestris*) characterise the zone on the continent. Mires cover extensive areas. Boreal deciduous trees such as birch (*Betula pubescens*), aspen (*Populus tremula*), goat willow (*Salix caprea*), rowan (*Sorbus aucuparia*) and grey alder (*Alnus incana*) are common in mixtures with coniferous trees or as separate stands. In the humid western parts of the boreal zone, birch (*Betula pubescens*) covers large areas, some places from sea level to the alpine zone. There is a gradual change to the north/higher altitudes reflecting lower productivity and species richness, more open forest with higher cover of birch. Accordingly, the zone is divided in three subzones; the northern boreal, middle boreal and southern boreal zones. In the southern boreal zone temperate broadleaved trees and other species with a southern distribution often occur under favourable conditions. In the northern boreal zone some alpine plants may occur. The zone is delimited from the alpine areas at higher altitudes on mountains by the tree-line. This line also delimits the boreal region from the Arctic to the north, although there is a gradual change. Normally mountain birch (*Betula pubescens* ssp. *tortuosa*) forms the tree border. In the northern boreal zone summer farming was very common, with large areas used for haymaking and as pastures in the outfields. At least in Norway summer-farming is still practised.

Boreo-nemoral (suffix **BN**)

The boreo-nemoral zone is a transition zone between the temperate deciduous forests of the nemoral zone and the coniferous forests to the north. Both species of the nemoral and boreal regions occurs, but temperate species tend to occur in favourable, warm places. Most of the nemoral tree species occurs also in the boreo-nemoral zone except for field maple (*Acer campestre)* and large-leaved linden (*Tilia platyphyllos).* Hornbeam (*Carpinus betulus*) is restricted to the southern part of the zone. Agricultural land covers large areas.

Nemoral (suffix **N**)

The nemoral vegetation zone is characterised by broadleaved deciduous trees species of the temperate zone in Europe. This zone extends northward to its northern limit in Scandinavia (Denmark and the southern part of Sweden and Norway). Forest with oak (*Quercus robur* and *Quercus petraea*) and beech (*Fagus sylvatica*) is typical. Other characteristic species are ash (*Fraxinus excelsior*), elm (*Ulmus glabra*), Norway maple (*Acer platanoides*), lime (*Tilia cordata*) and hornbeam (*Carpinus betulus*). Floristically the zone is species rich and characterised by many southern and south-western species. Large areas are used for agriculture. Mires cover small areas and wetlands are often drained.

4.4 Aggregation of sub-habitats

The aim of aggregating sub-habitat types into broader habitat aggregates is to give an appropriate picture of the quantity and quality of different Nordic nature types. These aggregates have to be meaningful in several perspectives. They should reflect the different functions as habitats for different animal and plant species and reflect different types of genesis. The 1st level in the habitat classification reflects an aggregated level itself. For example, N2 Regularly or recently cultivated and N4 Coastal are meaningful habitat aggregates. For other habitat types, e.g. N8 Grasslands and shrub heathlands, (dis)aggregating into different bio-geographical zones would be useful. Similarly, aggregating forests into nemoral, boreo-nemoral and boreal forest would be relevant. This approach reflects the large regional variation within the Nordic countries.

Table 4.1 presents examples of aggregated habitat classes and bio-geographical divisions, which are relevant in a Nordic context. Sub-habitats are listed according to the class they are aggregated into. If relevant, the suffix for the bio-geographical region is added to the sub-habitat.

Table 4.1: Examples of relevant habitat aggregates of Nordic habitat types

Habitat aggregate	Sub-habitats
Coastal	N4.1 Coastal sand and dune N4.2 Coastal shingle N4.3 Rock cliffs, ledges and shores N4.4 Coastal and seashore meadows and marshes
Inland surface waters	N5.1 Surface standing waters N5.2 Surface running waters
Mires, bogs and fens	N7.1 Raised and blanket bogs N7.2 Poor fens and valley mires N7.3 Aapa mires N7.4 Palsa mires N7.5 Wooded mires
Grasslands and shrub heathlands of the nemoral, boreo-nemoral and boreal regions	N8.1 N/B/BN Dry calcareous and alvar grasslands N8.2 N/B/BN Dry/mesic open grasslands N8.3 N/B/BN Dry/mesic wooded grasslands N8.4 N/B/BN Wet or seasonally wet grasslands N8.5 N/B/BN Shrub heathlands
Scrubs and shrub heathlands of the arctic / alpine region	N9.4 A Mountain birch forest N8.5 A Shrub heathlands
Forests of the nemoral region	N9.1 N Deciduous forest N9.2 N Coniferous forest N9.3 N Mixed deciduous and coniferous forest
Forests of the boreo-nemoral region	N9.1 BN Deciduous forest N9.2 BN Coniferous forest N9.3 BN Mixed deciduous and coniferous forest
Forests of the boreal region	N9.1 B Deciduous forest N9.2 B Coniferous forest N9.3 B Mixed deciduous and coniferous forest

4.5 Geographical coverage and data availability

Table 4.2 summarizes in which countries the different habitat types exist and whether area data for these habitat types are available. The availability of areal data differs substantially between countries and habitat types. In some cases habitat definitions differ between the different Nordic countries and hence national classifications are difficult to harmonise with the definitions from the Nordic habitat classification.

Table 4.2: Geographical coverage and data availability of Nordic habitat types

Nordic habitat classification	Habitat exists?					Area data exist?				
Code and name	FI	SE	NO	DK	IS	FI	SE	NO	DK	IS
N1 Constructed habitats	Y	Y	Y	Y	Y	Y	Y	N	Y	Y
N2 Farmland	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
N2.1 Unmixed and mixed crops	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
N2.2 Fallow or recently abandoned land	Y	Y	Y	Y	Y	Y	Y	N	Y	N
N3 Marine habitats	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
N4 Coastal habitats	Y	Y	Y	Y	Y	Y	N	N	Y	Y
N4.1 Coastal sand and dune	Y	Y	Y	Y	Y	Y	N	N	Y	N
N4.2 Coastal shingle	Y	Y	Y	Y	Y	N	N	N	N	N
N4.3 Rock cliffs, ledges and shores	Y	Y	Y	Y	Y	N	N	N	N	N
N4.4 Coastal and seashore meadows and marshes	Y	Y	Y	Y	Y	N	N	N	Y	Y
N5 Inland surface waters	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
N5.1 Surface standing waters	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
N5.2 Surface running waters	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
N6 Unvegetated or sparsely vegetated habitats	Y	Y	Y	Y	Y	Y	N	N	N	Y
N6.1 Inland cliffs, rocky outcrops and screes	Y	Y	Y	Y	Y	Y	Y	N	N	N
N6.2 Snow or ice dominated habitats	N	Y	Y	N	Y	Y	Y	Y	N	Y
N6.3 Recent volcanic features	N	N	N	N	Y	N	N	N	N	Y
N6.4 Miscellaneous habitats with sparse/no veget.	Y	Y	Y	Y	Y	N	N	N	N	Y
N7 Mires, bogs and fens	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
N7.1 Raised and blanket bogs	Y	Y	Y	Y	N	N	N	N	N	N
N7.2 Transition mires and poor fens	N	Y	Y	Y	Y	N	N	N	N	N
N7.3 Aapa mires	Y	Y	Y	N	Y	N	Y	N	N	N
N7.4 Palsa mires	Y	Y	Y	N	Y	Y	N	N	N	N
N7.5 Wooded mires	Y	Y	Y	Y	Y	Y	Y	Y	N	N
N8 Grasslands and shrub heathlands	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
N8.1 Dry calcareous and alvar grasslands	N	Y	Y	Y	N	N	Y	N	N	N
N8.2 Dry / mesic open grasslands	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
N8.3 Dry / mesic wooded grasslands	Y	Y	Y	Y	N	Y	Y	N	N	N
N8.4 Wet or seasonally wet grasslands	Y	Y	Y	Y	Y	Y	Y	N	Y	N
N8.5 Scrubs and shrub heathlands	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
N9 Forest	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
N9.1 Deciduous forest	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
N9.2 Coniferous forest	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
N9.3 Mixed deciduous and coniferous forest	Y	Y	Y	Y	Y	Y	Y	Y	N	Y
N9.4 Mountain birch forest	Y	Y	Y	N	Y	Y	Y	Y	N	Y
N9.5 Other forest	Y	Y	Y	Y	Y	Y	Y	N	Y	N

Y = Yes / N = No

5. Definition of quality indicators

In NordBio2010 we have defined that changes in the quality of biodiversity is measured as changes in species populations and, when applicable, as other habitat quality parameters such as habitat structure, e.g. proportion of old trees or grazing pressure (see Chapter 3.1). The advantage of species abundance indicators is that they conform to many of the quality criteria, required of a good indicator (as listed in Table 2.1). They are representative, regularly updated, easy to use and understand, comparable, simple to aggregate and sensitive to environmental changes. However, they can also suffer from bias owing to subjective or inappropriate selection of species, for example when trends are only extracted from well-studied and data-rich species and localities. Species *composition* is not considered as a measure of biodiversity in this project, due to lack of data and a common methodology that can describe changes over time.

In principal, all quality indicators are state indicators (S in the DPSIR-concept; see Chapter 2.3). However, there are few exceptions to this. For example, the proportion of drained mires or the grazing pressure of domestic animals in grasslands may be interpreted as pressure indicators (P in DPSIR). However, they are still relevant indicators for describing the state of biodiversity in the habitat types of interest.

5.1 Selection of indicators

Selection of species abundance indicators can be done by either a *bottom-up* or a *top-down* approach. When following a bottom-up approach, all data series that are available are obtained and indicators are produced based on these. This is the approach of for example the Living Planet Index for which all available species abundance trends are aggregated into one global index (Loh et al. 2005). On the contrary, European bird indices (Gregory et al. 2005) are calculated using a top-down approach where a limited number of bird species that are known to be representative of for example farmland or forest are selected.

In NordBio2010 we decided to follow a top-down approach because it would be very time consuming to collect all species data that may exist and in many cases not possible because of differences in methodologies and lack of data in certain periods of time. The top-down approach requires that for each main habitat, species that are associated to the particular habitat and are known or judged to be adequate indicators for biodiversity quality are selected. Also, other habitat quality indicators will be selected based on the same top-down approach.

For example, for the forest habitats (N9) we have defined the following species abundance and habitat quality indicators to be indicative for the biodiversity quality of forest:

Species indicators:

- Woodland insects
- Woodland birds
- Trees
- Mosses
- Lichens
- Rodents
- Some mammals
- Vascular plants
- Orchids
- Hunting statistics (deer, moose,..)

Habitat indicators:

- Volume of dead wood
- Proportion of old forest
- Proportion of large trees
- Proportion of clear cutting

For a more detailed description, see Chapter 14 on forest. Each indicator should be representative for the selected habitat at a national (or regional) scale and conform to a majority of the indicator quality criteria set out in Table 2.1. The selection of indicators is based on existing scientific literature and expert judgements. At least two data points are required in order to produce a trend. For many data sets like atlas surveys, monitoring has only been performed once and hence a trend can not be obtained. Some available time series are dependent on economic and cultural interests and may be biased, for example game statistics and large mammals. These should be used with precaution.

6. Definition of a biodiversity index

Based on the concept of measuring both the quantity and quality dimension of biodiversity, a two-dimensional biodiversity index can be computed. In Figure 6.1 quantity of biodiversity is appointed to the x-axis and quality of biodiversity to the y-axis. In a baseline situation – for example in a pre-defined baseyear or in pre-industrial time – both parameters are set to 100. Loss of biodiversity over time is shown in Figure 6.1. However, an increase in biodiversity may also be the case.

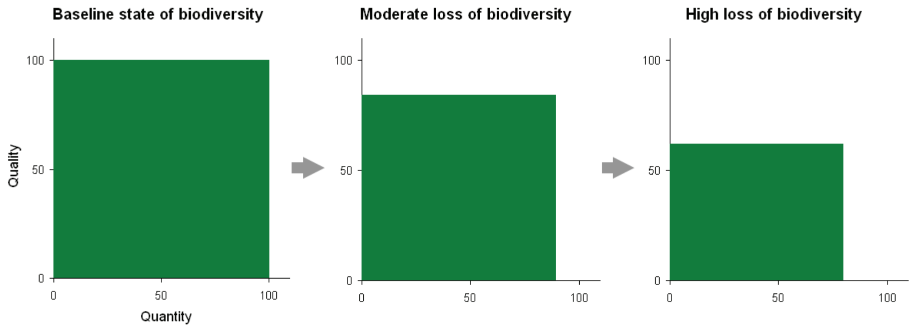

Figure 6.1: A model for a Nordic biodiversity index. The purpose is to show both the quantity and quality dimension of biodiversity.

Index values in the biodiversity index are calculated as simple averages of indexed time series. For example for forest, the quantity value would be the indexed value of the area of the forest habitat and the quality value would be the average of indexed time series of e.g. woodland birds.

A biodiversity index can be calculated at habitat level, country level, regional level or for the whole Nordic region. Figure 6.2 illustrates how biodiversity indices at different levels can be ordered into a hierarchy. Ideally, it would be of great interest to be able to calculate just one overall index; a Nordic biodiversity index that can describe changes in biodiversity in all habitat types in all Nordic countries. However, aggregating data to such high level of information would require abundant biodiversity data of good quality and temporal resolution that cover most habitat types in most of the Nordic region. This is certainly not the case. Therefore, in this report we have focused on calculating biodiversity indices at 1) a national level and 2) only for those habitats, where adequate data exist. In practice this means that we have been able to calculate biodiversity indices for the following main habitats: N1 Constructed habitats, N2 Farmland, N7 Mires, N8 Grassland and shrub heathland and N9 Forest. However, if additional efforts were directed towards obtaining data and advancing the interpretation and processing of data, it is very likely that additional and more robust biodiversity indices could be computed (see also Chapter 15).

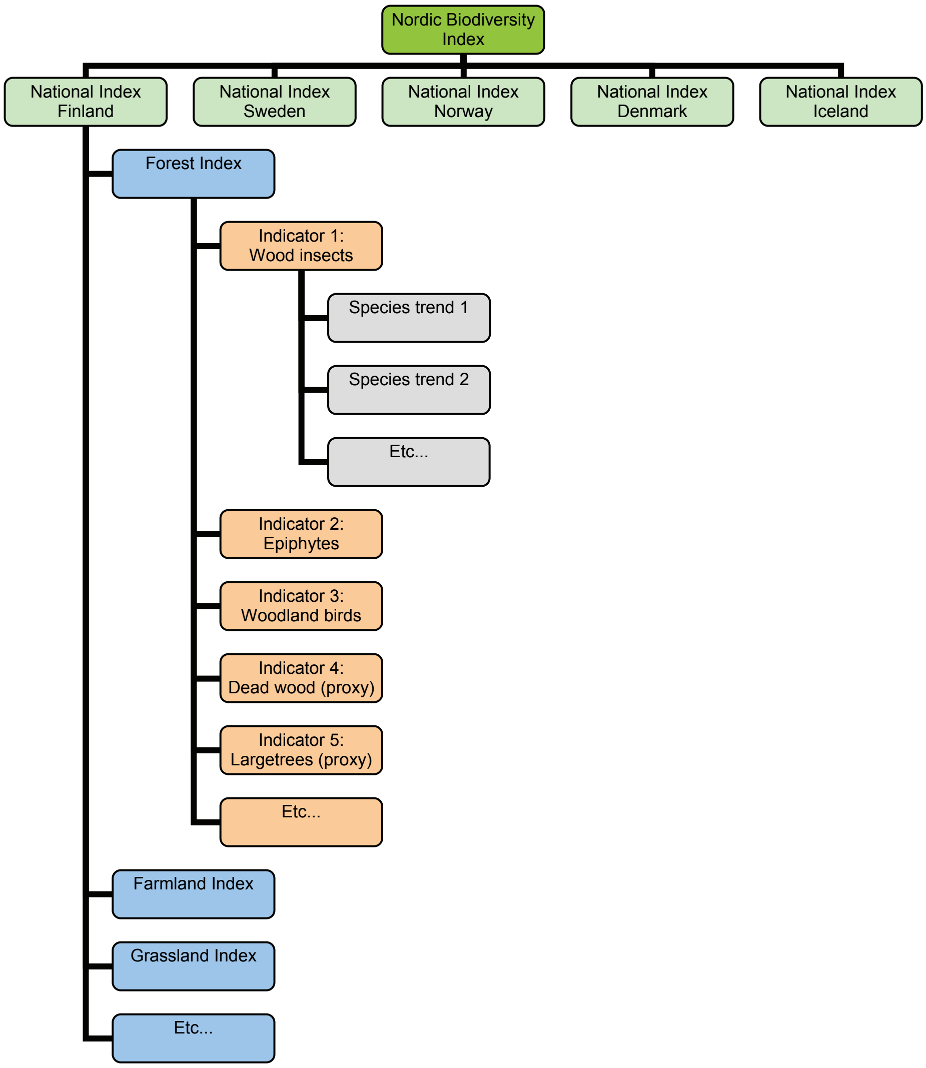

Figure 6.2: Hierarchal structure of biodiversity indices. The indices can be calculated at a habitat level (e.g. forest), at a national level (e.g. Finland) and at a regional level (e.g. the whole Nordic region).

It should be noted that in terms of habitat area (i.e. quantity of biodiversity) calculating indices for all habitats involves essentially a zero-sum game. As no marked changes in the total area of the Nordic countries has occurred since World War II, the quantity of one habitat type can only increase at the expense of another. Therefore, if available data would enable us to calculate a total Nordic biodiversity index, the quantity aspect of this index would always remain at 100. What using this kind of definition for the quantity of biodiversity allows, however, is comparing area changes between habitat types. For example, during the past decades there have been considerable shifts of area from the mire class into the forest and farmland classes in the Nordic countries. Also the area of constructed habitats has increased at the expense of other habitats.

7. Indicators for constructed habitats

Key messages	
☹	The area of constructed habitats has increased in all countries with an average growth of 15% since 1990, leading to increased pressure on biodiversity.
😐	Outside Denmark the area taken up by constructed habitats remains quite small.
☺	Populations of birds in urban areas have increased between 30% and 40% in Finland and Denmark, and decreased slightly in Sweden since 1980.
😐	Relatively good availability of area data but limited availability of data for biodiversity quality.

Constructed habitats include human settlements, buildings, industrial developments, the transport network, certain green areas such as parks and gardens within cities, waste dump sites and areas with surface exploitation (quarries or gravel pits). Regularly or recently cultivated land and larger artificial lakes are not included. Further sub classification is not used for this main habitat class.

7.1 Quantity of biodiversity

The availability of area data for constructed habitats in the Nordic countries is shown in Table 7.1. The most comprehensive data series has been obtained in Denmark, where national inventories go as far back as 1881. In the other Nordic countries data going back a few decades have been obtained.

Table 7.1: Availability of area data for constructed habitats

Habitat	FI	SE	NO	DK	IS
N1 Constructed habitats	1980–2005	1990–2005	2000–2007	1881–2000	1970–1995

In Figures 7.1 and 7.2 the present quantity of constructed habitats is shown for the Nordic countries. Altogether constructed habitats take up 19 000 km^2 in the Nordic region, which corresponds to about 1.5% of the total land area of the region. The largest share of all Nordic constructed habitats is found in Finland (31%), closely followed by Sweden (28%) and

Denmark (22%) (Figure 7.1). However, when taking the relative size of the countries into consideration, one country clearly deviates from the others: in Denmark as much as 10% of the total land area is covered by constructed habitats, whereas the same figure ranges from 1 to 2% in the other countries (Figure 7.2).

When looking into the countries' definitions of constructed habitats it is likely that the figures are under-estimated. The main reason is that transport networks and certain rural man-made localities (e.g. rural housing and extraction sites) are only partly included. For example, in a data series that is produced by the Finnish National Forest Inventory, constructed habitats are defined more loosely as the area claimed by population centres, factories, farm estates, houses, unvegetated peat extraction sites, roads, railroads and airports with their verges or close vicinities. This definition leads to an area size of constructed habitats, which is about twice the size (15 000 km^2) that we have used for Finland here. However, for comparison reasons, we choose not to use this data source.

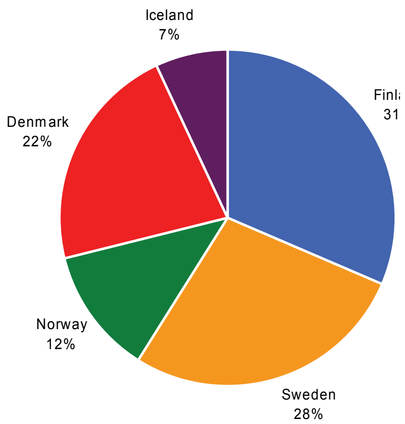

Figure 7.1: Distribution of constructed habitats between the Nordic countries (total area: 19 000 km^2).

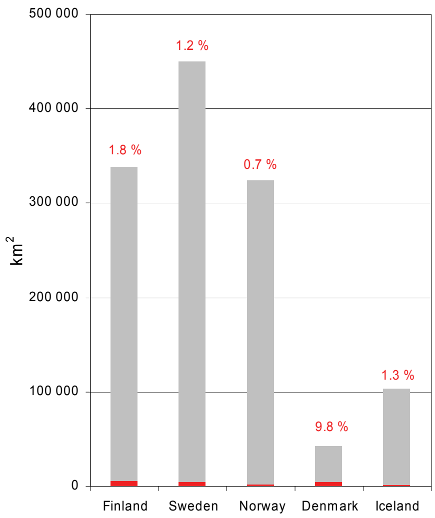

Figure 7.2: Proportion of constructed habitats of total land area in each of the Nordic countries.

In all Nordic countries the area of constructed habitats has increased significantly, with an average growth of 15% since 1990 (Figure 7.3). In particular, Finland has experienced a strong increase (> 60%) from the 1980s until today. Likewise, Denmark's area of constructed habitats has more than doubled since the 1920s.

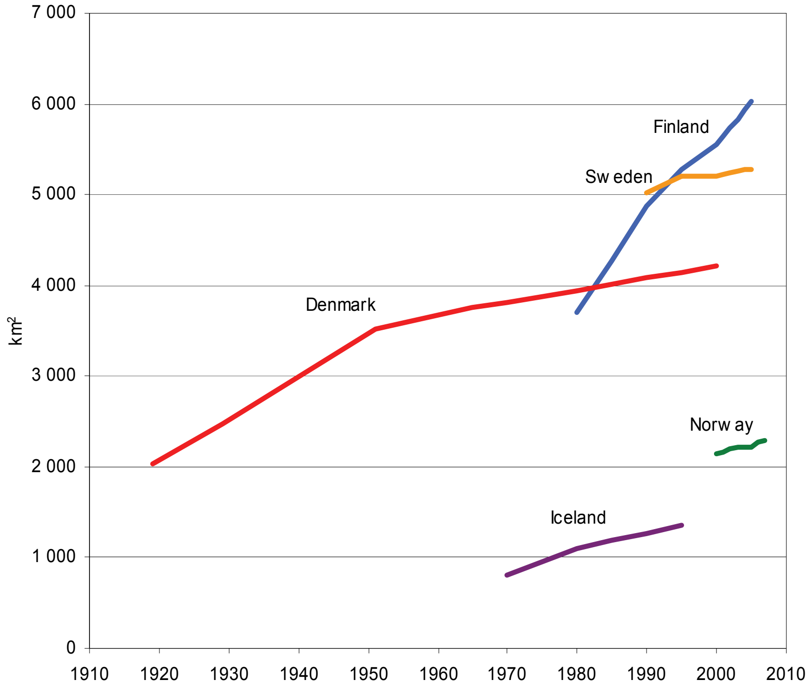

Figure 7.3: Trends in the area of constructed habitats in the Nordic countries.

7.2 Quality of biodiversity

Although constructed habitats are highly artificial, certain urban or man-made habitats may host high biological diversity, including both remnant species and species purposefully or unintentionally introduced by human actions (Petersen et al. 2007). The highest biodiversity is often found in green and blue sub-habitats such as parks, gardens, (artificial) lakes and harbour areas. However, even as hostile environments as concrete buildings and paved roads may host living organisms and hence biodiversity.

Because of the diverse and artificial characteristics of constructed habitats it is difficult to describe the quality of biodiversity in these habitats. In Table 7.2 we propose indicators that would be relevant to assessing the quality of biodiversity, focusing on indicators mainly associated to the quality and extent of green areas within urban zones. Overall, the availability of relevant monitoring data, however, is very limited.

Table 7.2: Proposed biodiversity indicators for constructed habitats

Quality indicators	Data availability				
	FI	SE	NO	DK	IS
Species indicators					
City and garden birds	1979–2007	1975–2007	1995–2007	1976–2007	1970–2007 (only wintering)
Tree and plant species in city areas	Grass-herb forest and fen plants in Helsinki 1900–2004	Inventory of 316 urban woodlands in 34 cities 2004	Possibly, some estimates can be made	No data	No data
Small rodents/mammals	No data	No data	No data	Possibly, data for red fox	No data
Underwater plants in city lakes	No data	No data	No data	No data	No data
Habitat indicators					
Proportion of green areas in cities	Possibly, some estimates can be made	Green area cover in cities 1980–2000	Possibly, some estimates can be made	Copenhagen: 2000. Possibly, historical estimates can be made	Possibly, some estimates can be made

Certain bird species can be associated with city areas such as parks and gardens and hence be used as indicator species for these sub-habitats (Jacobsen 2002). For example, the blackbird (*Turdus merula*) is well adapted to conditions of man-made habitats, including nesting and feeding in private gardens. Figure 7.4 shows population trends for selected urban birds in Finland, Sweden and Denmark. The selection of species was made by experienced ornithologists. Bird population increases between 30% and 40% are seen in Finland and Denmark since 1980, whereas the tendency is slightly decreasing in Sweden. The data suggest that birds in gardens and parks are generally adapting well.

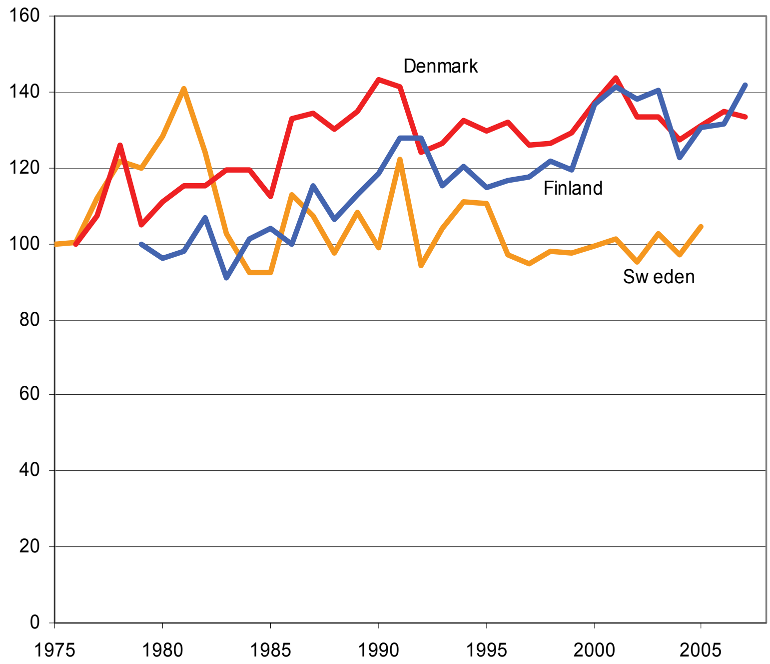

Figure 7.4: Population indices for breeding birds associated with city areas (parks and gardens) in Finland, Sweden and Denmark.

FI: 14 species: common pheasant (*Phasianus colchicus*), stock pigeon (*Columba oenas*), wood pigeon (*Columba palumbus*), common swift (*Apus apus*), house martin (*Delichon urbicum*), white wagtail (*Motacilla alba*), fieldfare (*Turdus pilaris*) , blue tit (*Cyanistes caeruleus*), great tit (Parus major), magpie (*Pica pica*), jackdaw (*Corvus monedula*), hooded crow (Corvus cornix), greenfinch (*Carduelis chloris*), and house sparrow (*Passer domesticus*)

SE: 7 species: common swift (Apus apus), greenfinch (Carduelis chloris), house sparrow (Passer domesticus), tree sparrow (Passer montanus), blackbird (Turdus merula), jackdaw (Corvus monedula) and magpie (Pica pica).

DK: 8 species: common swift (*Apus apus*), greenfinch (*Carduelis chloris*), house sparrow (*Passer domesticus*), tree sparrow (*Passer montanus*), collared dove (*Streptopelia decaocto*), blackbird (*Turdus merula*), jackdaw (*Corvus monedula*) and magpie (*Pica pica*).

Industrial and post-industrial development has transformed most European regions into societies where a vast majority of the population is living in towns and cities. In the Nordic countries 76–92% of the population is living in settlements with more than 200 inhabitants and 25–70% in urban agglomerations with more than 100 000 inhabitants (Gundersen et al. 2005). Urban areas in the Nordic countries have relatively large proportions of green areas compared to many southern and western European cities. In Copenhagen 13% of the city area remains occupied by green areas (Copenhagen Municipality 2003), in Helsinki over one third of the city area is designated as ‘green space’ (Vähä-Piikkiö & Maijala 2005) and in Swedish cities urban woodlands cover an average proportion of 20% (Hedblom & Söderström 2008). Furthermore, studies in Sweden have shown that larger proportions of deciduous trees and dead wood are found in city woodlands and woodlands close to the city than in the average Swedish forest (Hedblom & Söderström 2008). Also, urban woodlands in Sweden have the same number of bird species within the city as in the woodlands surrounding the city, suggesting that biodiversity could be high in cities (Hedblom 2007). Only few historical data, however, have been obtained and hence it has not been possible to deduce trends in extent and quality of urban green areas.

7.3 Biodiversity index

As described in Chapter 6, we aim at describing the state of biodiversity by computing an index that shows the *quantity* dimension of biodiversity on the x-axis and the *quality* dimension on the y-axis. As the data availability for constructed habitats (N1) is very limited, we chose to calculate indices based on birds data only. Therefore, the quality dimension of the indices should be interpreted with caution.

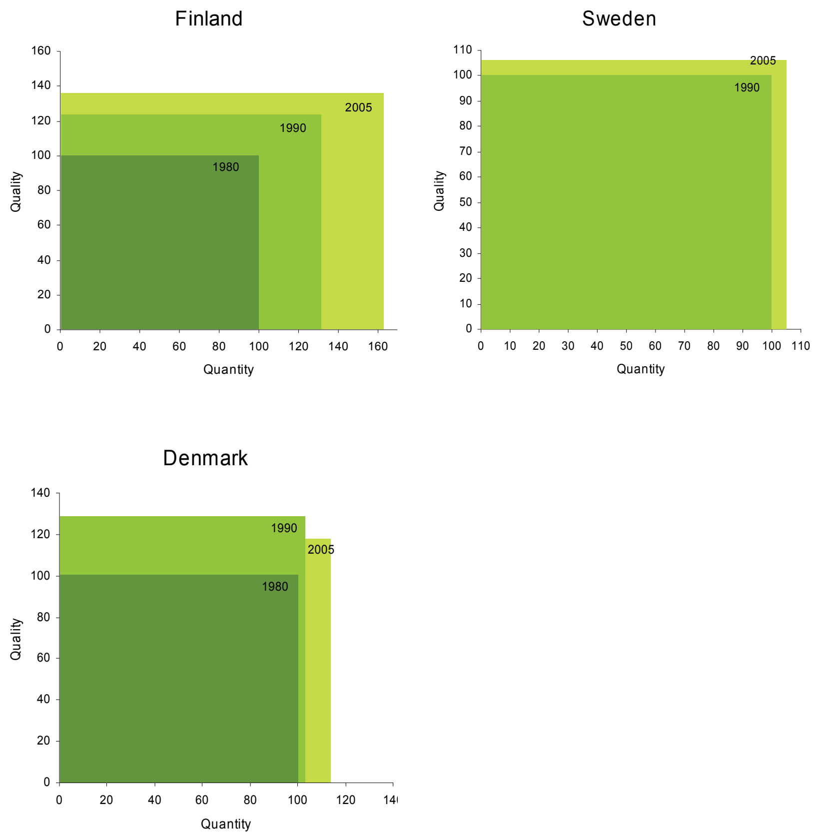

Figure 7.5: Biodiversity indices for constructed habitats in Sweden, Finland and Denmark. Quantity is measured as the area of constructed habitats (N1) and quality as the abundance of urban birds. Units are indexed with the first year = 100.

Figure 7.5 illustrates the development in indices for constructed habitats for Finland, Sweden and Denmark. Although there are differences between the three countries, the general tendency is the same. Over the last 2-3 decades both quantity and quality have increased, most markedly in Finland. Whereas the increase in the quality dimension signals a positive trend for biodiversity, the increase in quantity of constructed habitats has – in contrast to the other main habitats – a negative impact on biodiversity (see below).

7.4 Conclusions and recommendations

In all Nordic countries the quantity of constructed habitats is growing at a steady rate. This trend in land use puts biodiversity under increasing pressure, because cities and infrastructure are increasingly replacing habitats with higher biodiversity values, such as forest coastal habitats, farmland and grasslands. The current trend indicates that reaching the target of halting biodiversity loss by 2010 is weakened by the ongoing expansion of constructed habitats in the Nordic countries.

Present data available for urban areas suggest that there are surprisingly good potentials for high biodiversity in certain urban sub-habitats such as parks and woodlands (Hedblom & Söderström 2008). However, there are relatively few existing time series, describing biodiversity quality in urban areas and hence it is difficult to describe temporal changes. More information is expected to be available in the near future, for example in Sweden when the Environmental Monitoring Program (NILS) will start monitoring urban areas.

We recommend that monitoring of biodiversity in urban areas will become an integrated part of future monitoring programmes in the Nordic countries and that the definitions concerning constructed habitats will be made more uniform in future. Focus should be directed at determining the extent of green areas in cities and on monitoring key species such as birds, vascular plants and tree composition. Since urban biodiversity plays an important role for the general state of biodiversity (e.g. Petersen et al. 2007) it is relevant that urban planning in all major cities in the Nordic region will deal with the protection of biodiversity. Finally, we would like to emphasize that if the 2010 target is to be met in the Nordic countries, the on-going expansion of constructed habitats (including buildings and infrastructure) will need to be reduced.

8. Indicators for farmland

Key messages
The area of farmland has decreased by about 3% since 1990.
Populations of common farmland birds have decreased between 10% and 30% since 1980.
The share of fallow land has dropped dramatically, from 11% in 2005 to 6% in 2008 (following the phase-out of EU set-aside schemes).
The share of organic farming stands unchanged at 6% since 2000.
Relatively good data availability for farmland.

Farmland includes agricultural and horticultural areas that are cultivated or have been cultivated recently. For the purpose of this project farmland is divided into two sub-classes. The Unmixed and mixed crops sub-habitat (N2.1) includes all land that is regularly cultivated; i.e. is part of a regular agricultural rotation cycle. Unlike permanent grassland, rotational grassland is included in this class. Furthermore, this class also includes market gardens and horticulture. Fallow or recently abandoned land (N2.2) includes agricultural land that is not part of a regular rotation cycle but has been cultivated recently and which has a high probability of being cultivated again within few years. The class includes fields abandoned or left to rest, and other interstitial spaces on disturbed ground.

8.1 Quantity of biodiversity

The availability of area data for farmland is listed in Table 8.1. It shows that area data go back more than a hundred years in Sweden, Norway and Denmark, whereas data are only available since 1975 and 1980 in Finland and Iceland, respectively. Area data for the sub-habitats N2.1 and N2.2 are available in Finland since 1975, in Sweden since 1981 and in Denmark since 1861. In Norway and Iceland no data for sub-habitats are available.

Table 8.1: Availability of area data for farmland

Habitat	FI	SE	NO	DK	IS
N2 Regularly or recently cultivated land	1975–2007	1865–2007	1900–2007	1861–2007	1900–2007
N2.1 Unmixed and mixed crops	1975–2007	1981–2007	1900–2007	1861–2007	1900–2007
N2.2 Fallow or recently abandoned land	1975–2007	1981–2007	No data	1861–2007	No data

Figures 8.1 and 8.2 show the present quantity of farmland in the Nordic countries. The total of 85 000 km² of farmland makes up about 6.5% of the total land area of the Nordic countries. Farmland covers approximately 25 000 km² in each of the countries Finland, Sweden and Denmark, summing up to almost 90% of the total farmland area in the Nordic Countries. Norway and Iceland have a relatively small share of farmland in the Nordic region. In Denmark farmland constitutes as much as 60% of the total national land area. In comparison farmland takes up only 6% of the land area in Finland and Sweden, 2.2% in Norway and 1.3% in Iceland (Figure 8.2).

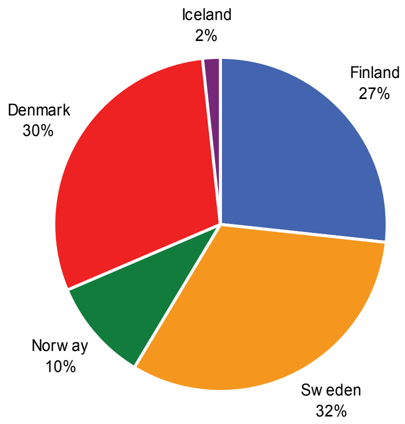

Figure 8.1: Distribution of farmland between the Nordic countries (total farmland area: 84 700 km²).

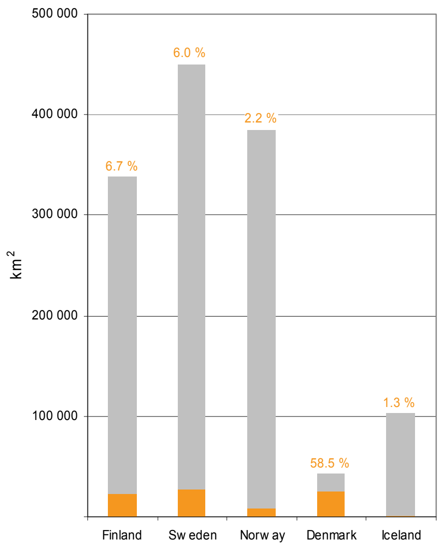

Figure 8.2: Proportion of farmland of total land area in each of the Nordic countries.

In Norway, Denmark and Sweden the area of farmland increased until the first half of the 20th century (Figure 8.3). Following this period, the area of farmland decreased substantially in Sweden and to some degree in Denmark. This decrease was mainly caused by the abandonment of agricultural land. The same tendency can be seen for Finland, while in Norway and Iceland the area of farmland has only changed slightly in this period. Overall, the area of farmland in the Nordic countries has decreased only slightly (3%) since 1990. While the overall tendencies in the development of farmland area are realistic, some of the annual fluctuations (e.g. the substantial decrease in Finland in the mid 1990s) are probably caused by changes in definitions and methods.

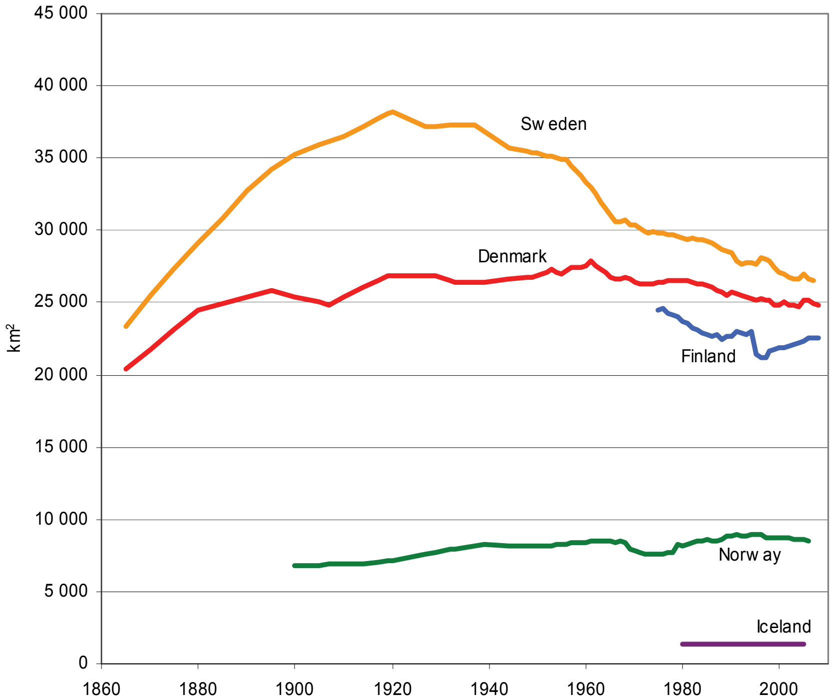

Figure 8.3: Trends in the area of farmland (N2) in the Nordic countries.

8.2 Quality of biodiversity

In Table 8.2 we propose indicators that would be relevant in order to assess the quality of biodiversity in farmland. The list includes information on existing data-sources with a sufficient geographical coverage. The best comparable data are found for the abundance of farmland birds, the proportion of organic farming and for the proportion of fallow land. Also, hunting statistics are available in all countries, but these are only indirect measures of biodiversity.

Table 8.2: Proposed biodiversity indicators for farmland

Quality indicators	Data availability				
	FI	SE	NO	DK	IS
Species indicators					
Farmland birds (breeding)	1983–2007	1975–2007	1995–2007	1976–2007	No data
Butterflies/insects	1999–2007	2004–2008 (butterflies and bumble bees)	No data	Population trends may be constructed from red lists and atlas surveys	No data
Wild plants/weeds	Abundance of the most common weeds on spring cereal fields in the 1960s, 80s and 90s	No data	Few data series	No data	No data
Mammals	1989–2007	2003–2007 (field hare and elk)	Few data series	Population trends may be constructed from atlas surveys	No data
Hunting statistics	Few data series	1939–2007 (deer, boar, wild rabbit, fox)	1900–2007	1941–2007 (roe deer and hare)	1995–2006 (birds)
Habitat indicators					
Share of organic farming	1990–2007	2001–2007	1992–2007	1988–2007	1996–2007
Share of fallow land	1975–2007	1981–2007	No data	1861–2007	No data
Density of small biotopes such as hedgerows	No data	2003–2008	Possibly	1992–2006	No data
Density of field margins	No data	2003–2008	Possibly	1998–2006	No data
Mean field size	1990–2007	No data	Possibly	1998–2006	1998–2006
Soil quality	N-balance 1985–2005	N-balance some data	Fertilizer use 1900–2006	N-balance 1980–2005	Fertilizer use 1921–2007

The best farmland species indicator that we could establish is the abundance of common farmland birds in Finland, Sweden, Norway and Denmark (Figure 8.4). Expert ornithologists have found that bird species are useful indicators for the state of biodiversity in different habitats, including farmland (Gregory et al. 2005). Farmland birds feed on insects, which again feed on weeds and green plants in and around the fields.

Figure 8.4 shows population trends of eight common farmland birds. Although there are yearly fluctuations in the abundance, there is a clear tendency that over the last three decades the abundance of these farmland birds has decreased in all countries. Since 1980, the bird populations show decreases between 10% and 30%. This indicates a general decrease in the habitat quality of farmland. At a European level, similar indicators for farmland birds have been calculated and these also show declines over the past 2–3 decades (Gregory et al. 2005, EEA 2007).

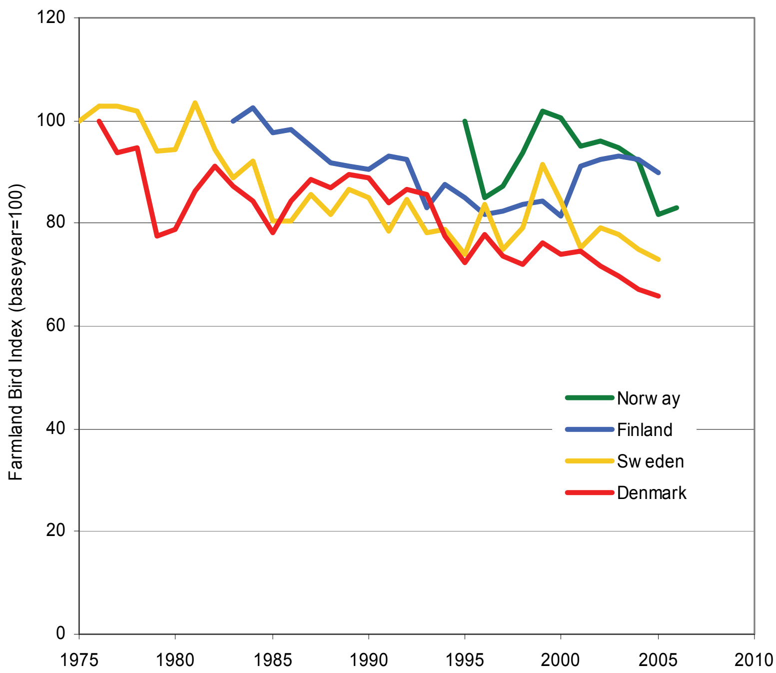

Figure 8.4: Population trends of eight common farmland birds in the Nordic countries (except Iceland).

We have selected species that are common in all four countries and for which data on the abundance are available. The species are: lapwing (*Vanellus vanellus*), wood pigeon (*Columba palumbus*), skylark (*Alauda arvensis*), swallow (*Hirundo rustica*), whinchat (*Saxicola rubetra*), whitethroat (*Sylvia communis*), starling (*Sturnus vulgaris*) and yellowhammer (*Emberiza citronella*).

For Finland, Denmark and Sweden, data on the area of fallow or recently abandoned land (N2.2) are available. Fallow land and abandoned fields often form spaces for plant and animal species within the more intensively farmed land and are hence important for the conservation of biodiversity. Figure 8.5 shows development in the share of fallow or recently abandoned land over the last three decades. The sudden changes that occur lie in government policies. In the mid 1990s the European Commission introduced set-aside schemes with the purpose to reduce agricultural production. This lead to a substantial increase in the area of fallow land in Denmark and a more modest increase in Sweden. In Finland, however, the story was different; before Finland joined the EU in 1995 farmers were obliged to let at least 15% of their fields lie fallow. This obligation was lifted in 1995 and since then the fallow area declined.

Although it is difficult to estimate the impact of area changes in fallow land on the quality of farmland, it has probably had a beneficial effect on the abundance of many farmland and open land species. In the long run a beneficial effect on farmland species would depend on the stability of fallow and abandoned land. However, as prices for agricultural products are now currently rising and EU's set-aside schemes have been phased out from 2008, the area of fallow and abandoned land has decreased dramatically. The share of fallow land in Finland, Sweden and Denmark has almost halved, from 11% in 2005 to 6% in 2008. The decrease has been most markedly in Denmark where the area of fallow land dropped by as much as two thirds from 2006 to 2008 (Figure 8.5).

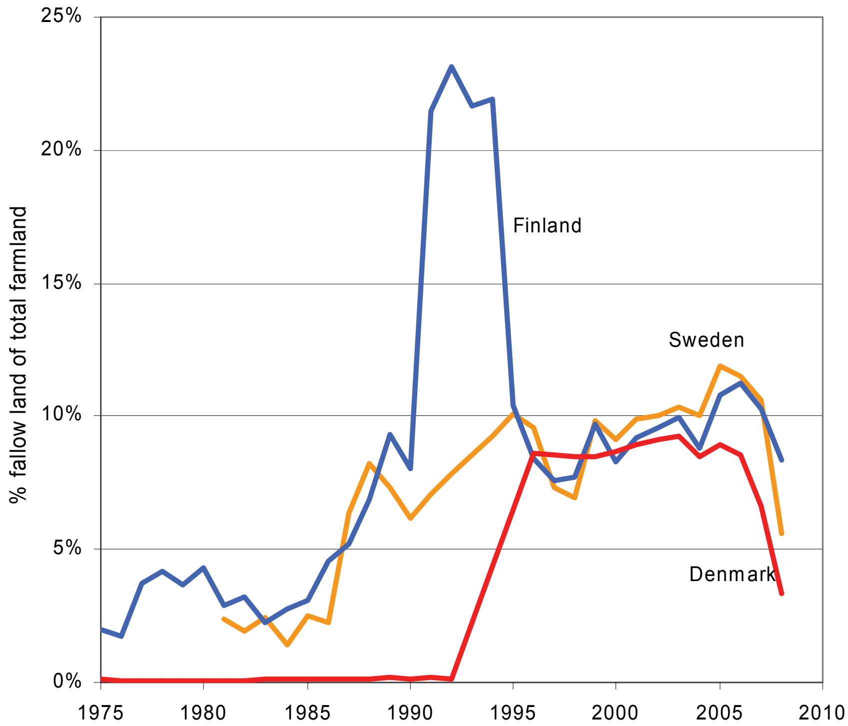

Figure 8.5: Trends in the share of fallow or recently abandoned land (N2.2) in Sweden, Finland and Denmark.

It is relatively well-documented that organic farming due to the ban on chemicals has a beneficial effect on flora and fauna within the area of cultivated land and in edge biotopes (Aude et al. 2003, Tybirk et al. 2003). Furthermore, recent research indicates that organic farming leads to higher crop diversity and smaller field parcels, which is beneficial for many farmland species (Levin 2007). The proportion of organic farming is hence a useful proxy-indicator for the general habitat quality of farmland. Figure 8.6 shows the development of the proportion of organically farmed land in the Nordic countries. Following high growth rates in the 1990s the growth stopped around 2000 in all Nordic countries except Norway. The proportion of organically farmed land currently makes up

6.0% of all farmland in the Nordic countries. Sweden and Finland have the largest proportions (6.8% and 6.4%, respectively).

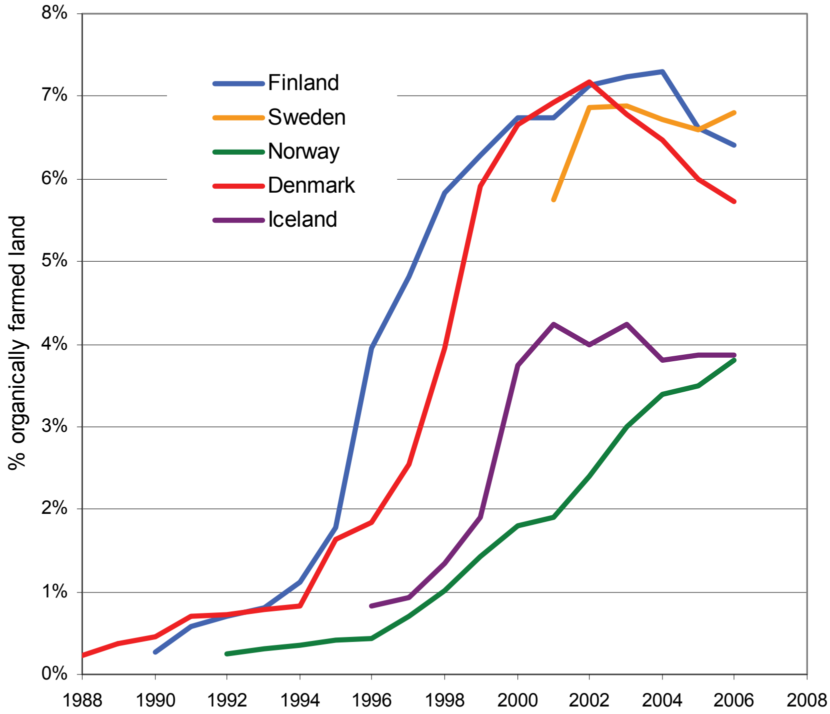

Figure 8.6: Trends in organically managed farmland in the Nordic countries as a percentage of total farmland.

8.3 Biodiversity index

As described in Chapter 6, we aim at describing the state of biodiversity by computing an index that shows the *quantity* dimension of biodiversity on the x-axis and the *quality* dimension on the y-axis. We have chosen to calculate a farmland index on the basis of trends in farmland area and on the basis of population trends of farmland birds, which is a well-established quality indicator for farmland. Although data for some habitat structure indicators are available (e.g. share of fallow land), we have chosen abundance of farmland birds as this is the most consistent and therefore comparable dataset for farmland quality.

Figure 8.7 shows farmland indices for Norway, Finland, Sweden and Denmark. As the availability of data varies between countries, for each country a different index year was chosen. Although there are differences between the countries, the general tendency is the same. Over the last approximately three decades both quantity and quality has decreased. The most dramatic changes are seen in Denmark, where the biodiversity quality has declined by more than 30% since 1976.

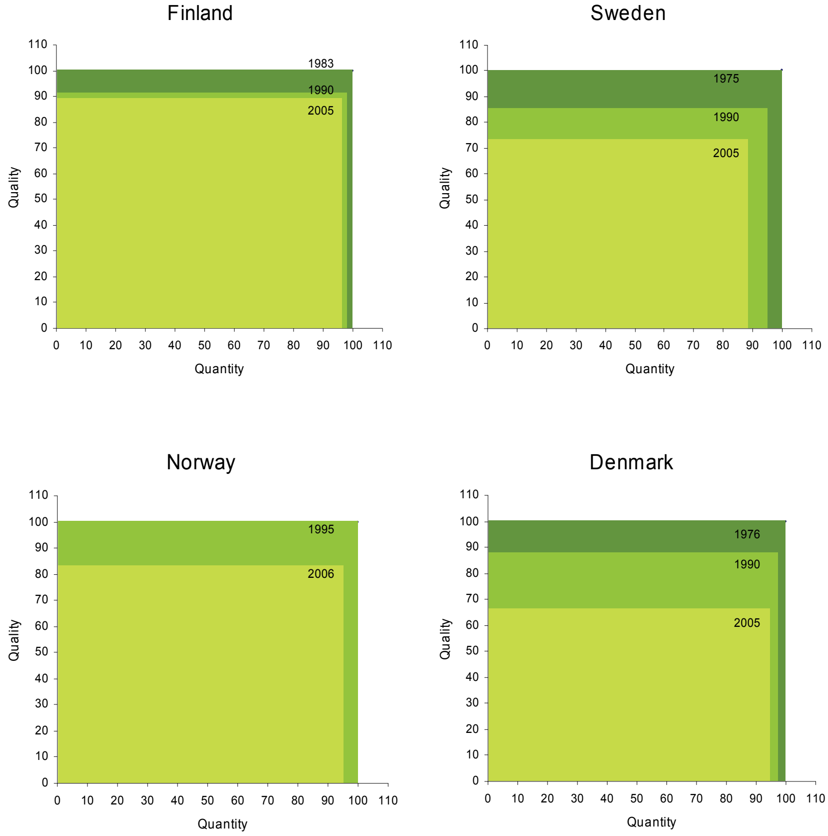

Figure 8.7: Farmland indices for the Nordic countries (except Iceland). Quantity is measured as the area of farmland (N2) and quality as the abundance of eight common farmland birds. Units are indexed with the first year = 100.

8.4 Conclusions and recommendations

The total farmland area in the Nordic region has decreased since the second half of the last century. In Sweden the decrease was about 30%, whereas minor decreases were found in Denmark and Finland and *status quo* in Norway and Iceland. In Denmark farmland takes up the majority (about 60%) of the total land area, whereas in the other countries farmland constitutes a minor share (less than 6%).

Since the mid 1990s the area of fallow land and set-aside land increased substantially. However, as EU subsidies to set-aside land are currently being phased out large parts of these areas have been and is expected to be re-cultivated within the near future. As a consequence the long term effect on biodiversity of the increase in fallow land during the past 20 years is probably limited. Since the introduction of national schemes for organic farming about 30 years ago, the area under organic farming has increased considerably. This increase has probably had a beneficial effect on many farmland species. During the last three decades the abundance of common farmland birds has decreased in Finland, Norway, Sweden and Denmark, suggesting that the biodiversity quality is decreasing.

While the availability of area data for farmland in the Nordic countries is good, there is a general lack of data for the biodiversity quality of farmland except for birds. In order to properly evaluate the development of farmland habitats, there exists a need to strengthen assessments of relevant parameters for farmland quality. These include abundances of farmland species but also information on the spatial composition of farmland landscapes. Moreover, as most farmland species depend not only on cultivated land, but also on natural and semi-natural habitats, imbedded in a matrix of cultivated land, we recommend that more effort should be put into the assessment of the whole farmland landscape. A landscape approach, focusing on the farmed landscape as a mosaic of cultivated, semi-natural and natural habitats and on linkages between these habitat types would be valuable. Recently started landscape monitoring systems as the 3Q programme in Norway (Dramstad et al. 2003), NILS in Sweden (Esseen et al. 2008) and the small biotope programme in Denmark (Levin and Brandt 2006) as well as comparable data from Finland (Hietela-Koivu 2003) can form a useful data source for a more landscape oriented assessment.

If the 2010 target for farmland (i.e. halting the decline in biodiversity by 2010 for this habitat class) is to be met, it will require a reduction of the negative pressures such as the use of agro-chemicals. We recommend that the restoration and establishment of natural and semi-natural habitats in the farmed landscape is promoted. Furthermore, making environment-friendly agricultural production more economically attractive would be a way forward in order to preserve biodiversity.

9. Indicators for coastal habitats

Key messages	
☹	The area of dunes and seashore meadows has decreased dramatically in Denmark (not documented in the other countries).
☺	Populations of white-tailed eagle and seals have increased significantly since 1990.
☹	The area of Norway's coastal zone that is affected by buildings has increased by 5% since 1990.
☹	Lack of data prevents a thorough assessment of state and trends of biodiversity in coastal habitats.

This main class includes land areas occupying coastal features and characterised by their proximity to the sea. Coastal habitats include coastal sand and dune (substrate composed of sand including inland dunes), coastal shingle (substrate composed of shingle), rock cliffs, ledges and shores, and seashore meadows and marshes. The latter consist of substrate composed of siliceous or decomposing organic material and they are often characterised by a saline or brackish water supply and plant species tolerating these conditions.

9.1 Quantity of biodiversity

The availability of area data for coastal habitats in the Nordic countries is very poor as shown in Table 9.1. Only a few data series have been obtained, mainly in Denmark.

Table 9.1: Availability of area data for coastal habitats

Habitat	FI	SE	NO	DK	IS
N4 Coastal habitats	2005 (estimate)	No data	No data	2000	2000
N4.1 Coastal sand and dune	No data	No data	No data	1881–1919, 2000	No data
N4.2 Coastal shingle	No data	No data	No data	No data	No data
N4.3 Rock cliffs, ledges and shores	No data	No data	No data	No data	No data
N4.4 Coastal and seashore meadows and marshes	No data	No data	No data	1946–2000	2000

In Figures 9.1 and 9.2 the present quantity of coastal habitats is shown for Finland, Iceland and Denmark. No data was obtained for Sweden and Norway. Coastal habitats take up 1 500 km^2 in Finland, 750 km^2 in Iceland and 568 km^2 in Denmark. In Denmark, the extent of the nature types sand and dune (N4.1) and meadows and marshes (N4.4) have declined dramatically in the 20th century (Figure 9.3). Similar data could not be obtained in the other Nordic countries.

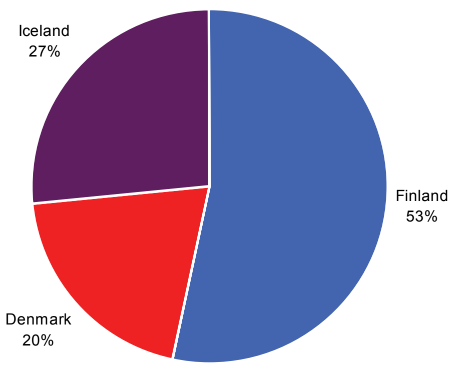

Figure 9.1: Distribution of coastal habitats in the Nordic countries (total area: 2 800 km^2).No data for Sweden and Norway.

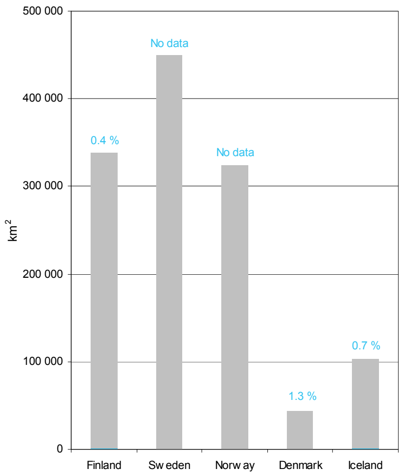

Figure 9.2: Proportion of coastal habitats of total land area in each of the Nordic countries.

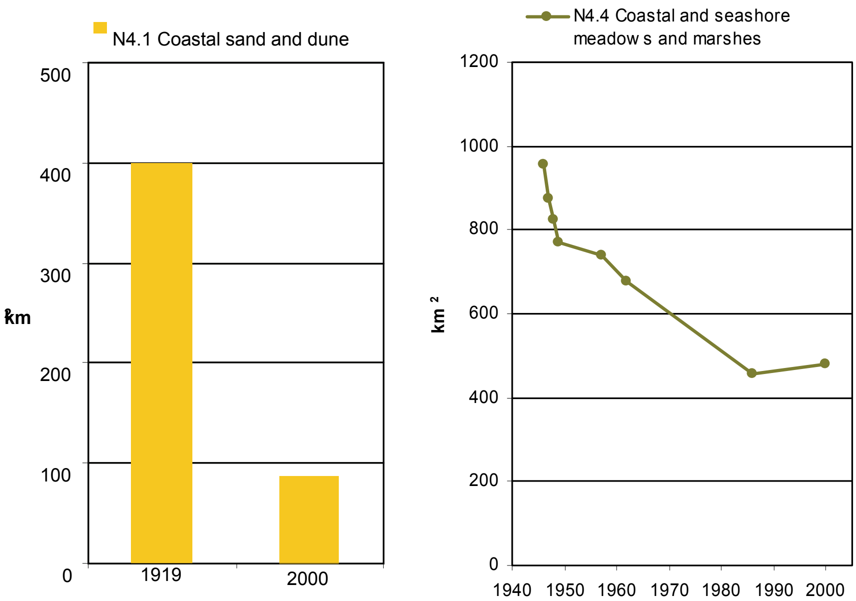

Figure 9.3: Trends in the area of two coastal habitats in Denmark.

9.2 Quality of biodiversity

In Table 9.2 we propose indicators that are relevant to assessing the quality of biodiversity in coastal habitats. The table includes information on existing national monitoring schemes with a sufficient geographical coverage. Overall, the availability of relevant monitoring data is limited. Data series for birds and seals are the most comprehensive available.

Table 9.2: Proposed biodiversity indicators for coastal habitats

Quality indicators	Data availability				
	FI	SE	NO	DK	IS
Species indicators					
Waterfowl and birds nesting on rock cliffs	1983–2007	1975–2007	1995–2007	1976–2007	Possibly data on eider
White-tailed eagle (and other birds of prey)	1970–2007 (sporadic data for pre-1970)	1924–2007 (sporadic data for pre-1900)	2000 (estimate)	1950–2007 (sporadic data for pre-1950)	1870–2008
Seals	2000–2008 (grey seal)	1976–2007 (harbour, ringed and grey seal)	Some data	1976–2007 (harbour seal)	1975–2008
Habitat indicators					
Buildings in coastline	1999	1992–2005	1985–2007	No data	No data
Proportion of pristine meadows	No data	No data	No data	No data	No data

Breeding populations of white-tailed eagle are found along the coasts of Northern Europe, where they feed on fish and smaller birds. At present there are about 5 000 pairs in the Nordic region of which about 4 000 pairs nest in Norway. As illustrated in Figure 9.4 the white-tailed eagle underwent dramatic declines in the first half of the 20th century, which even led to its extinction in Denmark. However, since the 1970s it has recovered in all parts of the Nordic region. This is a result of general improvements in feeding and nesting conditions and of directed conservation actions such as the protection of breeding areas. Hence, this trend for white-tailed eagle indicates a positive development for the conservation of biodiversity, although the pre-1900 state has not yet been reached.

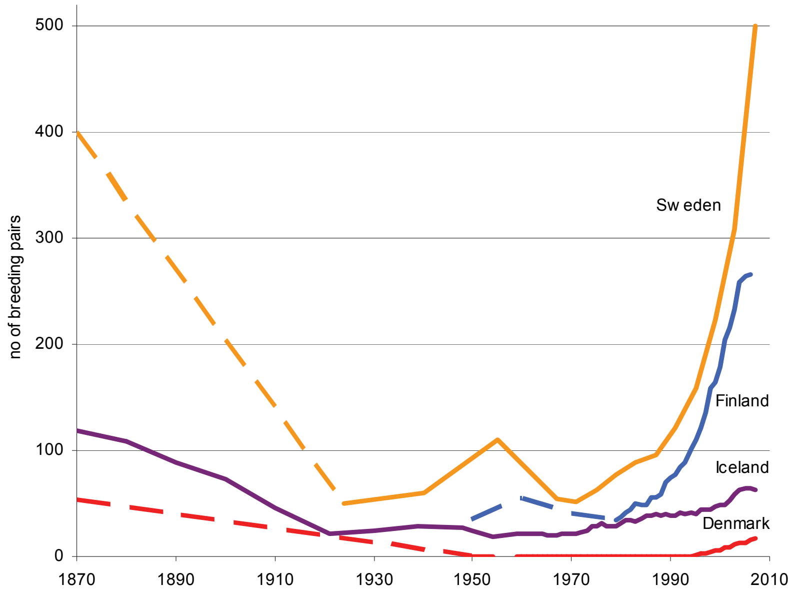

Figure 9.4: Occurrence of white-tailed eagle in Sweden, Finland, Iceland and Denmark. No trend data could be obtained for Norway but it is estimated that 3 500 to 4 000 pairs are nesting along the Norwegian coastline.

Information about waterfowl and birds nesting on rock cliffs can be obtained from the comprehensive data series on bird point counts performed since the 1970s in the Nordic countries (except Iceland). However, the distinction of waterfowl between different coastal, inland water and other habitats is very difficult and has not been solved within the timeframe of this project. Therefore, only data for the white-tailed eagle is shown here.

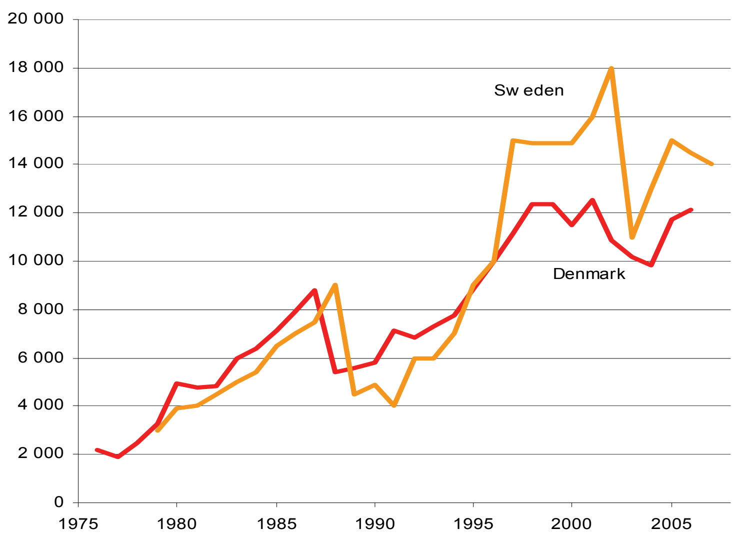

Figure 9.5: Estimated numbers of harbour seal (Phoca vitulina) in the coastal areas of Sweden and Denmark.

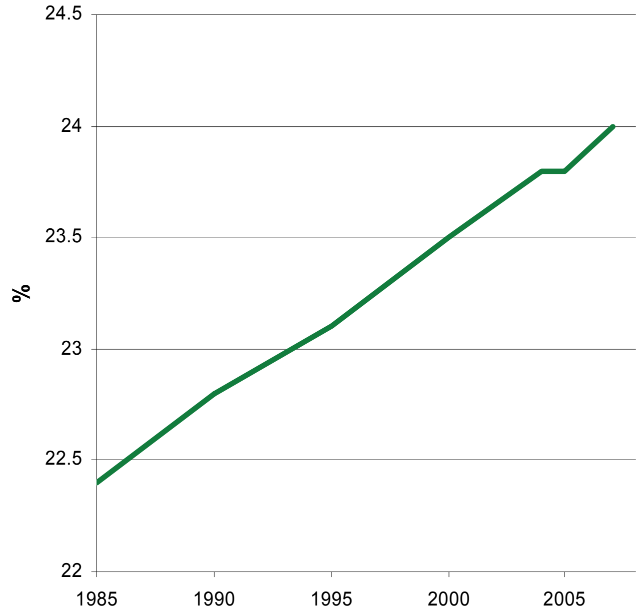

Figure 9.6: Proportion of Norway's coastal zone affected by buildings (areas less than 100 m from buildings).

Various species of seals live in the coastal areas of the Nordic region. Seal colonies are often concentrated around sites on undisturbed coasts, reefs, beaches and islands, where they breed, moult and rest. The seal populations in most parts of the Nordic region have experienced repeated declines caused by hunting and epizootics in the 19th and first part of the 20th century (Olsen et al. 2009). However, after the introduction of protection laws in the 1960–70s, the populations of seals have generally increased in the Nordic region. For example, the number of harbour seal (*Phoca vitulina*) in Sweden and Denmark has increased by more than 500% in 30 years (Figure 9.5). Also, in recent years the grey seal (*Halichoerus grypus*) has slowly started to recover after its near-extinction in the Nordic region about 100 years ago (Härkönen et al. 2007). The positive trends are mainly due to bans on seal hunting and protection of breeding sites. Population trends for seals should therefore be used with caution when assessing the state of biodiversity.

To assess changes in biodiversity in coastal areas, more indirect indicators than population trends may also be applied. For coastal meadows and marshes (N4.4) the proportion of pristine sites would be a useful measure of biodiversity (as is the case for mires; see Chapter 12.2). But no such data including data on drainage could be obtained. Another possible measure is the proportion of man-made constructions, such as harbours, buildings and holiday homes, in the coastal zone. In Norway the percentage of the coastal zone affected by buildings has increased from 22.4% in 1985 to 24.0% in 2007 (Figure 9.6). Data from Sweden and

Finland suggest similar trends. These trends indicate an increased pressure on the state of coastal nature habitats.

9.3 Biodiversity index

As described in Chapter 6, we aim at describing the state of biodiversity by computing an index that shows the *quantity* dimension of biodiversity on the x-axis and the *quality* dimension on the y-axis. However, it is currently not possible to produce such an index for any of the coastal habitats, due to lack of area data (quantity) and to some extent also quality data. Further scrutinising available data series may lead to the construction of additional indicators but this would require additional work, which will exceed the scope of this project.

9.4 Conclusions and recommendations

Trends in the extent of coastal habitats is difficult to describe because of lack of historic data. However, we believe that the main change that has occurred during the last decades is the expansion of built-up areas as indicated by data on buildings in the coastal zone. As a consequence the extent of coastal nature types has decreased. In Denmark negative trends in the extent of dunes and coastal meadows is well documented.

Data on white-tailed eagle and seals show positive trends. However, these trends are mainly influenced by directed protection actions and should therefore be taken with caution as indicators for biodiversity. Based on the existing knowledge we are not able to determine an overall trend in the quality of biodiversity in coastal habitats.

We recommend that existing data series on birds are investigated further to obtain relevant indicators for coastal habitats. Furthermore, monitoring of land use in coastal areas should be standardized and extended in all Nordic countries, including the analysis of historical information and maps. Also, we recommend that monitoring of buildings in the coastal zone should be implemented in all countries, based on the methods used in Norway. Overall, the changes in land use in the coastal zone suggest that the goal of halting biodiversity loss by 2010 is not met for this main habitat class as long as natural areas are replaced by and/or increasingly influenced by the development of constructed habitats.

10. Indicators for inland waters

Key messages	
☺	The ecological quality of lakes (measured as nutrient loads and visibility depth) has improved in Denmark and is unchanged in Finland since 1990.
☺	The ecological quality of running waters has improved in Denmark since 1990 (no data for the other countries).
☹	Populations of important macro invertebrates, pondweed and fish species in Danish streams have more than halved in the second half of the 20th century.
😐	Relatively good data availability for running waters but more limited availability for standing waters. No historical area data available.

The habitat class inland surface waters consists of all inland areas with a water surface and of the adjoining littoral zones such as sedges and reed beds. Standing waters (N5.1) refer to lakes, ponds and extremely slow-moving parts of rivers. Running waters (N5.2) refer to rivers, streams and springs. Small ponds and streams only a few meters wide are generally not included.

10.1 Quantity of biodiversity

The data availability for the area of inland surface waters in the Nordic countries is shown in Table 10.1. Present data are available. Historical data are difficult to obtain but in some cases rough estimates can be made.

Table 10.1: Availability of area data for inland surface waters

Habitat	FI	SE	NO	DK	IS
N5.1 Surface standing waters	2000	2000	2007	2000	2000
N5.2 Surface running waters	2000	2000	2007	2000	2000

In Figures 10.1 and 10.2 the present quantity of inland water bodies is shown for the Nordic countries. Standing waters cover a total of 93 000 km^2 in the Nordic region, which corresponds to about 7.4% of the total land area of the region. Most of the standing waters are found in Sweden and Finland with 42% and 35% of the total Nordic standing water area, respectively (Figure 10.1). The area of standing waters is relatively small in Iceland and Denmark, amounting to only 1–2% of the total water area. Running waters take up a total of 4 000 km^2, corresponding to 0.3% of the total land area of the Nordic region. Sweden, Finland and Norway have each 25% to 30% share of running waters (Figure 10.1).

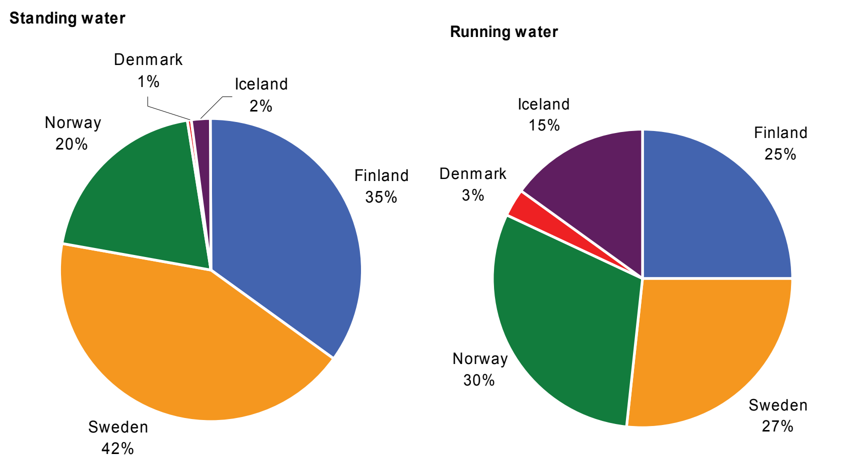

Figure 10.1: Distribution of standing waters (total: 93 000 km^2) and running waters (total: 4 000 km^2) between the Nordic countries.

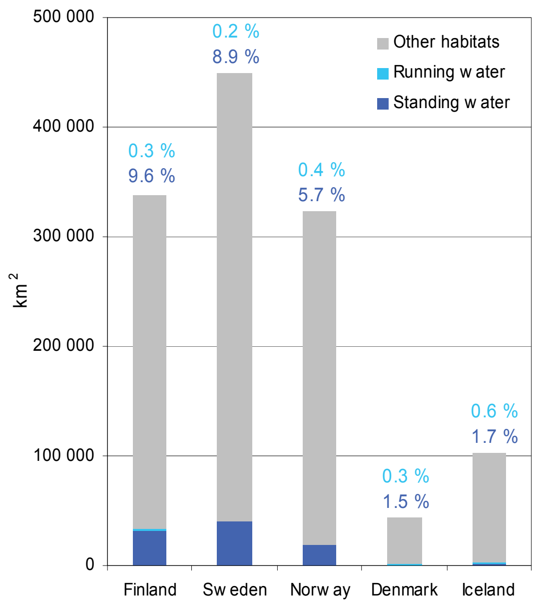

Figure 10.2: Proportion of inland waters of total land area in each of the Nordic countries.

When taking the relative size of the countries into consideration, Finland and Sweden have the largest proportions of inland waters; i.e. almost 10% of the total land area (Figure 10.2). Denmark has the smallest coverage with 1.8% of the total land area.

It has not been possible to obtain consistent historical data for the quantity of inland waters in the Nordic countries. Only a few rough estimates can be made. For example in Finland, the biggest change in the past century has been the construction of about 800 km^2 artificial lakes (water reservoirs), corresponding to a 2.5% increase. Also, a number of smaller lakes have been drained in Finland in the past century, but these changes will not contribute much to the total trend in Finland's area of inland waters. In Denmark, the landscape is criss-crossed by about 35 000 km of natural watercourses and 25 000 km of artificial ditches and channels. Development, and especially agricultural development, has meant that watercourses have been changed extensively.

The drainage of land for agriculture and forestry purposes that has taken place in large parts of the Nordic region during the past century have possibly lead to decreases in the extent of inland water bodies. Straightening of streams, particular in Denmark and the southern parts of Sweden and Finland, for the purpose of drainage channels may also have lead to a decrease in the total area of running waters. However, it has not been possible to obtain consistent data that can describe these developments.

10.2 Quality of biodiversity

In Table 10.2 and 10.3 we propose indicators that would be relevant to assessing the quality of biodiversity in inland water habitats. The tables include information on all existing national monitoring schemes with a sufficient geographical coverage. Overall, the availability of relevant monitoring data is relatively good for running waters but more limited for standing waters.

Table 10.2: Proposed biodiversity indicators for standing waters

Quality indicators	Data availability – N5.1 standing waters				
	FI	SE	NO	DK	IS
Species indicators					
Underwater plants (macrophytes)	No data	No data	Some data	No data	No data
Macroinvertebrates	Crayfish 2006–	No data	Some data	No data	No data
Fish	Vendace 1988–2006	1979–2007 (fishing data)	Some data	No data	1970–2008 (fishing data)
Waterfowl	1986–2007	1976–2007	1995–2007	1976–2007	1976–2008 (lake Mývatn)
Mammals	Ringed seal in Saimaa lake 1990–2007	No data	No data	No data	No data
Habitat indicators					
Ecological quality indices[1]	Benthic quality index	Benthic quality index	No data	No data	No data
Visibility depth	1980–2006	1986–2007 (individual lakes)	Some data (individual lakes)	1989–2007	No data (only Mývatn)
Chlorophyll concentration	1980–2006	1978–2007 (individual lakes)	Some data (individual lakes)	1989–2007	No data (only Mývatn)
Phosphorous/nitrogen concentration	1980–2007	1978–2007 (individual lakes)	Some data (individual lakes)	1989–2007	No data (only Mývatn)
Underwater vegetation cover	No data	1986–2007 (individual lakes)	Some data (individual lakes)	1993–2007	No data (only Mývatn)

[1] See Skriver (2001) for description of ecological quality indices

Table 10.3: Proposed biodiversity indicators for running waters

Quality indicators	Data availability – N5.2 running waters				
	FI	SE	NO	DK	IS
Species indicators					
Underwater plants (macrophytes)	No data	1986–2007	Some data	16 pondweed and 18 other plant species 1896,1996	No data
Macroinvertebrates	Crayfish 2006–	No data	Some data	43 species 1915,1940, 1960,1975	No data (only Laxá)
Fish	European river lamprey 1977–2005 Atlantic salmon in two rivers 1979–2004 Saimaa salmon in river Pielisjoki 1990–2005	1989–2007 (data for 13 000 running waters)	Some data	14 fish species 1967,2000	1970–2008 (fishing data)
Waterfowl	No data	No data	Some data	No data	No data (only Laxá)
Mammals	Perhaps otter	Some data for otter	Some data	Otter 1985–2004	Not relevant
Habitat indicators					
Ecological quality indices[1]	No data	Danish Water Fauna Index	No data	Danish Water Fauna Index 1984–2007	No data
Visibility depth	1960–2006	1962–2008	Some data (selected rivers)	No data	No data
Chlorophyll concentration	1982–2006	1962–2008	Some data (selected rivers)	No data	No data
Phosphorous/nitrogen concentration	1976–2007	1962–2008	Some data (selected rivers)	1989–2007	No data
Underwater vegetation cover	Sporadic monitoring data from some lakes	No data	Some data (selected rivers)	No data	No data

[1] See Skriver (2001) for description of ecological quality indices

In the case of standing waters, few species data sources are available, mainly for waterfowl. However, a clear definition of what species of birds that can be associated to standing waters in the different parts of the Nordic region has not yet been made. Further work here may result in a useful bird indicator for standing waters.

The best available data series for the quality of standing waters are those linked to physiochemical characteristics, such as phosphorous, nitrogen and chlorophyll-*a* concentrations. However, the available data series generally cover only a limited number of lakes (Sweden, Norway and Iceland) and therefore it is difficult to estimate trends at a national level. For Denmark and Finland we have obtained data at a national level.

The concentrations of phosphorus and chlorophyll-*a* have decreased and the visibility depth has increased in 22 Danish lakes since 1989 (Figure 10.3). These trends indicate a positive development for biodiversity. In Finland, data on chlorophyll-*a* reveal no measurable changes in both eutrophic, humic and clear-water lakes since 1982 (Figure 10.4). Pre-1980 data could not be obtained.

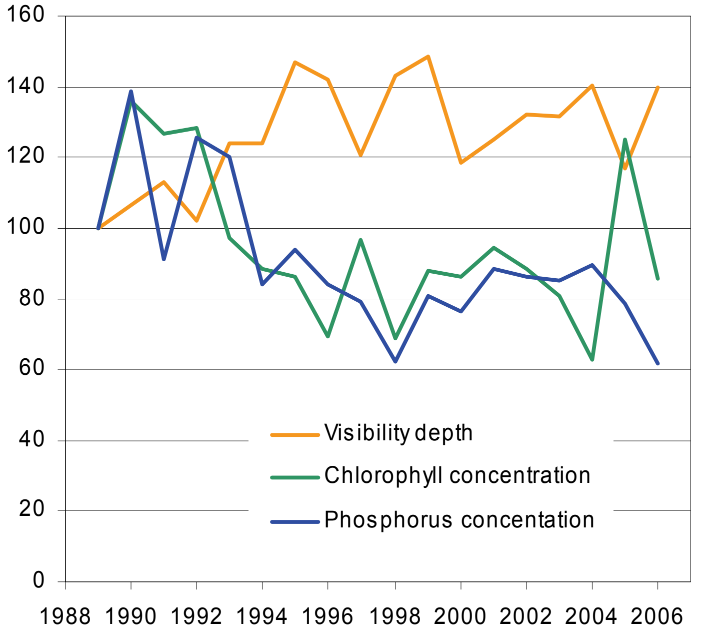

Figure 10.3: Trends in phosphorous and chlorophyll concentrations and visibility depth in 22 lakes in Denmark (Index 1989 = 100).

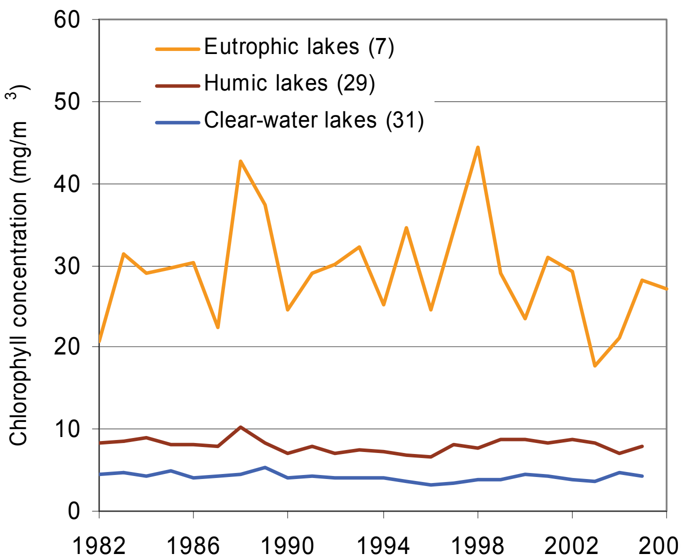

Figure 10.4: Trends in chlorophyll concentrations in 7 eutrophic, 29 humic and 31 clear-water lakes in Finland.

For running waters, the data availability is better than for standing waters. Especially in Denmark, historic data series of high relevance exist. In Figures 10.5 to 10.7 various indicators for aquatic species suggest that the biodiversity quality in Danish streams has declined substantially during the 20th century. On the positive side, however, Figure 10.8 indicates that the quality has increased since 1984 as indicated by the Danish Watercourse Fauna Index (WFI) and the occurrence of European otter (*Lutra lutra*). The WFI is based on a range of measures of ecological quality in a network of stations in more than 1000 locations.

Quality of Danish streams I
(16 pondweed and 18 non-pondweed species)

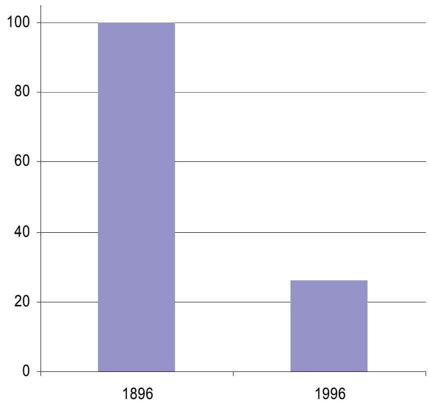

Figure 10.5: Occurrence of 16 pondweed species and 18 other underwater plant species in streams in Denmark in 1896 and 1996. Index 1896 = 100.

Quality of Danish streams II
(43 macro invertebrates)

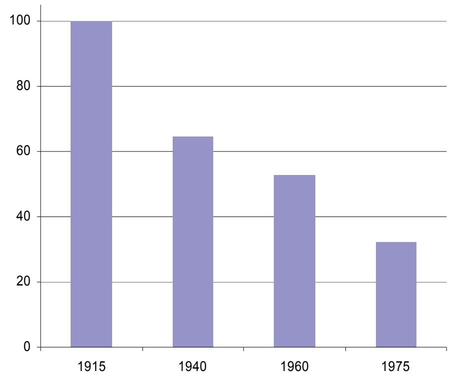

Figure 10.6: Occurrence of 43 macro invertebrates (23 may fly species and 20 stone fly species) in streams in Denmark in 1915, 1940, 1960 and 1975. Index 1915 = 100.

Quality of Danish streams III
(14 fish species)

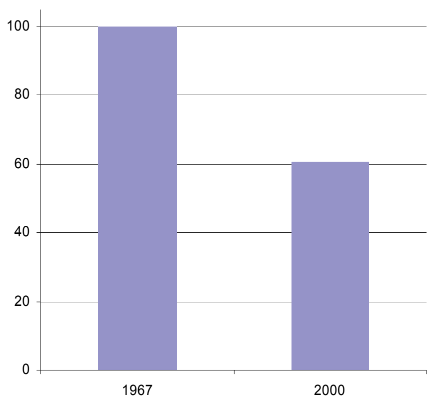

Figure 10.7: Occurrence of 14 freshwater fish species in three streams in Denmark in 1967 and 2000. Index 1967 = 100.

Quality of Danish streams IV
(Watercourse Fauna Index and occurrence of otter)

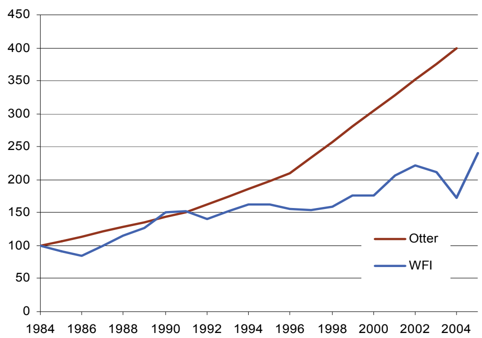

Figure 10.8: The Watercourse Fauna Index (WFI) and occurrence of European otter (Lutra lutra) in Denmark since 1984. WFI corresponds to the proportion of streams in a good ecological state (classes 5, 6, 7). Index 1984 = 100.

10.3 Biodiversity index

As described in Chapter 6, we aim at describing the state of biodiversity by computing an index that shows the *quantity* dimension of biodiversity on the x-axis and the *quality* dimension on the y-axis. However, it is currently not possible to produce such an index for the inland water habitats, because we were not able to obtain data that show temporal changes in the quantity of these habitats. Further scrutinising available data series may lead to the construction of additional indicators but this would require additional work, which will exceed the scope of this project.

10.4 Conclusions and recommendations

It is well known that some main changes in the extent of inland water bodies in the Nordic region have occurred in the past century. These changes include the drainage of smaller lakes, straightening of streams and construction of water reservoirs. Yet, no historical data that can describe these trends at a national or regional level could be obtained.

Some indicators on the biodiversity quality of inland waters exist. In Denmark these indicators suggest that the biodiversity quality of inland waters have decreased substantially in the past century but that it seems to be recovering since the 1980s. In Finland data on chlorophyll reveals no measurable changes since the 1980s. Less data have been obtained for the other Nordic countries, but – based on information about individual lakes and rivers – similar trends as in Denmark and Finland are anticipated. That is, strong declines in biodiversity during the second half of the 20th century followed by improvements or steady-state over the past one to two decades. However, these are assumptions and not based on a sufficient amount of data.

In order to properly evaluate the development of inland water habitats, there exists a need to strengthen assessments of relevant parameters for both quantity and quality. These include historical trends in the extent of water bodies and the abundances of indicator species. We recommend that common quality indices, such as the Danish Watercourse Fauna Index (WFI), will be applied to lakes and rivers in all of the Nordic countries. Moreover, it is necessary to establish monitoring of selected indicator species if changes in biodiversity are to be measured in the future. We find that if the 2010 target for inland waters (i.e. halting the decline in biodiversity by 2010) is to be met, it will require a reduction of the negative pressures such as the loss of nitrogen and phosphorous from agriculture and forestry. However, it is not the aim of the NordBio2010 project to suggest which policy actions would be needed.

11. Indicators for unvegetated/ sparsely vegetated habitats

Key message
☹ Lack of data and methodology prevents an assessment of the state of biodiversity in these habitat types

This main class includes inland areas with no or very little vegetation cover (less than 30%), such as inland rocks, snow or ice dominated habitats and volcanic areas. These habitats are mainly found in the alpine zones of the Nordic region.

11.1 Quantity of biodiversity

The availability of area data for unvegetated/sparsely vegetated habitats in the Nordic countries is very limited. Only area estimates for Finland, Norway and Iceland could be obtained (Table 11.1).

Table 11.1: Availability of area data for unvegetated/sparsely vegetated habitats

Habitat	FI	SE	NO	DK	IS
N6 Unvegetated/sparsely vegetated habitats	**2000**	**No data**	**2007 (estimate)**	**No data**	**2000**
N6.1 Inland cliffs, rocky outcrops and screes	2000	No data	No data	No data	2000
N6.2 Snow or ice dominated habitats	2000	No data	No data	Not relevant	2000 (extent of glaciers)
N6.3 Recent volcanic features	Not relevant	Not relevant	Not relevant	Not relevant	2000
N6.4 Miscellaneous habitats with very sparse or no vegetation	No data	No data	No data	No data	2000

The total Nordic area of unvegetated/sparsely vegetated habitats constitutes 143 000 km^2. Of this area 44% is found in Iceland, 41% in Norway and the remaining 15% in Finland (Figure 11.1). It can be assumed that the area of these habitat types is negligibly small in Denmark, except perhaps for a few rocky formations in Bornholm. For Sweden information is lacking on the area of these habitats. In Iceland the unvegetated/sparsely vegetated habitats are dominant and cover more than 60% of the total land area (Figure 11.2). Glaciers constitute 18%, volcanic areas 16% and inland bare fields and rocks the remaining 66% (Figure 11.3). The interior, the highlands, of Iceland belongs to the arctic/alpine zone. The lack of trees and the nakedness are typical features of the interior highlands. Forests, dominated by birch and willow, occupy only 1% of the Icelandic land area (Icelandic Agriculture Ministry 1986). Changes in the distribution of the unvegetated/sparsely vegetated habitats can occur as a result of climate change (e.g. extension/contraction of permanent snow and ice), human impacts (e.g. reforestation) or volcanic activity. However, no historical data to illustrate these changes could be obtained for this project.

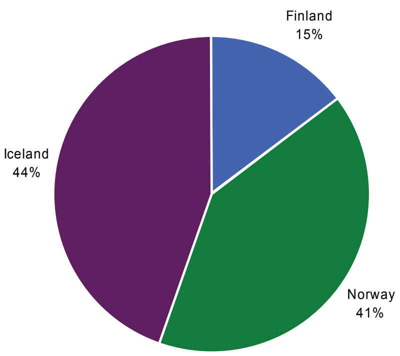

Figure 11.1: Distribution of unvegetated/ sparsely vegetated areas in the Nordic countries (total area: 143 000 km²).No data for Sweden, Norway and Denmark

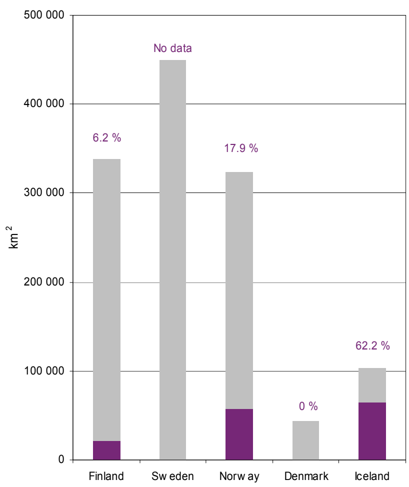

Figure 11.2: Proportion of unvegetated/sparsely vegetated of total land area in each Nordic country.

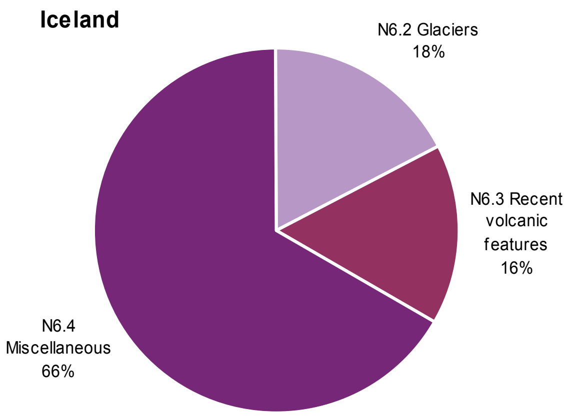

Figure 11.3: Distribution of unvegetated/sparsely vegetated sub-habitats in Iceland. 'Miscellaneous' includes inland rocks.

11.2 Quality of biodiversity

Given the fact that these habitat types by definition contain very sparse or no vegetation the biodiversity is low. Nevertheless, some organisms depend on these hostile habitats. A general lack of data on species trends and lack of methodology prevents an assessment of the quality of biodiversity in these habitat types. Further scrutinising available data series and research done in these sparsely vegetated environments could lead to the development of a methodology that can describe the biodiversity. However, this would require additional work, which will exceed the scope of the NordBio2010 project.

11.3 Biodiversity index

It is not possible to produce an aggregated index for any of the unvegetated/ sparsely vegetated habitats, as a result of a general lack of data.

11.4 Conclusions and recommendations

Trends in the area of unvegetated/sparsely vegetated habitats can not be described adequately because of lack of data. These habitats are most predominant in Iceland (62% of total land area), including glaciers, inland rocks and volcanic features. The extent of glaciers and ice-covered areas will have to be monitored intensively in the future to document the impacts of climate change. We recommend that monitoring of biodiversity in sparsely vegetated habitats would need to be more coordinated with the aim to describe temporal developments of important indicator species. Such data is currently not available.

12. Indicators for mires

Key messages
The area of mires has decreased by 9% since 1950 and by 1% since 1990.
The share of pristine (non-drained) mires has decreased by 47% since 1950 and by 5% since 1990 in Finland and Iceland.
Populations of common mire birds have decreased between 17% and 30% in Finland and Denmark since 1980.
Populations of specialist mire butterflies have decreased by almost 50% in Finland since 1991.
Relatively good data availability for mires.

Mires, bogs and fens (henceforth simply mires) are defined as habitats where the uppermost layer of soil consists of peat or where peat-forming plants cover the largest part of the surface. According to this definition some habitats with a continuous tree-cover can also be considered mires. Especially spruce mires may be characterised by considerable tree stands and forest-like conditions. In some cases definitions of different types of mires are not consistent within the Nordic countries, which may cause problems when comparing national area estimates. In any case, the division between mire and forest will always be somewhat arbitrary since in reality the transition between these two habitats normally takes place along a perfect continuum rather than a well-defined edge.

12.1 Quantity of biodiversity

The availability of area data for mires is listed in Table 12.1. Most comprehensive data series are available from Sweden and Finland, where the total area of mires has been recorded by National Forest Inventories since the 1920s and 1950s, respectively. In these countries some individual estimates have also been made of the area of second level mire types such as aapa mires and palsa mires. In Iceland and Denmark data series beginning from the 1940s and 1950s exist for the total mire area, but we were not able to retrieve any estimates of the area of second level types. In Norway data exist only for the present extent of the total mire area and of wooded mires.

Table 12.1: Availability of area data for mires

Habitat	FI	SE	NO	DK	IS
N7 Mires, bogs and fens	1952–2005[1]	1929–2005[2]	2007	1951–2000	1940–2007
N7.1 Raised and blanket bogs	No data	No data	No data	No data	Not relevant
N7.2 Transition mires and poor fens	No data	No data	No data	No data	No data
N7.3 Aapa mires	No data	2000	No data	Not relevant	No data
N7.4 Palsa mires	1998	2007	No data	Not relevant	No data
N7.5 Wooded mires	1980–2005	2000	2007	No data	No data

[1] Annual data from 2003 onwards, before that data exist only for National Forest Inventory periods
[2] Annual data from 1992 onwards, before that data exist only for National Forest Inventory periods

In Figures 12.1 and 12.2 the present quantity of mires is shown for the Nordic countries. Approximately half of the total Nordic mire area (166 000 km^2) is found in Finland (Figure 12.1). Sweden has the second largest share of all mires, amounting to 27% of all Nordic mires. The remaining one-fifth of the area is divided between Norway (11%), Iceland (7%) and Denmark (1%). When mire areas are considered relative to the total areas of the countries in question the distribution becomes more even. In Finland one-quarter of the total land area is covered by mires (Figure 12.2). In Sweden and Iceland this figure is between 10% and 12%, whereas in Norway and Denmark 6% and 2% of the total area can be classified as mires, respectively.

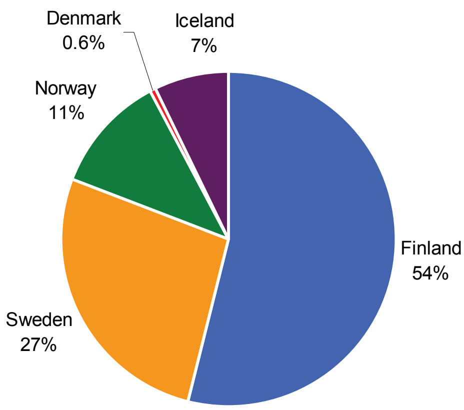

Figure 12.1: Distribution of mires between the Nordic countries (total mire area: 166 000 km^2).

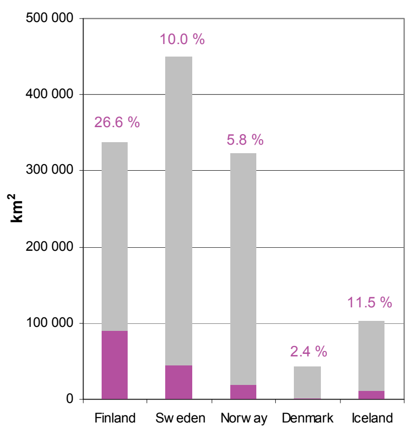

Figure 12.2: Proportion of mires of total land area in each of the Nordic countries.

In each Nordic country where time series on total mire area are available, the extent of mires has been declining since the 1950s (Figure 12.3). The total area of mires has decreased by 9% since 1950 and by 1% since 1990. The decline has been most pronounced in Sweden where the total mire area has shrunk by almost 15% since 1950. In Finland and Denmark the decline has been between 6% and 8%.

In Finland and Iceland, data on the area of pristine mires versus drained mires are also available. These show that of the remaining mire area in Finland and Iceland, 55% and 30% have been drained, respectively. The total share of pristine mires has decreased by 47% since 1950 and by 5% since 1990. In the lowland of Iceland the proportion of drained or affected mires is much higher. In the other Nordic countries mires have also been drained at a large scale but no exact data exist on this. In Denmark and Iceland mires have mainly been drained for agriculture and in Sweden and Finland for forestry. The biodiversity quality of newly drained farmland or forest habitats is normally quite low. Peatlands that have been turned into forest are normally heavily altered by forestry operations such as thinning, clear-cutting and soil preparation. Other uses of mires include peat production as well as construction of traffic areas and hydropower (water reservoirs built on mires).

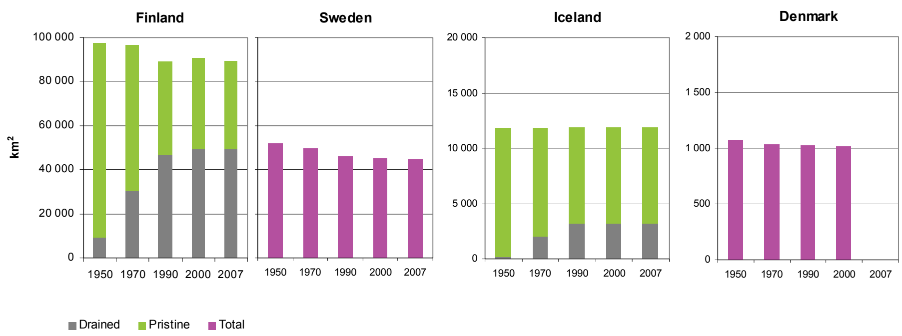

Figure 12.3: Trends in the area of mires in Finland, Sweden, Iceland and Denmark 1950–2007.

Little information exists on the area of the second level mire habitats. Due to mainly economic interests the area of wooded mires (spruce and pine mires) has been monitored in Finland at least from the seventh National Forest Inventory (1980–) onwards. The present area of wooded mires is also known for Sweden and Norway. Since very few wooded mires exist (or are defined as such) in Denmark and Iceland, the present wooded mire area in the Nordic countries can be estimated at 91 700 km^2, based on these figures. This equals more than half of the total mire area in the Nordic countries. The estimate is, however, made imprecise by the different definitions employed in different countries for wooded and open mires. In Sweden, for example, mires are considered open if the crown cover of trees growing on the mire is less than 30%. In Finland only virtually treeless mire are classified as open mires.

Recently, the extent of palsa mires has been estimated in Sweden and Finland. Palsa mires are of special interest in the Nordic countries since the Scandinavian mountain range and Iceland are the only localities where this habitat type occurs in non-Russian Europe. In Sweden the present area of palsa mires has been estimated at 251 km^2. In Finland a detailed survey found 42 km^2 of palsa hummocks, whereas the total area of mires with palsas was estimated at 415 km^2 (Sihvo 2002). The latter figure can be considered representing palsa mires in a wider sense. In Iceland mires with palsas are less than 50 km² scattered in the central highlands with the largest in Þjórsárver and Guðlaugstungur, 12 and 10 km² respectively. No figures exist yet for Norway although a palsa mire monitoring programme has been underway since 2004 (Hofgaard 2004).

12.2 Quality of biodiversity

In Table 12.2 we propose indicators that would be relevant to assessing the quality of biodiversity in mire habitats. The table includes information on all existing national monitoring schemes with a sufficient geographical coverage. Overall, the availability of relevant monitoring data is limited. In total we have proposed three species indicators and five habitat indicators. Most indictors, however, could be determined for only one or two countries. Several data series on breeding birds are available, but outside Finland the data covers only a small part of the mire avifauna. In Finland 12 of the altogether 20 mire bird species are amongst the approximately 90 most common breeding birds covered sufficiently by annual transect counts. The population trends for these species could be derived using standardised methods. In Denmark trend data for six wetland/mire bird species could be obtained and in Sweden reliable data exist only for two mire bird species.

Table 12.2: Proposed biodiversity indicators for mires

Quality indicators	**Data availability**				
	FI	**SE**	**NO**	**DK**	**IS**
Species indicators					
Birds (breeding and migrant)	1983–2007	1975–2007	1995–2007	1980s–2007	No data
Butterflies	Occurrence of 8 day-active species 1991–2007	No data	No data	No data	No data
Plants	Occurrence and coverage of >100 species 1950–1995	No data	No data	No data	No data
Habitat indicators					
Proportion of pristine mires[1]	1950–2007	2003–2007	No data	No data	1950–2007
Conservation status for mires (EU Habitats Directive)	2007	2007	No data	2007	No data
Area of restored mires	1989–2005	No data	No data	No data	1996–2005
Dead wood in wooded mires	Possibly 1996–		No data	No data	No data
Connectivity	Pre 1950s vs. present state	No data	No data	No data	No data

[1] Shown in Figure 12.3

The best mire species indicators that we could establish are breeding populations of Finnish and Danish birds (Figure 12.4) and the occurrence of Finnish day-active butterflies (Figure 12.5). All of these indicators show declining trends over the past decades. In the case of birds, population decreases between 17% and 30% occur in Finland and Denmark since 1980. In Finland, the distribution area of mire specialist butterflies have been shrinking especially in Southern Finland, where almost a 50% decline in occurrence has taken place in 1991–2006. Surprisingly, a considerable decline seems to have taken place also in Northern Finland where the state of mires is much better than in the south. Some of the decline may, however, be explained by changes in observation effort.

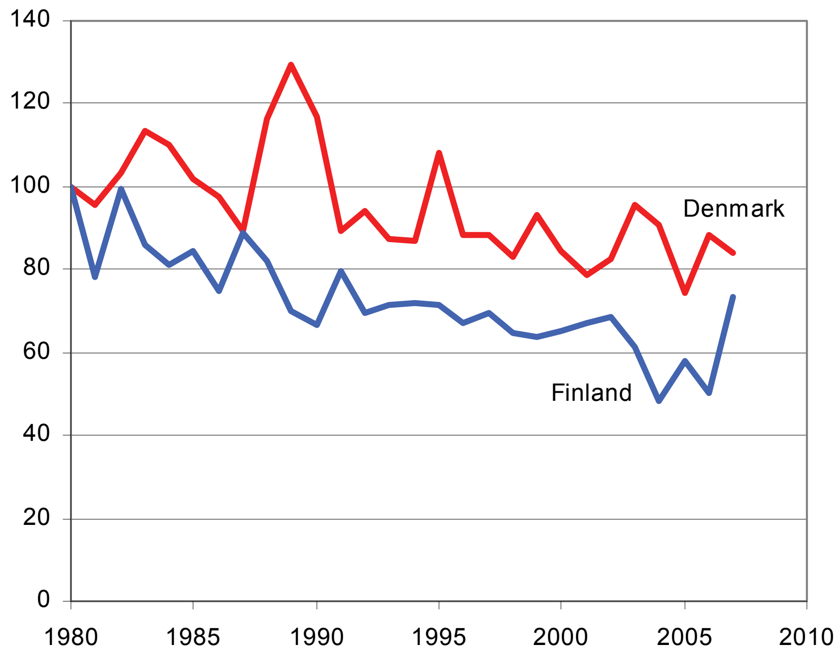

Figure 12.4: Population indices of 12 mire bird species in Finland and 6 mire bird species in Denmark 1980–2007.

Finnish species: common crane (*Grus grus*), golden plover (*Pluvialis apricaria*), ruff (*Philomachus pugnax*), jack snipe (*Gallinago gallinago*), whimbrel (*Numenius phaeopus*), wood sandpiper (*Tringa glareola*), common greenshank (*Tringa nebularia*), meadow pipit (*Anthus pratensis*), yellow wagtail (*Motacilla flava*), lapland bunting (*Calcarius lapponicus*), rustic bunting (*Emberiza rustica*) and reed bunting (*Emberiza schoeniclus*).

Danish species: reed bunting (*Emberiza schoeniclus*), common moorhen (*Gallinula chloropus*), marsh warbler (*Acrocephalus palustris*), common snipe (*Gallinago gallinago*), common grasshopper-warbler (*Locustella naevia*) and sedge warbler (*Acrocephalus schoenobaenus*).

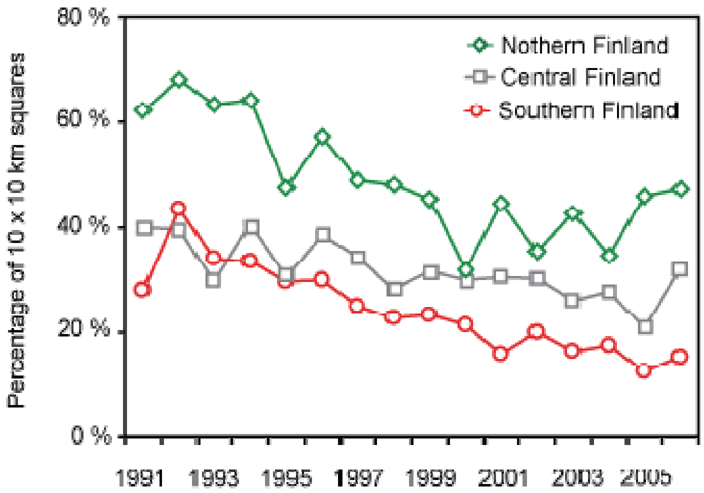

Figure 12.5: Occurrence of eight specialist day-active butterfly species in 10 x 10 km observation squares in Finland 1991–2006.

Species: Grizzled Skipper (*Pyrgus centaureae*), Cranberry Fritillary (*Boloria aquilonaris*), Bog Fritillary *(Boloria eunomia*), Zig-zag Fritillary (*Boloria freija*), Willow-bog Fritillary, (*Boloria frigga*), Lapland Ringlet (*Erebia embla*), Baltic Grayling (*Oeneis jutta*), Large Heath (*Coenonympha tullia*).

In the 2007 reporting of the implementation measures of the EU Habitats Directive, the present conservation status of mire habitat types was determined (EC 2008c). In general, the assessment shows that mires in the northern boreal and alpine regions are clearly in a better state than mires in the southern continental and Atlantic regions. In the alpine region the conservation status of only palsa mires is presently either bad or unfavourable, whereas in the continental and Atlantic region all mire types belong to one of these two classes. In Denmark all mire types are considered to be in an unfavourable state.

12.3 Biodiversity index

No straightforward index could be calculated for mires due to the gaps and inconsistencies in data. However, some estimates can be given of the magnitude of change in the state of Nordic mires during the past 50 years in the form of some preliminary graphs. Based on the figures available from all Nordic countries except Norway, the total area of mires declined by 9% between 1950 and 2007. During the same time, the area of pristine mires shrank by almost 50% in Finland and Iceland, the two countries from where data on drainage exists (Figure 12.6). It is difficult to assess the true and final impacts of drainage on mire ecosystems. Depending on the scale and the possible repetition of drainage (in Finland more than 20 000 km^2 of mires have been drained for the second time so far) as well as the type of mire affected, the impacts of drainage vary greatly. Some drained areas will eventually turn into heathland while others may slowly regain their water balance.

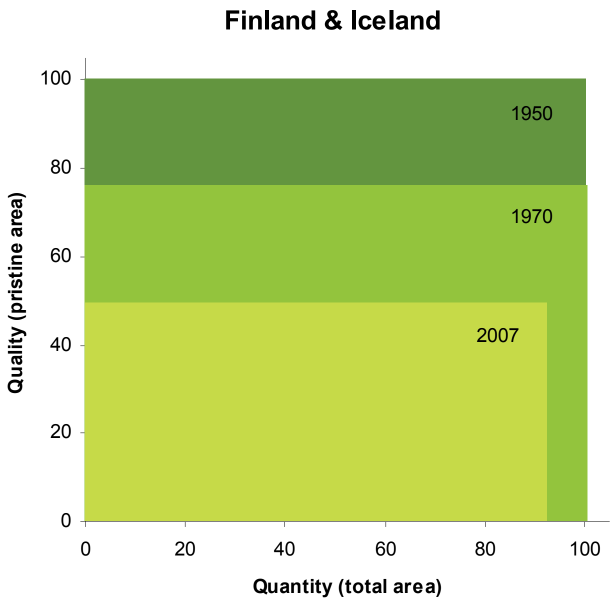

Figure 12.6: Biodiversity index for mires based on data from Finland and Iceland.Quantity is measured as the area of mires (N7) and quality as the proportion of pristine mires. Units are indexed with 1950 = 100.

In Figure 12.7 indices were constructed, where quantity refers to the total mire area and quality to mire bird populations for Finland and Denmark. While the quantity declines only a few percent in the period 1980 to 2000, the quality shows a decrease of 35% for Finland and 15% for Denmark in the same period.

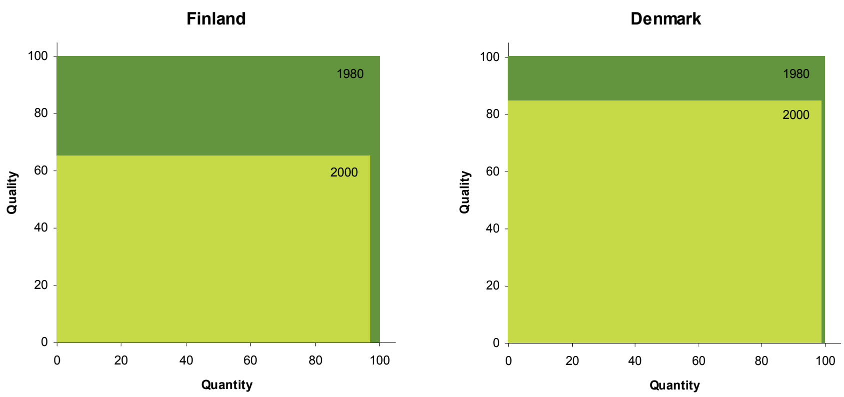

Figure 12.7: Biodiversity indices for mires in Finland and Denmark. Quantity is based on area data and quality on population data for mire bird species. Units are indexed with 1980 = 100.

12.4 Conclusions and recommendations

Mires in the Nordic countries are of special interest in a European policy context. The largest share of the total European mire area can be found in the Nordic countries. However patchy and insufficient they may be, the best monitoring data on mire biodiversity can also be retrieved from the Nordic countries. Thus, Nordic countries have a special responsibility in providing information on mire biodiversity and in keeping the habitat type on the agenda in general.

All of the preliminary indices that we could present in this study point toward a considerable decline in mire biodiversity. Because of the historically dominant view on mires as unproductive wastelands, mires have been heavily altered by humans. This has led to a drastic decline in pristine mire area. It also seems to manifest as declining bird and butterfly populations. Based on these measures, the target of halting biodiversity decline by 2010 is not likely to be met for the mire habitat class. By extending and developing the present monitoring schemes, the Nordic countries could begin to collect comprehensive data on the trends of mire biodiversity with a relatively small additional cost. The monitoring of mire birds and day-active butterflies with similar methods in all countries would already establish a considerable information base. The habitat scale monitoring of special mire types such as palsa mires in the north and raised and blanket bogs in the south should also be organised and coordinated as soon as possible.

13. Indicators for grasslands and shrub heathlands

Key messages	
☹	The area of grasslands has decreased by 40% since 1950.
☺	The area of grasslands has increased slightly since 2000.
☹	The area of scrubs and shrub heathlands has decreased by 40% in Denmark since 1950 (no trend data for the other countries).
☹	Populations of common grassland birds have decreased between 10% and 30% since 1990.
😐	Relatively good availability of area data but limited availability of data on the quality of these habitats.
☹	Varying definitions of habitats and sub-habitats between countries and through time make comparisons difficult.

In this main habitat class (N8) vegetation is dominated by grasses and scrubs. It covers a wide range of sub-habitats that may be divided into more than the five sub-habitats that we have defined here. However, one main obstacle for a more detailed habitat classification is differences in habitat definitions between countries and through time. As there are large differences in vegetation between the different bio-geographical zones, we have chosen to make a distinction between a non-alpine (nemoral/boreo-nemoral/boreal) and an alpine region. Coastal and sea-shore meadows are not included here but in N4.3 (Salt and brackish marshes).

13.1 Quantity of biodiversity

The availability of area data is shown in Table 13.1 with a distinction between non-alpine (N/BN/B) and alpine (A) areas. Based on agricultural statistics time series on grasslands go back more than a hundred years in Denmark and Norway and in Sweden data go back to 1927. In Finland and Iceland only data for one year (1998 and 2000, respectively) could be obtained. In Finland, estimates of changes between 1950 and 2000 in size of red-listed grassland biotopes have been made. However, the results have not yet been made available.

As most of the Nordic data series on grasslands are based on agricultural statistics they are subject to changes in definitions and administrative regulations. For example, a large increase in the grassland area in Sweden from 1993 to 1994 is not realistic but caused by the fact that subsidies for set-aside land were introduced. The definitions of different grassland types deviate between the Nordic countries, and there are several management-dependent grassland types that are not included in the agricultural statistics.

Table 13.1: Availability of area data for grasslands and shrub heathlands

Habitat	FI	SE	NO	DK	IS
Nemoral, boreo-nemoral and boreal (N/BN/B)					
N8 Grasslands and shrub heathlands	1998[1]	With heathland: 2007 Without heathland: 1927–2003	2007[3]	With heathland: 1881–1965, 2000 Without heathland: 1861–2007	2000
N8.1 Dry calcareous and alvar grasslands	No data	2002–2007	No data	Included in N8.2	Not relevant
N8.2 Dry / mesic open grasslands	1998[1]	2002–2007	1900–2006	1861–1962, 2000	No data
N8.3 Dry / mesic wooded grasslands[2]	1998[1]	2007	No data	No data	No data
N8.4 Wet or seasonally wet grasslands	1998[1]	2007	No data	1861–1962, 2000	No data
N8.5 Scrubs and shrub heathlands	1998[1]	2007	No data	1881–1965, 2000	2000[3]
Alpine (A)					
N8 Grasslands and shrub heathlands	No data	2007	No data	Not relevant	2000
N8.1 Dry calcareous and alvar grasslands	No data	2007	No data	Not relevant	Not relevant
N8.2 Dry / mesic open grasslands	No data	2007	No data	Not relevant	No data
N8.4 Wet or seasonally wet grasslands	No data	2007	No data	Not relevant	No data
N8.5 Scrubs and shrub heathlands	No data	2007	2007	Not relevant	2000[3]

[1] The Finnish data represent the most valuable traditional rural biotopes and are hence underestimated compared to the other countries
[2] The sub-habitat N8.3 exists only in non-alpine areas
[3] Expert estimates

Figures 13.1 and 13.2 show the present quantity of grassland and shrub heathland in the Nordic countries. The estimated total area of 126 000 km^2 makes up about 10% of the total land area of the Nordic countries. Norway has the largest share of grassland and shrub heathland (58%.)

Then follows Sweden and Iceland with each 20%. Finnish data are believed to be underestimated compared to the other countries as they cover only *most valuable* traditional rural biotopes.

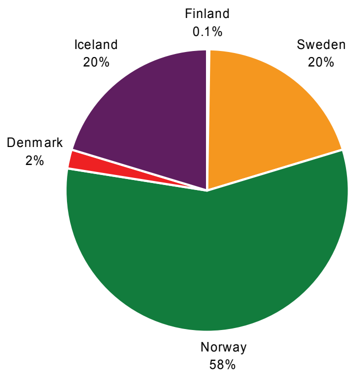

Figure 13.1: Distribution of grassland & shrub heathland (N8) in the Nordic countries (total area: 126 000 km²).

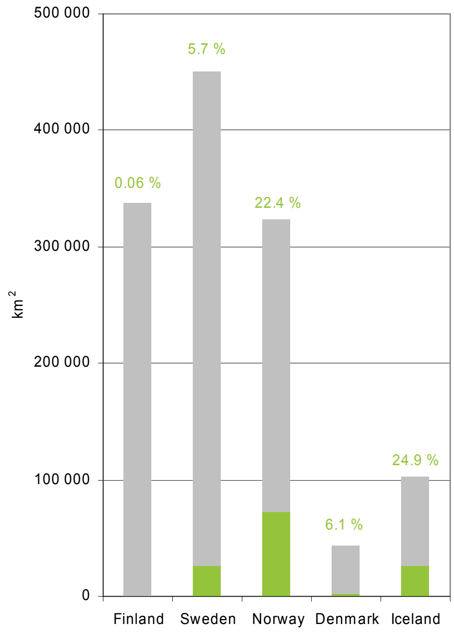

Figure 13.2: Share of grassland & shrub heathland of total land area in each of the Nordic countries.
Finnish data represent most valuable traditional rural biotopes and are hence underestimated compared to the other countries.

Historic data series for grassland was obtained for Sweden, Norway and Denmark and the results show dramatic decreases in grassland area in the 20th century (Figure 13.3). Overall, the area of grasslands has decreased by 40% since 1950. In Norway and Sweden the decline stopped in the 1990s. However, the large increase in the grassland area in Sweden from 1993 to 1994 is not realistic but caused by the fact that EU subsidies for set-aside land were introduced, of which some were classified as grassland. Grasslands are strongly influenced by management. Within the nemoral and boreal zones they are formed by grazing and/or mowing. Grasslands in alpine areas vary a bit more in how they are formed. For example, Sweden has large areas that have previously been grazed and mowed but are now abandoned. Due to that the succession in these areas is slow and the grasslands still exist although abandoned decades ago. In Norway and Iceland there is still a lot of active grazing on alpine grasslands and shrub heathlands. An unknown proportion of the grassland area is influenced by fertilization and often former cultivation. The semi-natural grasslands have considerably larger values for biodiversity than the more cultivated ones, but it is not possible to separate these back in time from the available time series. Historical data for shrub heathland could only be obtained for Denmark. These show an even stronger decline in area than the decline seen for grassland. Since 1950, the heathland area has decreased by 40% in Denmark (Figure 13.4).

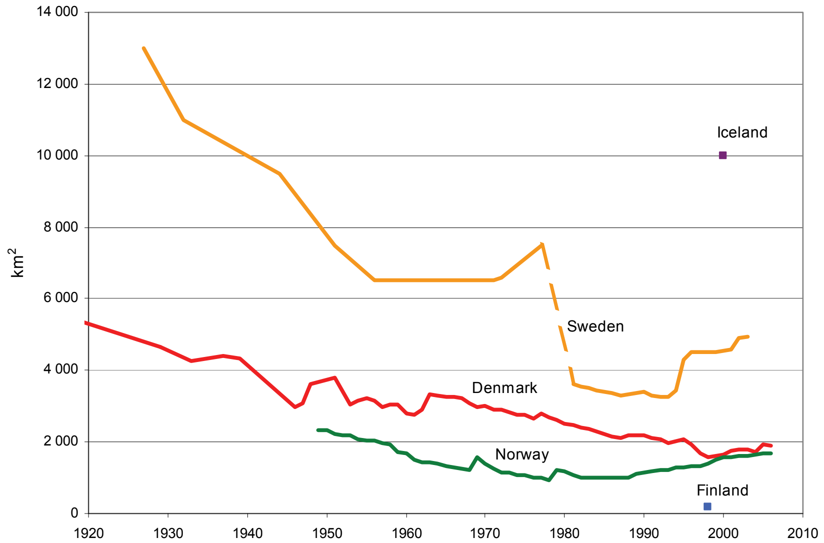

Figure 13.3: Trends in the area of grasslands in the Nordic countries.
Alpine areas and 'scrubs and shrub heathlands' (N8.5) are not included. Finnish data is likely to be under-estimated as explained in the text. Icelandic data is an expert estimate. Swedish data are based on two different data sources; a pre-1980 and post-1980 (which does not include farms with less than 2 ha arable land).

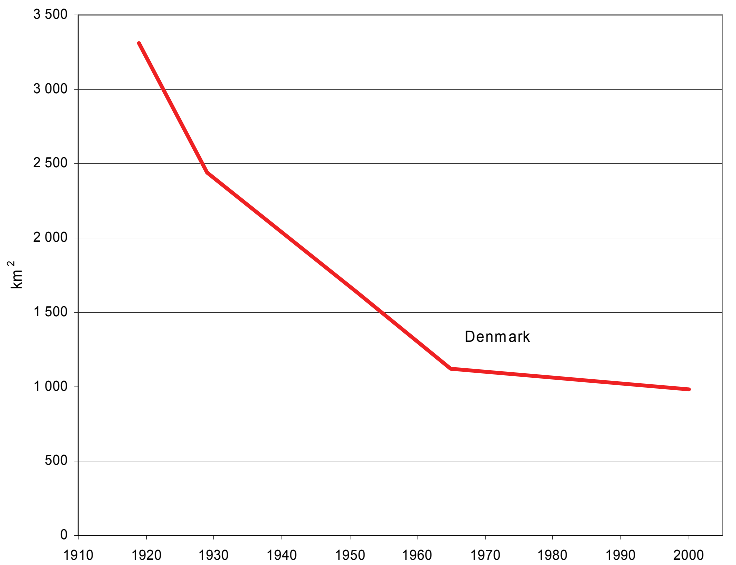

Figure 13.4: Trend in the area of shrub heathland (N8.5) in Denmark.Similar trend data is not available in the other Nordic countries

The present area of all grassland and shrub heathland sub-habitats (N8.1–N8.5) in the nemoral/boreal (N/BN/B) region and in the alpine (A) region is shown in Figure 13.5 and 13.6, respectively. Calcareous grasslands (N8.1) occur in all bio-geographical regions and are typically very species rich with a characteristic flora. In the alpine region, calcareous grasslands and heaths are typically characterised by the flowering plant, *Dryas octopetala*. Only Sweden has detailed information on the extent of calcareous grasslands. Among the most distinguished are the alvar grasslands on Öland in south-eastern Sweden, which occur on a plateau of calcareous bedrock with thin soil layers. The alvar grasslands contain many species that are rare in other parts of Sweden, such as ölandssolvända (*Helianthemum oelandicum*) and alvarmalört (*Artemisia oelandica*). On the island of Öland the alvar covers 255 km^2 which is considered to be the largest grazed alvar grassland in the world. In total there are 2 000 km^2 dry calcareous and alvar grasslands in Sweden of which 78% is found in the alpine region (Figures 13.5 and 13.6). The other Nordic countries (except Iceland) also host calcareous grasslands (e.g. Møn in Denmark) but these are not monitored separately from the other grassland types.

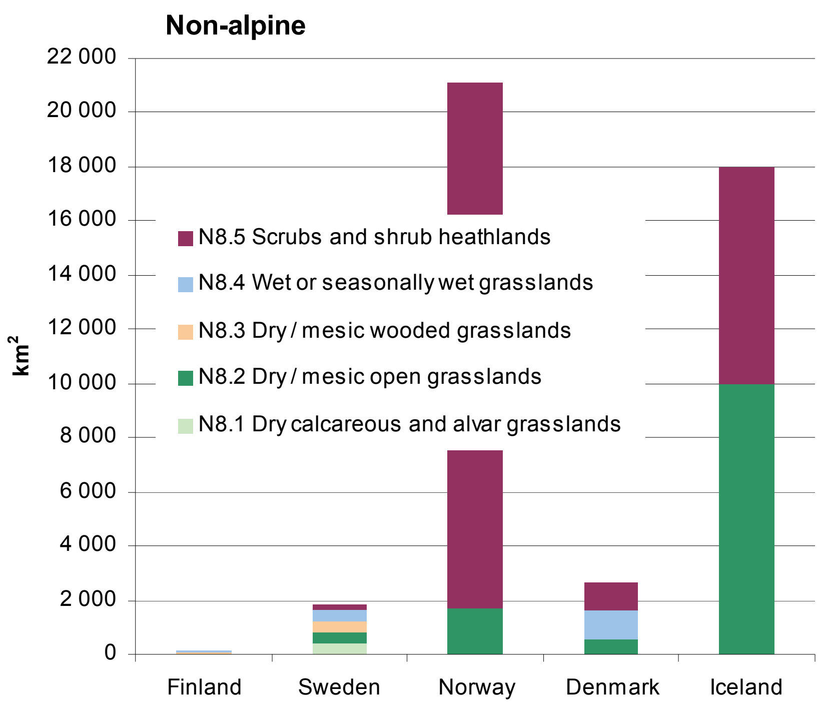

Figure 13.5: Areas of grassland and shrub heathland sub-habitats in the non-alpine (N/BN/B) region.

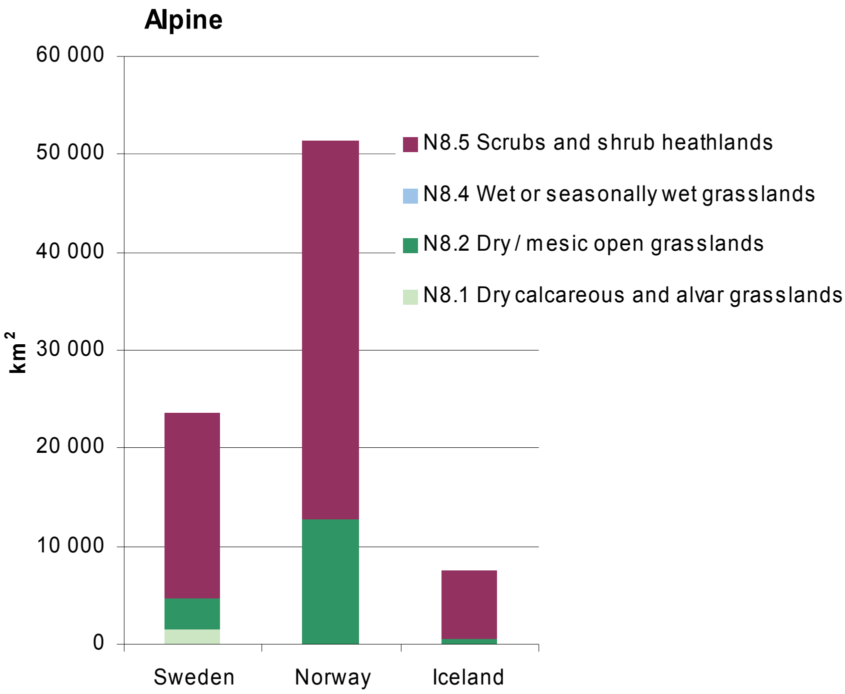

Figure 13.6 Areas of grassland and shrub heathland sub-habitats in the alpine (A) region.

Most grassland areas in the Nordic countries fall into the dry/mesic open grassland category (N8.2). The total area of N8.2 is estimated to 29 000 km^2 of which almost 60% is found in the alpine region. Most of the area of N8.2 is found in Norway with 50% of the total Nordic N8.2 area. Then follows Iceland (36%), Sweden (12%) and Denmark (2%).

The wooded grasslands (N8.3) are very characteristic for Southern Sweden (oak trees), but are rare in the other Nordic countries. In West Norway wooded grasslands with pollarded elm and ash trees are a characteristic traditional cultural type still found many places, but no area data exist. Only Sweden and Finland have data on wooded grasslands. The present area of this sub-habitat is 430 km^2 in Sweden and 74 km^2 (minimum estimate) in Finland. The most typical and valuable wooded grasslands are characterised by old, broad-canopy oaks, which are extremely valuable for a large number of epiphytic lichens, wood-living insects and other invertebrates, and a single oak tree may host up to 1 000 other species. Data on oaks, other valuable hardwood trees and their epiphytic lichens started to be monitored at a national scale in Sweden in 2006. Some local inventories before that also exist. The wooded grasslands with pollarded ash and elm trees in West Norway are very important habitats for a range of oceanic lichen species. Many of the species are red listed and some are only found in this type of habitat that is threatened because the traditional use of the pollards for fodder production has ceased.

Non-alpine wet and seasonally wet grasslands (N8.4) are mainly found in Denmark and the southern parts of Sweden and Finland. In Norway and Iceland wet grasslands is not monitored as an individual habitat type. According to our data sources, Denmark has the largest area of wet grasslands; 1 125 km^2, which is 71% of the total wet grasslands area. Next is Sweden with 24% and Finland with 5%.

All countries have data on scrubs and shrub heathlands (N8.5). As the only country Denmark also has historical data for this sub-habitat (Figure 13.4). The total Nordic area of shrub heathland is 93 000 km^2 of which 70% is estimated to be in the alpine region (Figures 13.5 and 13.6). Norway has the largest area of shrub heathland, corresponding to 62% of the total Nordic shrub heathland area. Most of the Norwegian heathland vegetation is found in the alpine region. However, a fraction of about 15% is also found along the Western coast of Norway. In these areas coastal heathlands have been used for centuries as pastures. The traditional use was regular burning to improve pastures. This traditional use has almost stopped and large areas are now subject to abandonment and regrowth with forest. Large areas are also planted with coniferous trees. The remaining area of N8.5 is divided between Sweden (21%) and Iceland (16%). Less than 1% is found in Denmark and Finland.

In Iceland about 40% of the land is vegetated (Guðjónsson & Gíslason 1998) of which more than half is defined as grassland and shrub heathland as described here. Forests, dominated by birch and willow, occupy 1% of the Icelandic land area (Icelandic Agriculture Ministry 1986). The lack of trees is a striking feature like the nakedness of the interior highlands. The Icelandic lowland is characterized by grassland, heathland and dwarf shrubland (birch and willow) up to 600–700 m above sea level. The lowland belongs to the boreal zone of the biotic regions or more precisely the sub-alpine birch forest belt of Fennoscandia, while the interior, the highlands, belongs to the arctic/alpine zone.

13.2 Quality of biodiversity

In Table 13.2 we propose indicators that are relevant to assess the quality of biodiversity in grassland and scrub/heath habitats. The lists are prepared based on previous reviews including Götmark et al. (1998) and Jordbruksverket (2005). The best data quality and coverage is found for birds. For the remaining indicators the availability of data is unfortunately limited and only found in one or two countries. Detailed monitoring, including inventory of species and proxy indicators in a large representative sample of valuable grasslands, was started in Sweden in 2006 (Esseen et al. 2008, Glimskär et al. 2008).

Table 13.2: Proposed biodiversity indicators for grasslands and shrub heathlands

Quality indicators	Data availability				
	FI	SE	NO	DK	IS
Species indicators					
Birds (breeding and migrant)	1983–2007	1975–2007	1995–2007	1976–2007	No data
Bumblebees	No data	2006–2008	No data	No data	No data
Butterflies	National butterfly recording 1991–2008 Butterflies in agricultural landscapes 1999–2008	2006–2008	No data	Estimates may be constructed from atlas surveys	1995–2008
Orchids	No data	No data	Some atlas data	Indicators under development 1980s–2007	No data
Vascular plants (herbs, scrubs, etc.)	No data	2003–2008	Some atlas data	Estimates may be constructed from atlas surveys	No data
Amphibians	No data	No data	Some data	Fire–bellied toad 1985–2005	Not relevant
Habitat indicators					
Old solitary hardwood trees (in wooded grasslands)	No data	2006–2008	No data	No data	Not relevant
Grazing pressure (sheep/horses/cattle)	No data	2006–2008	No data	No data	1900–2006

Certain bird species can be assigned as indicator species for open grassland habitats as they depend on these for feeding and/or breeding. The selection of species depends on regional and climatic conditions. However, when considering the nemoral and boreo-nemoral grassland areas in the Nordic countries, we have selected four common bird species as relevant indicators for grassland. Figure 13.7 shows population trends for these four bird species in Norway, Sweden and Denmark. Similar data could not be obtained for Finland and Iceland. Over the past three decades the index decreased with more than 40% in Sweden and Denmark. In Norway the decrease is limited/insignificant but data goes back only one decade. Figure 13.7 illustrates that birds that depend on open grasslands are in an unfavourable development.

Birds are not necessarily the best indicators for biodiversity in grassland habitats. However, it has not been possible for us to produce other indicators as not much data is available. Further scrutinising of data sources on insects may prove worthwhile. Also, data on plant species that are typical of various grassland and heathland sub-habitats would be very useful. The obstacle here is that it is most often not possible to deduce a trend through time. It is expected that national monitoring (e.g. in Sweden and Denmark) in the near future will result in better data series for vegetation.

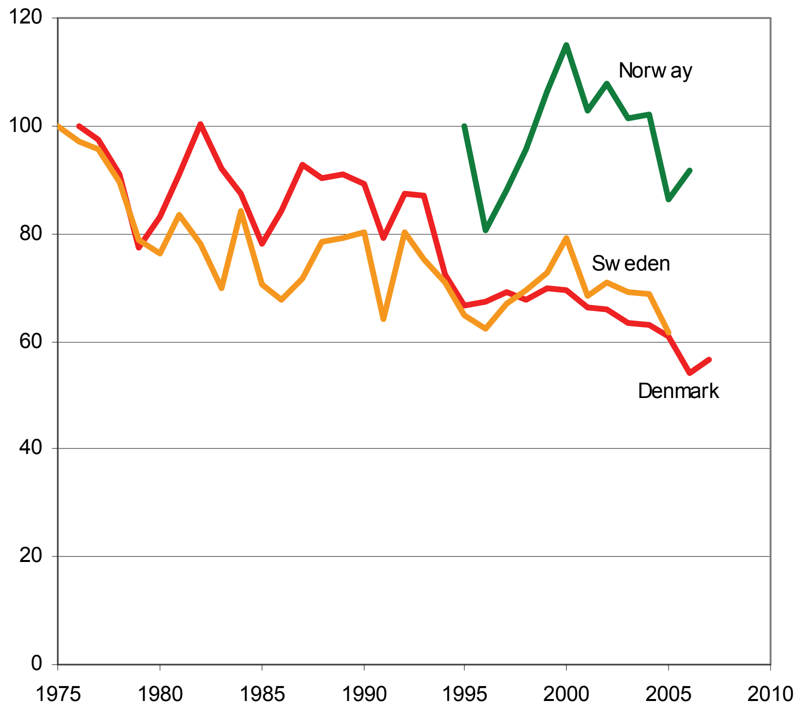

Figure 13.7: Population indices of four common grassland species in Sweden, Norway and Denmark.

The species are: Lapwing (*Vanellus vanellus*), whinchat (*Saxicola rubetra*), whitethroat (*Sylvia communis*) and starling (*Sturnus vulgaris*).

The development of natural values in the mountainous/alpine grasslands and heathlands is difficult to evaluate. Probably, the effects of extensive reindeer grazing vary through time, and there is some concern that shrub encroachment (willow) may increase in the Scandinavian mountain range. Sheep or cattle grazing may be locally important also in some areas in the mountain range. In some areas, ground disturbance caused by trampling (reindeers or humans) or vehicle tracks may change vegetation, but the actual extent of this is unknown. Finally, climate change will certainly change conditions along the forest-mountain gradient, potentially causing shrub encroachment and difficulties for many species to adapt to changing conditions. Much effort must be spent to increase monitoring of the vast areas of grasslands and heaths in the Scandinavian mountains.

13.3 Biodiversity index

As described above it is relevant to divide grassland and heathland into boreal/nemoral and alpine types. For lowland grassland, which is agricultural land that is dependent on continuous management by grazing or mowing, the area estimates are based on agricultural statistics. Area estimates based on monitoring data would possibly be more well-defined in terms of habitat quality. Even if alpine grasslands and heaths are to a large extent influenced by reindeer grazing, they are not considered to be agricultural land.

Just as for farmland, we have chosen to calculate a grassland index on the basis of trends in grassland area and in the abundance of common grassland birds. Although data for a few other quality indicators are available, we have chosen to use abundance of grassland birds, because this is the most consistent and therefore comparable indicator for grassland quality. Figure 13.8 shows grassland indices for Norway, Sweden and Denmark. As the availability of data varies between countries, different baseyears have been chosen for each country. It can be noted that during the past decade quantity has increased in Norway and Sweden but decreased in Denmark. However, the quality has decreased in all three countries, most markedly in Denmark.

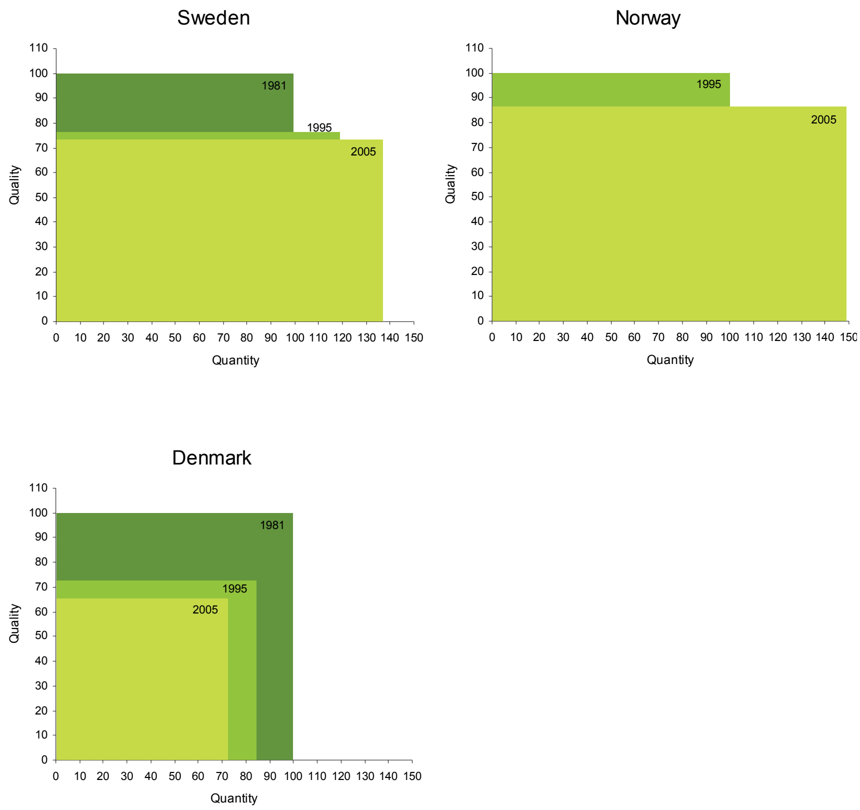

Figure 13.8: Grassland indices for Sweden, Norway and Denmark.
Quantity is measured as the area of grasslands (without shrub heathlands) and quality as the abundance of four common grassland birds. Units are indexed with the first year = 100.

13.4 Conclusions and recommendations

The total area of grasslands in the Nordic region has almost been halved since 1950. This is mainly because many of the semi-natural grassland habitats in the farmed landscape depend on grazing and/or mowing, and these types of extensive agricultural management have been abandoned for economic reasons in many places. Since 2000 there has been an increase in environmental payment for keeping grasslands open in Sweden. Such payment has contributed to a positive effect on the area of managed grasslands in Sweden and Norway in the past decade.

Since the values of grasslands and shrub heathlands are so strongly dependent on management, the quality may change quickly as management changes. The greatest problem is that there are so few data that describe quality. Data on common grassland birds, however, show population decreases between 10% and 30% since 1990. Even if the areal extent is maintained, the quality may deteriorate quickly if the management is insufficient or inappropriate for other reasons. It is therefore very important to start monitoring of quality indicators at high frequency for all important grassland and heathland habitat types in the Nordic region. Also, it is essential to make the monitoring more uniform, as varying definitions of habitats and sub-habitats between the Nordic countries and through time make comparisons difficult.

If the 2010 target for grasslands and heathlands is to be met, it will require that these habitat types will be managed (e.g. by grazing animals) and that negative pressures such as the use of agro-chemicals will be reduced. Most actions to sustain open grasslands and reduce negative pressures can lead to reductions in agricultural production and thus in farmers' incomes. Therefore, compensation for reduced incomes may be necessary. In marginal regions, especially in Finland, Sweden and Norway, abandonment of agricultural land use must decrease. The abandonment in marginal regions is caused by structural, social and demographic problems, and can therefore only partly be counteracted by environmental payments.

14. Indicators for forest

Key messages

- ☺ The area of forest has increased by about 3% since 1990.
- ☺ Populations of common forest birds have increased between a few percent and 20% since 1990.
- ☺ The share of old forest has increased since 1990 (except for in Finland).
- ☹ Populations of the mountain birch forest specialist, brambling bird, have decreased by more than 90% in Sweden since 1975 and by about 10% in Norway since 1995.
- ☺ Relatively good availability of data, except for species data.

Forest is defined as vegetation dominated by trees (usually with more than 30% crown cover). In the Nordic countries it is relevant to categorise forest into the types deciduous (N9.1), coniferous (N9.2) and mixed deciduous and coniferous (N9.3). Mountain birch forest is a dominant forest type along the climatic tree line in large parts of the Nordic region and has its own group (N9.4). The biodiversity varies considerably between these forest types. Coniferous forests are predominant in the boreal zone and dominated by Norway spruce (*Picea abies*) and Scots pine (*Pinus sylvestris*). Boreal deciduous trees such as birch (*Betula pubescens*) and aspen (*Populus tremula*) are common in mixtures with coniferous trees or as separate stands. Deciduous forests in the nemoral and boreo-nemoral zones are dominated by oaks (*Quercus* spp.), beech (*Fagus sylvatica*), ash (*Fraxinus excelsior*), Wych elm (*Ulmus glabra*), Norway maple (*Acer platanoides*), small-leaved lime (*Tilia cordota*) and hornbeam (*Carpinus betulus*).

14.1 Quantity of biodiversity

Forest covers large areas and harbours a large part of the biodiversity of the Nordic countries. The availability of area data for forest is relatively high (Table 14.1). Data for total forest area go back to 1866 in Denmark, 1940 in Iceland and 1952 in Finland. In Norway and Sweden we applied data for total forest area starting from 1990 and 1983, respectively. However, in Finland, Sweden and Norway the National Forest Inventories that started in 1921, 1923 and 1919, respectively, may provide additional historical area estimates if the available statistics were analysed further. Data series for the subtypes cover about the same time period as for total forest area. In Iceland no data for deciduous and coniferous forest exist, and in Denmark data series for mixed forest are lacking. Present areas for mountain birch forest are known but historical data for this forest habitat type could not be obtained.

Table 14.1: Availability of area data for forest

Habitat	FI	SE	NO	DK	IS
N9 Total forest	(1921) 1952–2005	(1923) 1983–2005	(1919) 1990–2005	1866–2000	1940–2006
N9.1 Deciduous forest	2000–2005	(1923) 1983–2005	(1919) 1990–2005	1881–2000	No data
N9.2 Coniferous forest	2000–2005	(1923) 1983–2005	(1919) 1990–2005	1881–2000	No data
N9.3 Mixed forest	2000–2005	(1923) 1983–2005	(1919) 1990–2005	No data	1940–2006
N9.4 Mountain birch forest	2000	2003–2008	2007	Not relevant	2000
N9.5 Other forest	2000–2005	(1923) 1983–2005	No data	1881–2000	No data

In Figures 14.1 and 14.2 the present quantity of forest in the Nordic countries are shown (mountain birch forest included). As much as 44% of the total Nordic area is covered by forest. The Nordic countries are hence one of the most forested regions in Europe (Hallanaro & Pylvänäinen 2001). Most of the forest area (total: 554 000 km^2) is found in Sweden, Finland and Norway with 44%, 33% and 23%, respectively (Figure 14.1). Forests in Denmark and Iceland make up only 0.9% and 0.3% of the total Nordic forest area, respectively.

When the forest areas in each country are considered relative to the total land area, the situation appears more even between Finland and Sweden, with just above 50% forest cover in each country (Figure 14.2). In Norway forests cover 40% of the total land area, whereas Denmark has 11% forest and Iceland 1.5%.

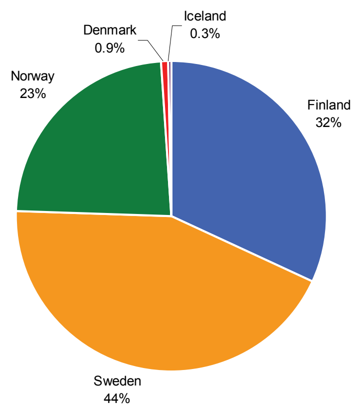

Figure 14.1: Distribution of forest area in the Nordic countries (total forest area: 554 000 km²).

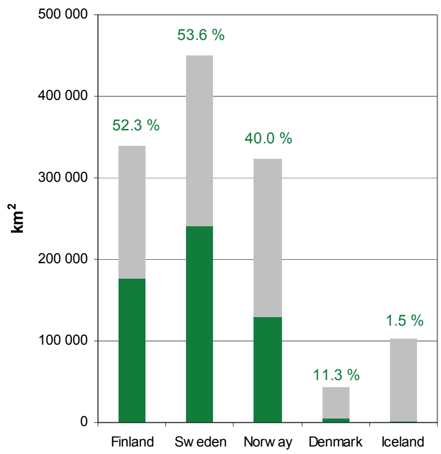

Figure 14.2: Proportion of forest of total land area in each Nordic country.

The trends for the total forest area in the Nordic countries are shown in Figure 14.3. Increasing trends are seen in all countries. Since 1990, the total Nordic forest area has increased by 3%. In Denmark the total forest area has more than doubled since the end of the 19th century. This is mainly a result of systematic planting of coniferous tree plantations (Levin & Normander 2008). The decline seen in Denmark from 1980 to 1990 is not realistic but caused by differences in statistical methods.

Because of a large variation along climatic and topographic gradients the forest of the Nordic countries exhibits a large variety. They form the northern and western border of the vast boreal Taiga belt characterised by coniferous forests of Scots pine (*Pinus sylvestris*) and Norway spruce (*Picea abies*). Important subtypes are found, such as the coastal spruce forests of Central Norway, which is restricted to low elevations (below 200 m a.s.l.) and areas with very high humidity. Also, a large variety of boreal deciduous forests are found in the Nordic countries. Recently 30 types of boreal deciduous forest are described from Norway (Bendiksen et al. 2008). In the nemoral and boreo-nemoral zone many important deciduous forest types of high importance for biodiversity are found.

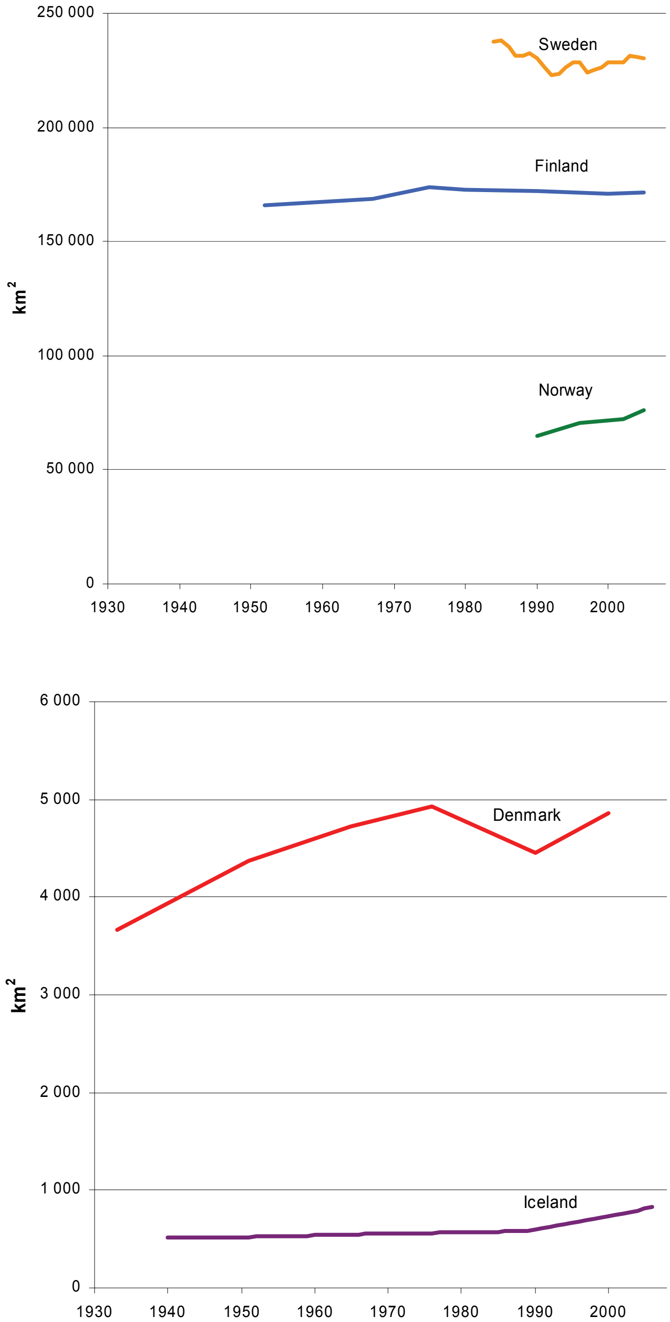

Figure 14.3: Trends in the area of forest in the Nordic countries. Mountain birch forest (N9.4) is not included because of lack of historical data.

In Figures 14.4 and 14.5 the distribution of different forest types is illustrated. Coniferous forest (N9.2) dominate the Nordic forests and constitute 58% of the total forest area (Figure 14.4). The majority of the coniferous forests are found in the boreal zone of Sweden, Finland and Norway but coniferous trees also grow in boreo-nemoral transition forests (mixed forests) and in plantations of the nemoral zone (Denmark and

Southern Sweden). Mixed coniferous and deciduous forest (N9.3) constitute 16% of the total Nordic forest area and are found in all countries but are not registered in Denmark. Deciduous forest (N9.1) cover 8% and include birch-dominated forests of the boreal/boreo-nemoral zone (Finland, Sweden, Norway) and oak and beech-dominated forests of the nemoral/boreo-nemoral zone (Denmark and Southern Sweden and partly southern Finland and Norway). Mountain birch forest (N9.4) cover 5% of the forest area and are dominant along the climatic tree line in large parts of the Nordic region. The remaining 13% (other forest; N9.5) could not be categorised as one of the main forest types either because of lack of information or because they are transition forests (i.e. newly planted or clear-cut). In Norway 'other forests' are primarily unproductive forests that are not categorised by forest type (e.g. deciduous or coniferous).

Coniferous forests constitute 70% of the Swedish, 65% of the Finnish and 61% of the Danish forest area (Figure 14.5). Most of the deciduous forests in the Nordic countries are found in Sweden and Norway. However, compared to the total forested area Denmark has the largest share of deciduous forest (36% of national forest area). Similarly, most of the mountain birch forests are found in Sweden and Norway but compared to the total forested area the share of mountain birch forest is highest in Iceland (45%). In Sweden the mountain birch forest is the largest continuous deciduous forest area (Linkowski et al. 2006). The area of birch forest within Natura 2000 designated areas are estimated to 7 970 km^2, which is about 75% of the total Swedish mountain birch forest (Linkowski & Lennartsson 2005).

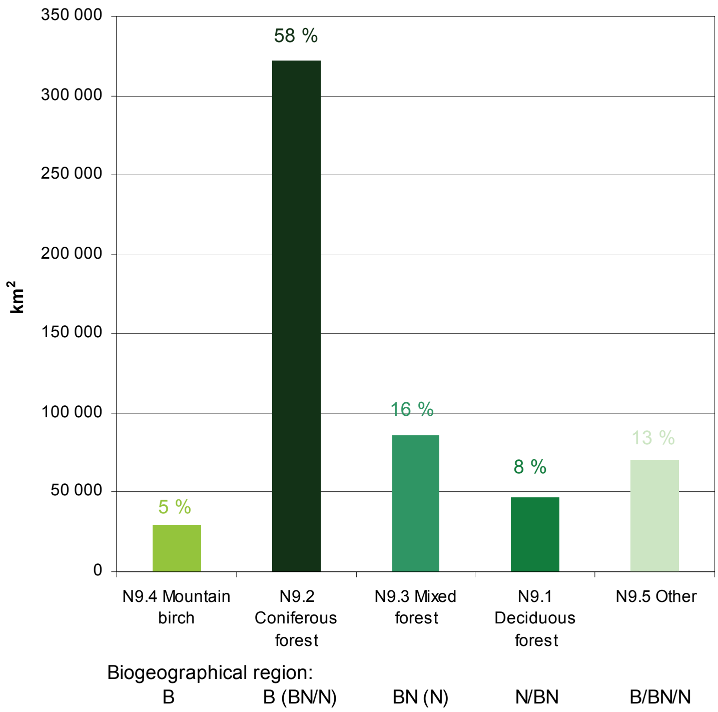

Figure 14.4: Distribution of different forest types in the Nordic countries (data from 2000–2007).

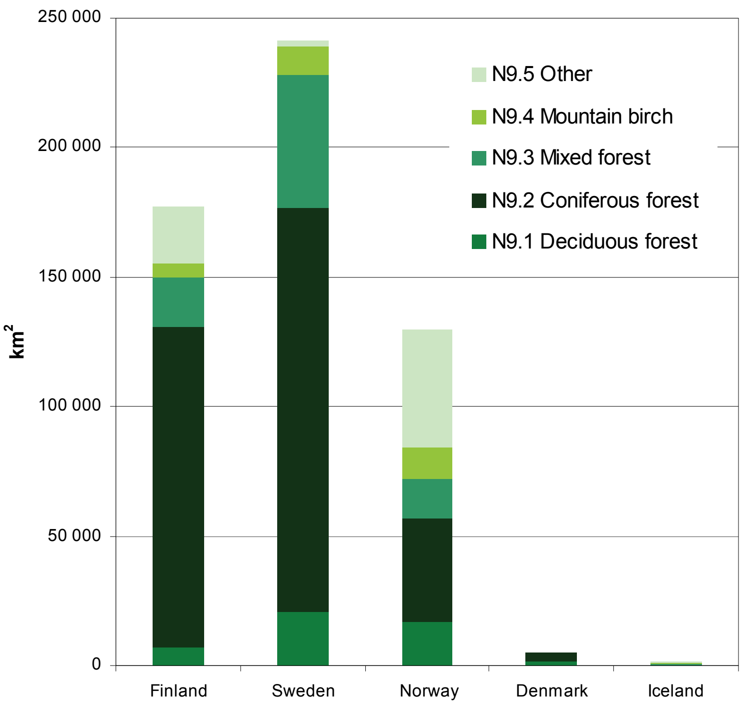

Figure 14.5: Share of different forest types in each of the Nordic countries (data from 2000–2007).

14.2 Quality of biodiversity

In Table 14.2 we have proposed a list of indicators that are relevant when assessing the quality of biodiversity in forest. The list is prepared based on previous research including proposals made by Stokland et al. (2003) and by suggestions from forest biodiversity experts. In total more than ten species indicators and five habitat indicators are proposed. Of these forest birds and proportion of old forest (e.g. > 140 year) can be determined for most countries. Most of the remaining indicators can be determined for two or three countries. Overall, the availability of relevant monitoring data is not perfect but it is good compared to the situation for most other habitat types.

Table 14.2: Proposed biodiversity indicators for forest

Forest quality indicator	Data availability				
	FI	SE	NO	DK	IS
Species indicators					
Woodland insects	No data	No data	No data	No data	No data
Birds (breeding)	1983–2007	1975–2007	1995–2007	1976–2007	2002–2005
Brambling (indicator for mountain birch forest)	1983–2008	1975–2007	1995–2007	Not relevant	No data
Tree species composition (e.g. Shannon–Weaner index)	1952–2005 (but needs to be analysed)	1983–2005	1993–2005	No data	No data
Mosses	No data	Some data	Some data	No data	No data
Lichens	No data	Some data	Some data	No data	No data
Rodents	Some data	1972–2006	Some data	2000	No data
Large mammals	Wildlife triangle census 1989–2008	1995–2007	Some data	2000	Not relevant
Vascular plants (selected species)	Mappings of coverage etc. in 1954, 1986 and 1995	1983–2005	1993–	Some data	No data
Orchids	No data	No data	Some data	Indicators under development 1980s–2007	No data
Hunting statistics (deer, moose, etc.)	Few data series	1939–2007	1900–2007	1950–2007	Not relevant
Habitat indicators					
Volume of dead wood	2000–2006	1996–2006	1996	2006	No data
Old forest (e.g. > 140 years)	1975–2005	1983–2005	1990–2002	1951–2000	No data
Proportion of large trees	No data	1985–2003	1925–2002	No data	No data
Proportion of burnt area/clear cutting	1975–2006	1983–2005	1950–1989	No data	No data
Proportion of natural/unproductive forest	1952–2005	1983–2005	1990–2005	Some data but methodology uncertain	No data

Several data series on monitoring of breeding birds in forests are available. However, only a limited number of species are covered in most Nordic countries. We have compiled data for six birds, which are all common breeding birds in the Nordic forests. The common forest bird index shows an increasing trend in Denmark since 1976, while in Sweden and Finland the indices remain almost unchanged (Figure 14.6). In Norway an increasing trend is also observed, although there is a large fluctuation. Danish Birdlife has calculated an index of 22 common forest birds, which shows an increase of 13% in the period of 1976 to 2007 (Heldbjerg & Eskildsen 2008). This increase is smaller than the increase of about 60% shown for Denmark in Figure 14.6.

Forests are also important habitats for many rare (red-listed) species, for example in Norway 48% of the red-listed species lives in forests (Kålås et al. 2006). Of these 60% are found in deciduous forests and 40% in coniferous forests. 20% of all red-listed species lives in old, natural forest with dead wood in different decay classes (Kålås et al. 2006) and 17% of all red-listed species depends on dead wood. The proportion of dead wood in forest is hence a very relevant indicator for biodiversity as a range of species, including Coleopera, Diptera, mosses, fungi and lichens, depend on dead and decaying wood. Some data on dead wood are available in Finland, Sweden and Norway. However, we have not been able to produce a common indicator due to differences in methodology and to some part lack of historical and representative data.

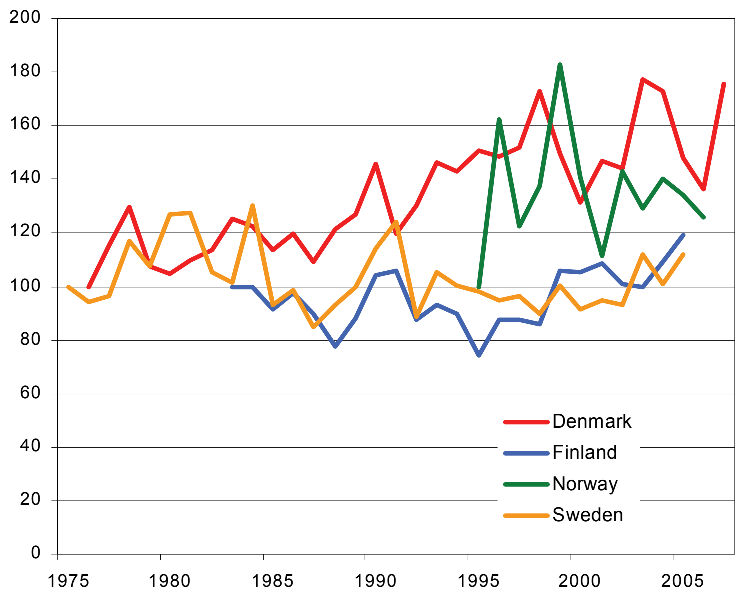

Figure 14.6: Population indices of six forest bird species common in the Nordic countries (no data for Iceland).

The species include: Great spotted woodpecker (*Dendrocopos major*), European robin (*Erithacus rubecula*), Eurasian jay (*Garrulus glandarius*), icterine warbler (*Hippolais icterina*), crested tit (*Lophophanes cristatus*), common chiffchaff (*Phylloscopus collybita*).

The proportion of old forest is a highly relevant indicator to assess the biodiversity quality of Nordic forests. Data on forest more than 140 years old have been compiled from Finland, Sweden and Norway and are shown in Figure 14.7. In Finland there is a decreasing trend of old forest from 1975 to 2005, while in Norway there seems to be a slightly increasing trend. The Swedish data shows a decreasing trend from 1983 to 1991 and then the area returns to the 1983-level in 2005. In Denmark the proportion of deciduous forest of age 120 years or more stands unchanged at about 10% since 1965 (Figure 14.8). However, in the pre-1965 period the proportions of old beech forest and old oak forest have decreased significantly. Old beech and oak declined from 16.5% and 13% in 1951 to 14% and 10% in 2000, respectively. Overall, the share of old forest has increased by between 3% and 7% in Sweden, Norway and Denmark and decreased by 5% in Finland since 1990.

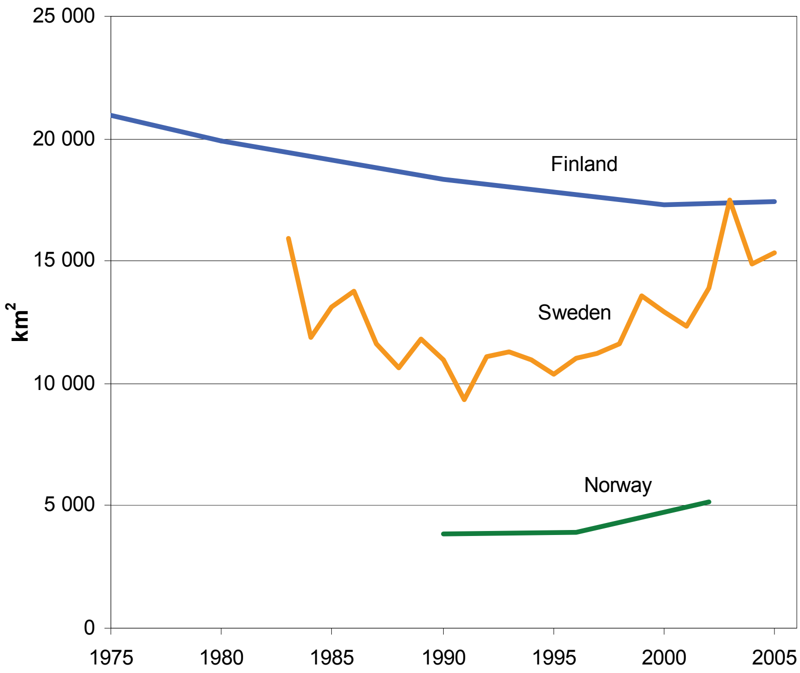

Figure 14.7: Trends in the area of forest more than 140 years old in Finland, Sweden and Norway.

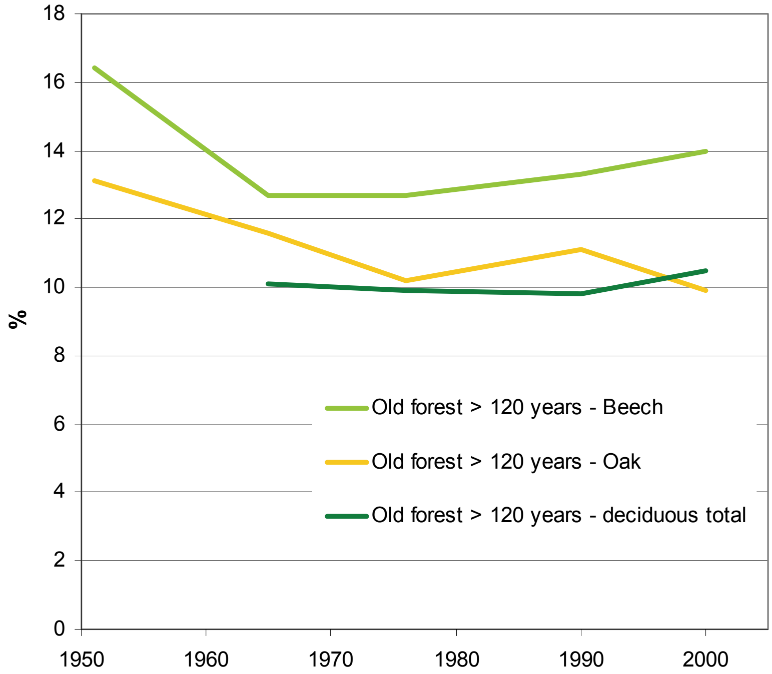

Figure 14.8: Proportion of deciduous forest types more than 120 years old in Denmark.

Mountain birch forest forms the ecotone between the boreal coniferous forest and the alpine areas (Wielgolaski 2001). There are many species within birch forests, but only a few are restricted to the mountain birch forest. One suggested indicator for mountain birch forest that is recommended by the Swedish bird monitoring is brambling (*Fringilla montifringilla*). Brambling is one of the most common birds in mountain birch forests, but it also breeds in other forest types. Comparing the data series shows a dramatic decrease of more than 90% since 1975 in Sweden and a fairly constant but slightly decreasing trend in Norway (Figure 14.9). The main threats to mountain birch forests are forestry, tourism and climate change that can move the altitude for the birch frontier. The mountain birch forests were previously heavily influenced by grazing and logging for fire wood at the summer farms. At present the grazing impact is less intensive and the forest canopy is closing, also probably as a result of climate warming.

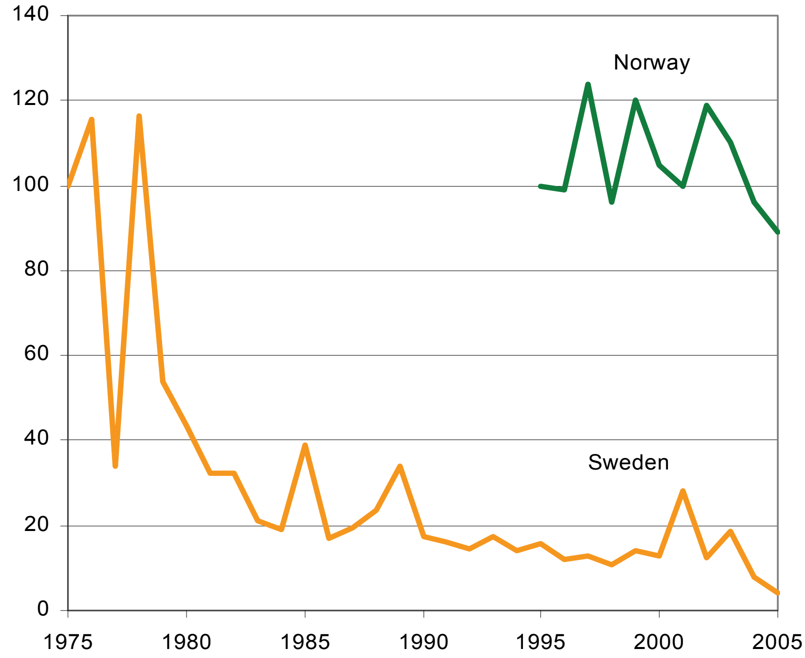

Figure 14.9: Population indices for brambling bird (Fringilla montifringilla) in Sweden and Norway.

14.3 Biodiversity index

As described in Chapter 6, we aim at describing the state of biodiversity by computing an index that shows the *quantity* dimension of biodiversity on the x-axis and the *quality* dimension on the y-axis. We have chosen to calculate a forest index on the basis of trends in forest area and in abundance of common forest birds. Although data for a few other quality indicators are available, we have selected abundance of forest birds, because this is the most consistent and therefore comparable indicator for forest quality. Figure 14.10 shows forest indices for all Nordic countries except Iceland. As the availability of data varies between countries, a different baseyear has been chosen for each country. Although there are differences between the countries, the general tendency is the same. Over the last 2-3 decades the quantity has increased a few percent except in Finland (0.5% decrease). In all countries the quality, measured as abundance of six common forest birds, has increased substantially. In Norway the increase was 34% (1995 to 2005) and in Denmark 26% (1980 to 2005).

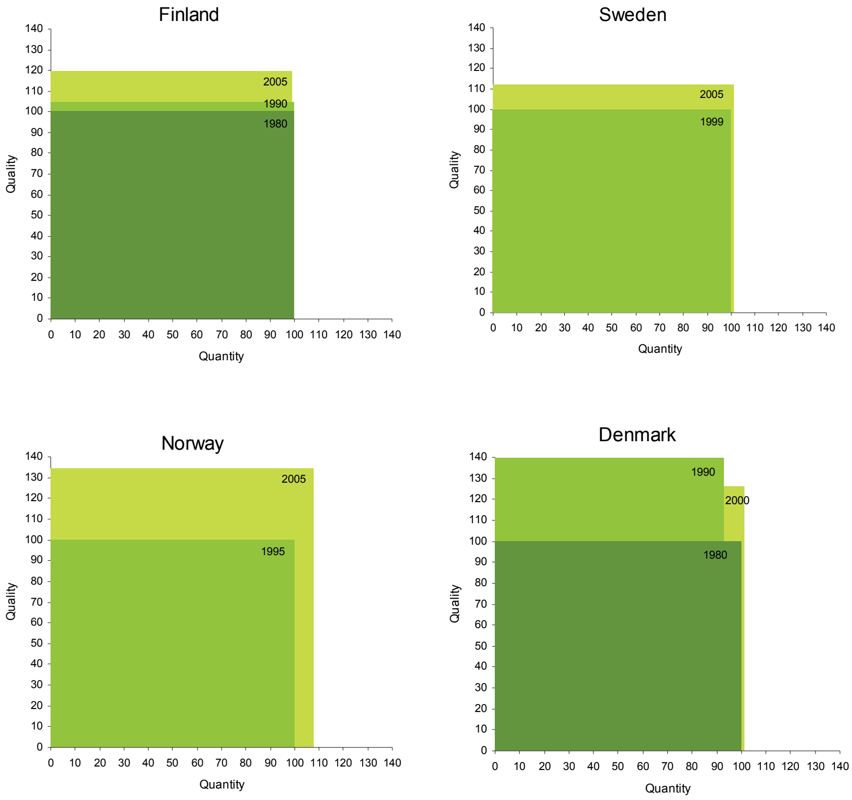

Figure 14.10: Forest indices for Finland, Sweden, Norway and Denmark. Quantity is measured as the total area of forest and quality as the abundance of six common forest birds. Units are indexed with the first year = 100.

14.4 Conclusions and recommendations

Forest takes up as much as 44% of the land area in the Nordic countries. Coniferous forests dominate and constitute 58% of the total forest area. Mixed coniferous and deciduous forests constitute 16%, deciduous forests 8% and mountain birch forests 5% of the forest area. Most of the Nordic forest area is found in Sweden, Finland and Norway with 44%, 33% and 23%, respectively. Forests in Denmark and Iceland make up only about 1% of the total Nordic forest area.

The forest area has increased by a few percent in all Nordic countries over the past decade. This increase may be of positive value to biodiversity. However, it may also be of limited or even negative value since much of the increase may be plantations on former open land such as coastal heath and unused agricultural land, which sometimes have been species-rich semi-natural pastures or hay meadows.

The main obstacle regarding biodiversity indicators in forests are lack of data despite that more data exist for this habitat than for other main habitat classes. This imposes delimitations for constructing relevant indicators within each country, and also for comparing the state of biodiversity between countries. However, some relevant indicators could be produced. An index of six common forest birds shows increasing trends in Denmark and Norway, while in Sweden and Finland the indices remain almost unchanged over the past 2–3 decades. Trends for six bird species clearly do not reflect the situation for a lot of forest organisms. For instance the use of red-listed forest birds (of which there are 33 in Norway) may give different results. But birds are at present the only available species indicator for forest.

The proportion of old trees and dead wood are highly relevant indicators for forest biodiversity since many species depend on old trees and decaying wood. Since 1990, the proportion of old forest has increased in Sweden, Norway and Denmark but decreased in Finland. It has not been possible to deduce trends on the proportion of dead wood.

In order to properly evaluate the development of the Nordic forests, there exists a need to strengthen assessments of relevant parameters for forest quality. These include abundances of forest species such as insects, fungi, lichens, mosses and vascular plants but also information on the structural quality of the forest, such as age and size of trees, tree species composition and proportion of dead wood. Among the most relevant data sources for forest are the National Forest Inventories (NFI), which have several features in common, which facilitate comparisons between countries. However, the methods and definitions of parameters have changed during time and only recently structural parameters have been included. In Norway forest in Finnmark and above the coniferous forest limit has not been inventoried until recently. There is a strong need to coordinate the NFIs between the Nordic countries and adapt comparable methodologies and indicators.

15. Overall assessment of biodiversity in the Nordic countries

Key messages	
☹	Our results show that biodiversity has declined in the Nordic countries since 1990.
☹	It is highly unlikely that the target of halting biodiversity loss by 2010 can be met in the Nordic countries.
☺	If further efforts are directed towards analysing existing data sources, additional indicators can be constructed and hence a better knowledge base can be achieved.
☺	We recommend that future nature and biodiversity monitoring be increasingly coordinated at a Nordic level.

This chapter gives an overall presentation and assessment of the major changes in the state of biodiversity that have occurred in the Nordic countries in the past decades. The chapter is based on the results presented in the previous chapters.

15.1 Biodiversity quantity

In Table 15.1 and Figure 15.1 we present the most recent statistics for land use in the Nordic countries. The charts illustrate the considerable differences in land use between the Nordic countries. Finland, Sweden and Norway are dominated by forests, Denmark by farmland and Iceland by sparsely vegetated land such as inland rocks, glaciers and volcanic areas. Moreover, mires take up a large area in Finland and Sweden, whereas grassland and shrub heathland, mostly in the alpine region, are predominant in Norway and Iceland. Denmark has the largest share of constructed habitats, including city areas and transport networks.

When looking into the development in land use over time, trends that may be important for biodiversity can be derived. The main changes that have occurred in land use over the past decades are:

- The area of constructed habitats (N1) has increased in all countries with an average growth of 15% since 1990.
- The area of farmland (N2) has decreased by approximately 3% since 1990.
- The area of dunes (N4.1) and coastal meadows (N4.4) has declined dramatically in Denmark since 1950 (trend data for other countries and other coastal habitats could not be obtained).
- Possible changes in the area of inland surface water (N5) and sparsely vegetated/unvegetated (N6) habitats could not be determined due to lack of historical data.
- The area of mire (N7) has decreased by 9% since 1950 and by 1% since 1990 (no trend data for Norway).
- The area of grasslands (N8) has decreased by 40% since 1950. Minor increases are seen since 2000 (no trend data for Finland and Iceland).
- The area of scrub and shrub heathland (N8.5) has decreased by 40% in Denmark since 1950 (no trend data for the other countries).
- The area of forest (N9) has increased by approximately 3% since 1990.

While the area of constructed habitats has grown considerably in all of the Nordic countries, the area of important nature types such as mire, grassland and heathland has decreased significantly. Each of these trends will cause the quantity of biodiversity to decline. On the positive side, however, a slight increase in the area of forests may count as the only trend in land use that may have a positive impact on biodiversity.

Table 15.1: Land use in the Nordic countries (km²)
Data are from 2000 to 2007, based on a range of national data sources (see Appendix 2)

Habitat	FI	SE	NO	DK	IS	Total
N1 Constructed	6 025	5 286	2 294	4 207	1 353	19 165
N2 Farmland	22 588	27 031	8 499	24 807	1 365	84 290
N4 Coastal	1 500	No data	No data	568	750	2 818
N5 Inland surface water	33 600	41 038	19 532	743	2 353	97 266
N6 Sparsely vegetated/unvegetated	20 900	No data	72 500[3]	0	64 081	157 481
N7 Mires, bogs and fens	89 830	44 810	18 770	1 017	8 704[4]	163 131
N8 Grassland and shrub heathland	186[1]	25 470	72 500[3]	2 649	25 644	126 449
N9 Forest	152 000[2]	241 370	129 600	4 862	1 516	529 348
N10 Undefined	11 511	64 959	0	4 241	0	78 032
Total land area	**338 140**	**449 964**	**323 782**	**43 094**	**103 000**	**1 257 980**
N3 Marine (territorial sea)	82 000	85 308	145 551	105 000	758 000	1 175 859

[1] Finnish grassland data represent the most valuable traditional rural biotopes and are hence underestimated compared to the other countries
[2] Unproductive forests not included
[3] Expert estimates
[4] Drained mires not included

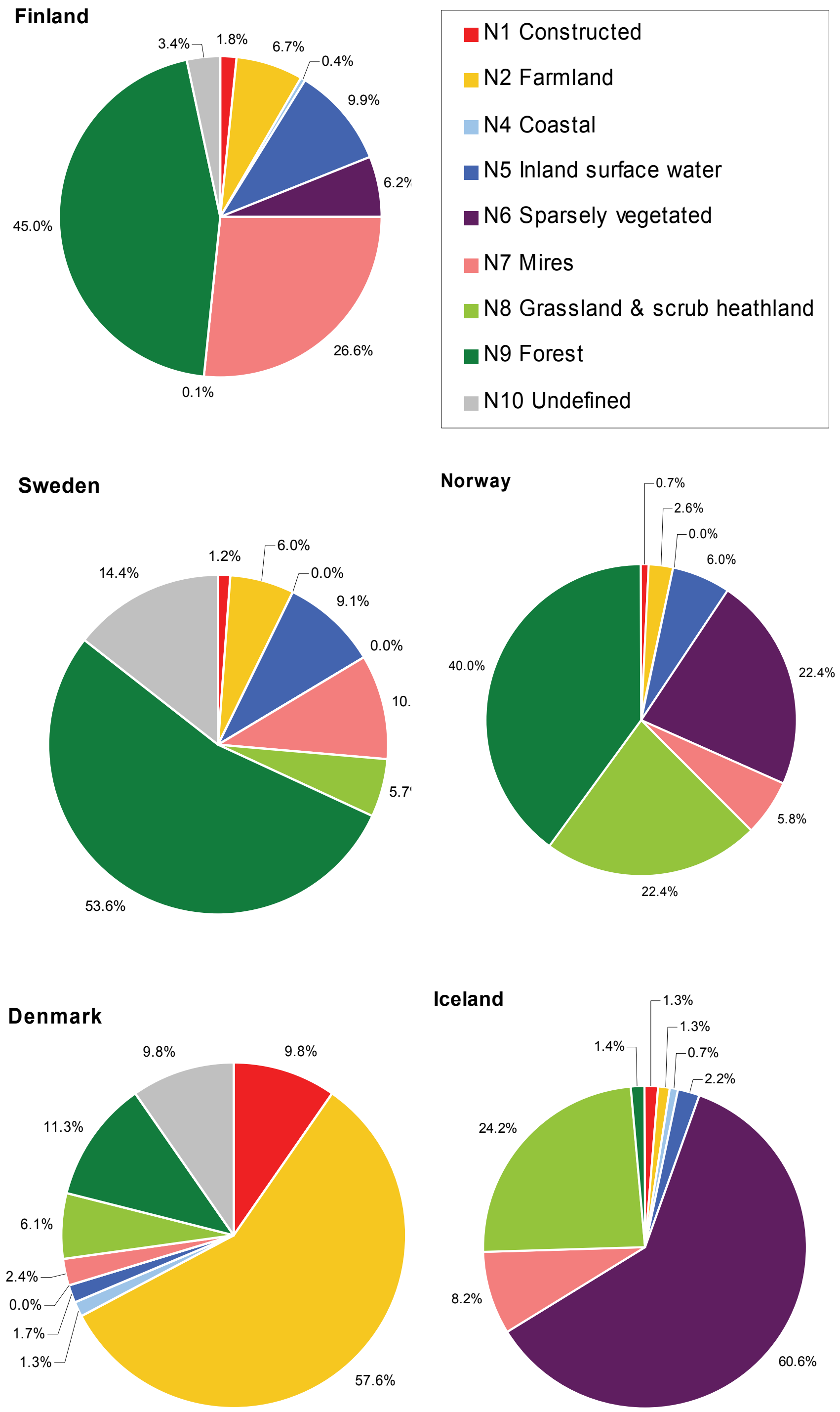

Figure 15.1: Relative land use in the Nordic countries.
Based on Table 15.1. Data from 2000–2007.

15.2 Biodiversity quality

In the previous chapters, indicators for biodiversity quality have been proposed for each of the main habitat types. However, the availability and quality of data have been sufficient to compute trends for all (or the majority) of the Nordic countries for only a fraction of the proposed indicators. Accordingly, the indicators presented cannot give a complete picture of biodiversity, only some of the most important trends. Dividing the biodiversity indicators between species trends and habitat quality trends, the following main changes over the past decades can be derived:

Species indicators:

- Populations of bird species in urban green areas have increased between 30% and 40% in Finland and Denmark and decreased slightly in Sweden since 1980.
- Populations of common farmland birds have decreased between 10% and 30% since 1980.
- Populations of white-tailed eagle and seals have increased significantly since 1990.
- Populations of important macroinvertebrates, pondweed and fish species in Danish streams have more than halved during the second half of the 20th century.
- Populations of common mire birds have decreased between 17% and 30% in Finland and Denmark since 1980.
- Populations of specialist mire butterflies have decreased by almost 50% in Finland since 1991.
- Populations of common grassland birds have decreased between 10% and 30% in Sweden, Norway and Denmark since 1990.
- Populations of common forest birds have increased between a few percent and 20% since 1990 (no trend data for Iceland).
- Populations of the mountain birch forest specialist, brambling bird, have decreased by more than 90% in Sweden since 1975 and by approx. 10% in Norway since 1995.

Habitat indicators:

- The share of fallow land has fallen from 11% in 2005 to 6% in 2008 in Finland, Sweden and Denmark (following the phase-out of EU set-aside schemes).
- The share of organic farming stands unchanged since 2000 at 6%.
- The area of Norway's coastal zone affected by buildings has increased by 5% since 1990.

- The ecological quality of lakes (measured as nutrient loads and visibility depth) has improved in Denmark and is unchanged in Finland since 1990.
- The ecological quality of running waters has improved in Denmark since 1990 (no data for the other countries).
- The share of pristine (non-drained) mire has decreased by 47% since 1950 and by 5% since 1990 in Finland and Iceland (similar trends expected in the other countries).
- The share of old forest has increased by between 3% and 7% in Sweden, Norway and Denmark, and decreased by 5% in Finland since 1990.

Two-thirds of the trends listed above show declines in biodiversity and the remaining one-third show improvements (or steady-state). While all of the indicators for farmland, mire and grassland show declines in biodiversity, the indicators for constructed and coastal habitats, inland water and forest reveal both positive and negative trends in biodiversity. However, none of the main habitat types exclusively shows improvements. In conclusion, the selected indicators give an overall picture of declining biodiversity in the Nordic countries over the past two decades.

The majority of the species indicators are based on bird populations. Even though birds generally are believed to be highly relevant indictors for biodiversity (e.g. Gregory et al. 2003, EEA 2007), they clearly represent only a corner of biodiversity. Hence, interpretation of the results should be made with great care. However, birds are the best-monitored species group in the Nordic countries and therefore constitute the best assessment tool for biodiversity. A limited number of population trends also exist for butterflies, mammals and a few plant species, whereas time series are almost non-existent for all remaining species groups. In conjunction with the well-established and highly relevant habitat indicators, however, the biodiversity quality indicators selected here represent valuable information on the trends and state of biodiversity in the Nordic countries.

15.3 Conclusions and recommendations

The outcomes of the NordBio2010 project constitute the first Nordic assessment of progress towards meeting the 2010 biodiversity target. A common Nordic habitat classification system has been developed and the most comprehensive documentation of land use in the Nordic countries to date has been presented. Furthermore, relevant biodiversity indicators for each of the main habitat types have been proposed and where data sources were sufficient these indicators have been calculated and presented.

To describe changes in biodiversity in the Nordic countries, a concept of measuring both the quantity and quality of biodiversity was applied. In respect to both of these dimensions of biodiversity our results indicate declining biodiversity in the Nordic countries over the past one to two decades. In particular, farmland, mire, grassland and heathland show declines in biodiversity, but also the remaining habitats show negative trends. Therefore, based on the findings from this study, we conclude that it is highly unlikely that the target of halting biodiversity loss by 2010 can be achieved by the Nordic countries.

A related conclusion was reached by the European Commission and the SEBI 2010 project in a mid-term assessment of implementing the European Biodiversity Action Plan (EC 2008a). The key conclusions were that the EU will fail to meet its target of halting biodiversity loss by 2010, and that intensive efforts will be needed, at the level of both the European Community and the Member States, if the EU is even to approach its objective (EC 2008b). Similarly, a Dutch assessment finds that the rate of biodiversity loss is slowing down in the Netherlands but has not yet been halted (Netherlands Environmental Assessment Agency 2008).

Our results should be perceived as a first attempt to make an overall assessment of the state of biodiversity in the Nordic countries. We believe that if further efforts were directed towards scrutinising existing and historic monitoring programmes and data sources, additional indicators could be calculated and hence a better knowledge base would be achieved. Also, our experience is that the monitoring programmes in the Nordic counties vary considerably between the individual countries and as a consequence it is often difficult to find matching datasets in all countries. We recommend that future nature and biodiversity monitoring be coordinated at a Nordic level to a greater degree, and that monitoring be more focused on measuring *temporal* changes in biodiversity.

If the target of halting biodiversity loss in the Nordic countries is to be achieved, major additional efforts will be necessary. It is not the scope of the NordBio2010 project, however, to suggest the policy actions that would be needed. It is simply the conclusion of this first assessment of Nordic biodiversity that further action is required if the Nordic countries are to approach their 2010 target.

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Appendix 1: Conversion between Nordic habitat classification and EUNIS

Nordic habitat code and name	EUNIS habitat code and name
N1 Constructed or highly artificial habitats	J Constructed, industrial and other artificial habitats I2 Cultivated areas of gardens and parks
N2 Regularly or recently cultivated habitats	I1 Arable land and market gardens
N2.1 Unmixed and mixed crops	I1.1 Intensive unmixed crops I1.2 Mixed crops of market I1.3 Arable land with unmixed crops grown by low-intensity agricultural methods
N2.2 Fallow or recently abandoned land	I1.5 Bare tilled, fallow or recently abandoned arable land
N3 Marine habitats	A Marine habitats
N4 Coastal habitats	B Coastal habitats
N4.1 Coastal sand and dune	B1 Coastal dunes and sandy shores
N4.2 Coastal shingle	B2 Coastal shingle
N4.3 Rock cliffs, ledges and shores	B3 Rock cliffs, ledges and shores, including the supralittoral
N4.4 Coastal and seashore meadows and marshes	A2.5 Coastal and seashore meadows and saline reed-beds D6 Inland saline brackish marshes and reedbeds
N5 Inland surface waters	C Inland surface waters J5 Highly artificial man-made waters and associated structures[1]
N5.1 Surface standing waters	C1 Surface standing waters J5 Highly artificial man-made waters and associated structures
N5.2 Surface running waters	C2 Surface running water; J5 Highly artificial man-made waters and associated structures
N6 Unvegetated or sparsely vegetated habitats	H Inland unvegetated or sparsely vegetated habitats
N6.1 Inland cliffs, rocky outcrops and screes	H2 Screes H3 Inland cliffs, rock pavements and outcrops
N6.2 Snow or ice dominated habitats	H4 Snow or ice dominated habitats
N6.3 Recent volcanic features	H6 Recent volcanic features
N6.4 Miscellaneous habitats with very sparse or no vegetation	H5 Miscellaneous habitats with very sparse or no vegetation

[1] J5 is included in inland surface waters and divided between standing and running waters, respectively

N7 Mires, bogs and fens	D Mires, bogs and fens
N7.1 Raised and blanket bogs	D1 Raised and blanket bogs
N7.2 Transition mires and poor fens	D2 Valley mires, poor fens and transition mires
N7.3 Aapa mires	D3.2 Aapa mires
N7.4 Palsa mires	D3.1 Palsa mires
N7.5 Wooded mires[2]	G1.4 Broadleaved swamp woodland not on acid peat G1.5 Broadleaved swamp woodland on acid peat G3.D Boreal bog conifer woodland; G3.E Nemoral bog conifer woodland
N8 Grasslands and shrub heathlands	F Heathland, scrub and tundra E Grasslands and lands dominated by forbs, mosses and lichens
N8.1 Dry calcareous and alvar grasslands[3]	E1 Dry grasslands E2 Mesic grasslands
N8.2 Dry / mesic open grasslands	E1 Dry grasslands E2 Mesic grasslands
N8.3 Dry / mesic wooded grasslands	E7 Sparsely wooded grasslands (G Woodland, forest and other wooded land)[4]
N8.4 Wet or seasonally wet grasslands	E3 Seasonally wet and wet grasslands
N8.5 Scrubs and shrub heathlands	F2 Arctic, alpine and subalpine scrub F4 Temperate shrub heathland
N9 Forest[5]	G Woodland and forest and other wooded land
N9.1 Deciduous forest	G1 Broadleaved deciduous woodland
N9.2 Coniferous forest	G3 Coniferous woodland
N9.3 Mixed deciduous and coniferous forest	G4 Mixed broadleaved and coniferous woodland
N9.4 Mountain birch forest	E7 Sparsely wooded grasslands (G Woodland, forest and other wooded land)
N9.5 Other forest	G5 Lines of trees, small anthropogenic woodlands, recently felled woodland, early-stage woodland and coppice (G Woodland, forest and other wooded land)
N10 Undefined	Undefined

[2] While in NordBio2010 wooded mires are classified under mires, bogs and fens, in EUNIS, wooded mires are classified under woodland

[3] EUNIS does not further divide into calcareous and alvar grasslands

[4] For woodlands EUNIS uses a canopy cover of >= 10%, while the Nordic classification uses >= 30%. Therefore, many wooded grasslands are in EUNIS classified as woodlands

[5] For woodlands EUNIS uses a canopy cover of >= 10%, while the Nordic classification uses >= 30% except for mountain birch forest (N9.4) for which the Nordic classification also uses >= 10%. Therefore, most mountain birch forest is classified as woodland in EUNIS

Appendix 2: Data sources

The table below lists the most important data sources that have been used to construct tables and figures in Chapters 7 to 15.

	Biodiversity quantity	Biodiversity quality
FI	Corine Land Cover 2000. Finnish agricultural statistics. Various. Finnish Forest Research Institute. National Forest Inventories. Various. Hildén et al. 2005 Suomen biodiversiteettiohjelman arviointi [Evaluation of the Finnish National Action Plan for Biodiversity].	Biodiversity.fi. http://www.luonnontila.fi (in Finnish) and http://www.biodiversity.fi (in English). Finnish Environment Institute. Monitoring of Butterflies in agricultural landscapes. Finnish Environment Institute. Water quality database Hertta. Finnish Forest Research Institute. National Forest Inventories. Various. Finnish Museum of Natural History. Monitoring breeding land birds. South Karelia Allergy and Environment Institute. National Butterfly Recording Scheme.
SE	Department of Aquatic Science and Assessment. http://www.ma.slu.se Geological survey of Sweden. http://www.sgu.se/sgu/eng National Inventory of Landscapes in Sweden (NILS). http://nils.slu.se Statistics Sweden. Various data series, e.g. agricultural data (http://www.scb.se/default____2154.asp) Swedish Board of Agriculture. Area of farmland. http://www.sjv.se Swedish Board of Fisheries. http://www.fiskeriverket.se Swedish Forest Agency. http://www.svo.se/episerver4/ Swedish University of Agricultural Sciences. National Forest Inventories. http://www-taxwebb.slu.se	Department of Aquatic Science and Assessment. http://info1.ma.slu.se/db.html National Inventory of Landscapes in Sweden (NILS). http://nils.slu.se Small rodents. http://www.emg.umu.se/projects/hornfeldt/ Species Gateway. http://www.artportalen.se Survey of seabirds. http://www.biol.lu.se/zooekologi/waterfowl/ANDINV/Andf_index.htm Swedish bird survey. http://www.biol.lu.se/zooekologi/birdmonitoring/res-hackfagel.htm Swedish University of Agricultural Sciences. National Forest Inventories. http://www-taxwebb.slu.se/
NO	Norwegian Forest and Landscape Institute. Norwegian forest inventories. Statens kartverk. N50 digital topographic maps. Statens Kartverk. Norge i tall. Statistics Norway. Various.	Johansen A. 1997. Myrarealer og torvressurser i Norge. Jordforsk rapport 1997: 1: 1–21. Norsk Ornitologisk Forening [Norwegian Birdlife]. Norwegian Forest and Landscape Institute. Norwegian forest inventories. Statistics Norway. Various.
DK	Levin G, Normander B. 2008. Arealanvendelse i Danmark siden slutningen af 1800-tallet [Land-use in Denmark from the end of the nineteenth century up until today]. DMU faglig rapport 682. National Survey and Cadastre. Kort10	Byrnak E et al. 2001. Fiskebestanden i Suså 2000. Storstrøms og Vestsjællands amt. Baagøe HJ, Jensen, TS. 2007. Dansk Pattedyr Atlas [Danish Mammals Atlas]. Danmarks Fiskeriundersøgelser. 1967. Unpublished fish data, monitored by Knud Larsen.

	digital topographic maps. Statistics Denmark. Agricultural statistics. Various. Statistics Denmark. Area statistics. Various. Statistics Denmark. Forest inventories. Various.	Dolby J, Jensen FS. 2001. Udsætningsplan for fynske vandløb. Dolby J. 1999. Udsætningsplan for Storåen. Heldbjerg H, Eskildsen A. 2008. Overvågning af de almindelige fuglearter i Danmark 1975-2007 [Point counts 1975–2007]. Dansk Ornitologisk Forening [Danish Birdlife]. Jensen, CF, Jensen, F. 1980. Vandløbsfaunaens udvikling i perioden 1900–1980. In: Møller, HS, Ovesen, CH. Status over den danske plante- og dyreverden. p 189–200. NERI. Arter 2004–2005 [Species 2004–2005]. DMU faglig rapport 582 (NOVANA). NERI. Arter 2006 [Species 2006]. DMU faglig rapport 644 (NOVANA). NERI. Den danske rødliste. http://redlist.dmu.dk NERI. Søer 2006 [Lakes 2006]. DMU faglig rapport 641 (NOVANA). NERI. Vandløb 2006 [Running water 2006]. DMU faglig rapport 642 (NOVANA). NERI. Vandmiljø og natur 2006 [Water environment and nature]. DMU faglig rapport 646 (NOVANA). NERI. Vildtudbyttestatistik [hunting statistics]. Plantedirektoratet. Økologisk jordbrug [Organic farming statistics]. Riis T, Sand-Jensen K. 2001. Historical changes in species composition and richness accompanying perturbation and eutrophication of Danish lowland streams over 100 years. *Freshwater Biology* 46:269–280. Statistics Denmark. Agricultural statistics. Various. Statistics Denmark. Forest inventories. Various.
IS	Guðjónsson G, Gislason E. 1998. Gróðurkort af Íslandi 1:500 000. Icelandic Institute of Natural History. Hagskinna. Icelandic Historical Statistics. Statistics Iceland 1997. Jónsson ÞH. 2004. Pers. Comm. Snorrason A. 2007. Pers. Comm. Statistics Iceland. 1998. Umhverfistölur 1997. Statistics Iceland. Agricultural statistics. Various.	Hermannson J. 2008. Pers. Comm. Skarphedinsson KH. 2003. Sea eagles in Iceland: Population trends and reproduction. Statistics Iceland. 1998. Umhverfistölur 1997. Statistics Iceland. Agricultural statistics. Various. UST. Veiðitölur 1995–2006. Vottunarstofan Tún ehf. 12.10.2008

Nordic Council of Ministers

Store Strandstræde 18
DK-1255 Copenhagen K
www.norden.org

State of biodiversity in the Nordic countries

The Nordic countries have agreed on a common target to halt the decline in biodiversity by 2010. This report aims at evaluating the 2010-target by presenting indicators that can describe trends in biodiversity in the Nordic countries.

Our results comprise the most comprehensive documentation of land use in the Nordic countries to date. The area of important nature types such as mire, grassland and heathland have decreased significantly over the past one to two decades, whereas the area of constructed habitats, including city areas and transport networks, has grown considerably in all of the Nordic countries. Each of these trends in land use will cause biodiversity to decline. Looking into the quality aspect of biodiversity, our results reveal that two-thirds of the quality indicators presented show declines and the remaining one-third show improvements (or steady-state).

Overall, our results indicate that biodiversity has declined in the Nordic countries since 1990. In particular, farmland, mire, grassland and heathland habitats show declines in biodiversity, but also the remaining habitats show negative trends. Therefore, based on the findings from this study, we conclude that it is highly unlikely that the target of halting biodiversity loss by 2010 can be achieved by the Nordic countries.

Our results should be perceived as a first attempt to make an overall assessment of biodiversity in the Nordic countries. We believe that if further efforts were directed towards scrutinising existing and historic monitoring programmes and data sources, additional indicators could be calculated and hence a better knowledge base would be achieved.

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