NORWEGIAN DIRECTORATE
FOR NATURE MANAGEMENT

REPORT

DN-report 1-2011

The Norwegian Nature Index 2010

The Norwegian Nature Index 2010

DN-report 1-2011

Publisher:
The Norwegian Directorate for Nature Management

Date: January 2011

Pages: 24

Emneord: biologisk mangfold, tilstand, naturindeks, ferskvann, hav, kystvann, myr, åpent lavland, fjell, skog, utvikling

Keywords: biodiversity, condition, state, Nature Index, freshwater, sea, coastal waters, mire, semi-natural habitats, mountain, forest, trends

Order:
The Norwegian Directorate for Nature Mangement.
PO BOX 5672 Sluppen, N-7485 Trondheim.
Tel: +47 73 58 05 00. Fax: +47 73 58 05 01
www.dirnat.no/publikasjoner

Referred as: Nybø, S., Certain, G. & Skarpaas, O. 2011. The Norwegian Nature Index 2010. DN-report 2011-1

ISBN (Trykt): 978-82-7072-877-0
ISBN (PDF): 978-82-7072-878-7
ISSN (Trykt): 0804-1504
ISSN (PDF): 1891-4616

Cover photo: Dag H. Karlsen

Layout: Guri Jermstad AS

ABSTRACT:

The Nature Index (NI) was established to provide an overview of the state and development of biodiversity in the major ecosystems in Norway, the marine, limnic (freshwater) and terrestrial ecosystems, and thereby measure progress towards the goal of halting the loss of biodiversity.

A number of indicators were chosen to represent the state of biodiversity. 125 scientists from various disciplines provided data and/or expert judgements, or modelled data for 309 indicators representing various aspects of biological diversity, such as trophic levels, key species and threatened and common species. In order to assemble all the data into an index, a reference value was estimated for each indicator. This reflects an ecologically sustainable value for the indicator. The nature index displays any divergence from the reference states. This report gives a brief presentation of the NI framework, the background and context, and the implementation and main results for Norway.

Summary

This report presents the first Nature Index for Norway. The Nature Index is intended to give an overview of the development of biological diversity and to help to measure whether its loss is being stopped, in accordance with international agreements. The index is based on international methodology for similar indices and develops these methods further. It calculates the state of biological diversity in major ecosystems from a set of indicators selected for each of these to represent its biological diversity. These indicators are either species or indirect indicators (surrogates) that indicate the potential for biological diversity for several species. Dead wood is an example of such an indirect indicator. The Nature Index consists of 309 indicators distributed over nine major ecosystems: seabed, open sea-pelagic, coastal waters-seabed, coastal waters-pelagic, fresh water, open lowland, forest, mire-wetlands and mountains. Obtaining sufficient information for some of these ecosystems has been challenging. This is, however, the most comprehensive comparison of data on biological diversity ever made in Norway, and we believe that it provides a good pointer to the state of major ecosystems.

The results show that the state of biological diversity in 2010 is good in the sea, coastal waters, fresh water and the mountains (NI = 0.69-0.80), where NI = 1 indicates the reference state for all the indicators in the given ecosystem. Overall, open lowland and forest have the lowest NI value of all the major ecosystems (NI = 0.43-0.44), while mire-wetlands is in a somewhat higher value (NI = 0.55). Open lowland consists mainly of semi-natural habitats, that is formerly cultivated meadows and coastal heathlands that are dependent on management such as grazing, heather burning or haymaking. The lack of management and grazing animals has led to considerable overgrowing of coastal heathlands and grass- and herb-rich pastures, which means that such habitats are becoming reduced in area, and the areas that remain are also in a consistently poor state.

The relatively low NI-value of forest is due to a combination of a long history of forestry (leading to e.g. less dead wood and fewer old trees) and the low numbers of predators. Furthermore, there are such large numbers of moose and red deer in some areas that they negatively affect other elements of biodiversity. The NI of of forests is lowest in central Norway and Hedmark. Mires have been exposed to extensive ditching, peat cutting and cultivation since the 1930s and there is a great geographical variation in the state of the mire-wetlands ecosystem. Some types of mire are particularly vulnerable to long-transported nitrogen input, climate change and motorised transport on ground when it is not covered by snow. Mountain areas are generally in a good state, but less so in some central parts of southern Norway due to combinations of such factors as long-transported pollution, changes in land use (less use of summer pastures, more powerlines, road construction and agglomerations of holiday homes) and climate change. In general, the state of biological diversity in Norway seems better than in many other parts of the world.

The Nature Index has been calculated for 1990, 2000 and 2010 to illustrate the developments in the ecosystems over the last 20 years. Both the sea and fresh water have seen an overall improvement in their state in Norway, 8 % for seabed, 10 % for open sea-pelagic and fresh water. Better management of commercial fish stocks has helped the biological diversity to improve or stabilise in all the major areas of sea, except the Skagerrak, where species living in open water (pelagic) have seen a worsening of their state. There may be problems with overfishing and eutrophication here. In fresh water, the improvement is linked to a number of specific management measures to improve environmental states. In southern, south-eastern and western Norway, the state of fresh water has substantially improved since 1990 (15-24 %). The international agreement on reducing emissions of compounds that lead to acid precipitation (the Gothenburg Protocol) and liming to combat acidification have contributed to this improvement. The improvement has been mainly reflected in one indirect indicator (critical level of acidification). The biological response to reduced acidification may be weaker, but we still lack good biological indicators to quantify this. For coastal waters, we cannot identify any significant change from 1990 to 2010 for the country as a whole, but there has been a great improvement in the Nature Index for coastal waters-pelagic in south-eastern (19.7 %) and southern (8.3 %) Norway during this period. This improvement reflects increased purification of sewage and less influx of contaminating nutrients from the southern North Sea, but the calculation is based on few indicators and

is therefore uncertain. In the same areas, the state of coastal waters-seabed has deteriorated (11.0 % in south-eastern Norway and 15.8 % in southern Norway). This is mainly due to eutrophication, which causes improvements to take effect later than in the open sea, impacts on sensitive coastal areas and overexploitation of fish stocks. The state of the coastal waters-seabed along the Nordland coast remains less good in 2010 due to the kelp forest being overgrazed by sea urchins, but this overgrazing is much less marked in central Norway in 2010 than in 1990. The causes of this overgrazing are not clear.

The Nature Index for the terrestrial ecosystems has deteriorated from 1990 to 2010, with the possible exception of forests, where key indicators were lacking in 1990.. Mountainareas and mire-wetlands have seen reductions of 4.1 % and 5.2 %, respectively. The reduction for the latter was most marked in northern Norway, where the climate-sensitive palsa bogs are slowly melting. Northern Norway also has the greatest reduction for mountain areas (6.7 %). The most dramatic deterioration overall is for open lowland, where the Nature Index has declined by 12.0 % during the period. This reduction is quite similar all over the country.

Work on the Nature Index has demonstrated that there is too little basic information on biological diversity. Information on vertebrates (fish, birds and mammals) is relatively good, but that on fungi, plants and invertebrates is very poor. Better monitoring data for plants and invertebrates are needed for all ecosystems, and better geographical coverage of such data is required for most indicators. More information will permit more dependable assessments of changes in biological diversity and hence more precise and better targeted management. This report gives a summary of prioritised gaps in our knowledge that must be filled to improve the information base for management agencies and to enhance the quality of the Nature Index when it is updated in 2015.

The researchers who provided data for the Nature Index responded to questions about what trends they envisaged for their indicators by 2020. Where they foresaw a negative trend, they indicated where measures are most urgently needed and whether their implementation would be straightforward or difficult. The researchers who assessed the indicators for open lowland were the most concerned about future trends and believed that measures must be introduced immediately to maintain a good standard here. They also believed that such measures would be relatively easy to implement (at least from a technical perspective) if they are introduced now. For the other major ecosystems, the researchers were either less concerned about the trends or less certain about what they will be. They were also less certain about whether measures to re-establish favourable states are either possible or urgent.

1 The Nature Index: main results

1.1 Biological diversity, sustainable development and the Nature Index

The Earth's biological diversity is of great importance for human beings. It is enormous, but we know too little about it. What do we really know about the development of biological diversity? What are the main trends? This report presents the Nature Index for Norway, which is both a figure and a framework that provides an overview of the development and draws links to human impacts and threat factors. This introductory chapter places biological diversity in context with sustainable development.

The wide-reaching technological and economic development, along with the population explosion in the last century, has put dramatic pressure on ecosystems. According to the Millennium Ecosystem Assessment (2005), changes in agriculture, forestry and physical encroachments pose the greatest global threats to the biodiversity on land, whereas the fisheries are the greatest threat in the sea. In fresh water, changes in water regimes, alien species and pollution, particularly eutrophication, are the greatest threats. Climate change is an increasing threat to all the ecosystems.

The biological diversity on the Earth is so large and extensive that no-one has an overview of all the species that exist (Box 1-1). Between one and two million species have so far been described, but it is estimated that between 5 and 15 million species remain to be discovered (Norwegian Biodiversity Information Centre, www.artsdatabanken.no). Species are now going extinct more rapidly than we are able to describe new ones, and the extinction rate is between 100 and 1000 times faster than it was 0.5-13 million years ago (Millennium Ecosystem Assessment 2005).

The conflict between the scale and loss of species and habitats is an ethical question, but it is also an existential issue. Mankind is directly dependent upon the ecosystem services which biodiversity produces (Box 1-2). For instance, marine fish are the most important source of animal protein for a billion people (ten Brink *et al.* 2009). The need for more food rises in pace with population growth. The global population has now reached 6.8 billion, and the UN forecasts that it will stabilise at 9.3 billion in 2050, an increase of 39 % from the present level (State of World Population 2009). Already today, 35 % of the Earth is being used to produce food, and the pressure on these areas will increase further.

Food production will need to increase by 70 % between now and 2050, if our food habits are not altered. People are also dependent upon clean water. Already today, 70 % of fresh water is used for

Box 1-1. Biological diversity is the diversity of ecosystems, species and genetic variations within the species and the ecological connections between these components.

(Nature Diversity Act).

Box 1-2. The ecosystems provide people with many types of benefits. These are generally termed ecosystem services. Examples of ecosystem services are:

- Provisoning: food, building materials, fuel, water
- Regulatory mechanisms: climate regulation, cleansing of water, air and soil, regulation of pests, flood regulation
- Cultural enjoyment: aesthetic experiences, sacred and religious sites, outdoor recreation, fresh air, knowledge of natural history
- Supportive functions that are required to produce other ecosystem services such as soil formation, pollination, primary production, oxygen production, cycling of nutrients

(Millennium Ecosystem Assessment 2005)

Box 1-3. Sustainable development is development which ensures the needs of the current generation without jeopardising those of future generations (the 1987 World Commission on Environment and Development).

agricultural production, and clean water is, and will remain, in short supply in many places. For many of the ecosystems, we know too little about which elements of the biodiversity are necessary to secure water supply and food production. What we do know is that it is cheaper to counter the loss of biological diversity than to restore it (http://www.teebweb.org). To prevent the loss, instruments are needed to link changes in biological diversity to their causes.

The threat situation in Norway is probably very similar to the international one, but the scale of the impacts is smaller here than in the most densely populated parts of the world. Climate change and alien species may prove to attain greater importance as threat factors in the future, but so far we have inadequate tools to determine the greatest threats to biodiversity in Norway. An important aim of the Nature Index is to view the trend in biodiversity in connection with human impacts and threat factors.

1.1.1 Sustainable development

Sustainable development is based on three foundation stones, all of which must be in a good state if the demand for sustainable development is to be met; these are economy, social conditions, and environment and ecology. Even though the development in biological diversity is most directly tied to environmental conditions and ecologically sustainable development, biodiversity is important for all three foundation stones. Norway Statistics (SSB) publishes annual reports which cite indicators for sustainable development in Norway relative to policies in the government's strategy for sustainable development (Brunvoll & Smith 2010).

Economic aspects of sustainable development In Norway, the economic aspects of sustainable development are measured, among other ways, by the national income per inhabitant and a generation account (Brunvoll & Smith 2010). One problem with the economic indicators for sustainability is that the economic models currently in use measure consumption and production from the Gross National Product and do not include the ecosystem services which biodiversity produces or the actual ecological cost of destroying nature and ecosystems (ten Brink *et al.* 2009). The work done by insects in pollinating fruit, berries and other useful plants so that people get a varied food production is an example of such an ecosystem service. Other examples are the ability of forests to store CO_2 to stabilise the climate and the contribution of freshwater organisms in cleansing water (Box 1-2). Negative ecological consequences may, among other things, be linked to ecosystems being pressed so hard that a "tipping point" is reached where they collapse and completely change their function (Leadley *et al.* 2010). Examples of ecosystems which may be approaching this critical point are the Amazon rainforest and the oceans (due to their acidification). Studies of sustainable development which chiefly consider economic conditions may underestimate the need for knowledge of ecological sustainability, not least to identify and reveal serious threats like loss of biodiversity. In the longer term, deteriorating ecologically sustainable development may also lead to very negative consequences for economic development.

Social aspects of sustainable development In Norway, the social aspects of sustainable development are measured using indicators linked to social inequalities in economy, education level, exclusion from working life, and health and welfare (Brunvoll & Smith 2010). In addition, the global dimension of sustainable development may be linked to the social aspect. Two indicators are used to measure this dimension: aid to and import from developing countries. Biodiversity is essential for food production globally and, hence, has great direct significance for human health and welfare. The global need for food will be doubled in the next 25-50 years. Much of the food production around the world derives from natural ecosystems, that is, from areas without active cultivation of food. Lack of food and its uneven distribution may lead to hunger, social disquiet, a shorter life expectancy and a radically reduced quality of life. Biological diversity also has great direct importance for human well-being as a source for enjoying nature through recreation, aesthetic and cultural experiences and outdoor pursuits.

Environmental and ecological aspects of sustainable development In Norway, the environmental and ecological aspects of sustainable development are measured using indicators for climate and pollution, energy consumption, natural resources, chemicals that are hazardous to health and the environment, cultural heritage sites and biodiversity (Brunvoll & Smith 2010). Three indicators for biological diversity are included in the national set of indicators – breeding birds in the mountains, woodlands and forests and the cultivated landscape, and the quality of water in fresh water and coastal waters,

respectively. To improve the basis for assessing the trend in biodiversity in Norway, this year's sustainability report from Statistics Norway also includes information on the trend of species on the Norwegian Red List, the amount of wilderness-like natural environment, and the trend in important seabird populations, using figures for kittiwakes, puffins, common eiders and shags.

The data sets for these three indicators are included in the Nature Index, which also contains many other data sets for biological diversity. The Ministry of Finance will begin to revise the Norwegian indicators for sustainable development around the turn of the year 2010-2011, and the question of whether to include the Nature Index in the set of national indicators will be considered. The Nature Index is intended to give an overall picture of the state of biodiversity in Norway and should be valuable for assessing the future trend in biological diversity in a sustainability perspective.

In 2002, the world's leaders agreed to reduce the loss of biological diversity by 2010, and this aim is included in the UN Millennium goal for development. The EU, and Norway, has reinforced this goal in a separate agreement: the loss of biodiversity must be halted by 2010 (Ministerial Conference in Kiev, Ukraine in 2003). It is now acknowledged that the loss of biodiversity cannot be halted by 2010 and that new international and national measures must be implemented to attain this goal (see the chairman's report from the Trondheim Conference in 2010 http://www.trondheimconference.org). The task of establishing a Nature Index for Norway is a step in the establishment of an instrument to measure this political decision. In its Soria Moria Declaration in 2005, the Stoltenberg Government stated that a Nature Index would be developed for Norway to get a better picture of development trends in the natural world, including the cultural landscape. In its second term of office, the Stoltenberg Government reaffirmed this aim (Soria Moria 2009). The principal goal of the index is to acquire an overview of the development of biological diversity in Norway and to identify impact factors. In addition, a better impression of the gaps in knowledge about biological diversity would be obtained, thus helping to implement the necessary mapping and monitoring of the Norwegian environment.

1.2 An overview of the state of biodiversity in Norway

Here we give an overview of the state of biodiversity in the major ecosystems, as it is revealed through the Nature Index (Box 1-4 summarises the methodology). The Norwegian report (Nybø 2010b) includes a chapter on each of the major ecosystems.

The Nature Index shows the state of the ecosystems on a scale between 0 and 1, where 1 means that the ecosystem is in a reference state, while 0 means that the biodiversity in the ecosystem is in a very poor state. Where the map of Norway is shown, red signifies a very poor state and blue a very good state (reference state). Orange, yellow and green signify gradual improvements towards blue (a very good state). In addition to the state of the ecosystems, it is also important to know how large areas they cover.

Box 1-4. The Nature Index measures the state and development of biodiversity in the major ecosystems based on a large selection of indicators. The indicators are naturally occurring species, diversity indices and so on. The indicator values are based on assessments by experts, monitoring data or models. The indicators are scaled in such a way that they measure deviation from a reference state, which is specified as an ecologically sustainable state for the indicator. The Nature Index is an average of the scaled values, and values range between 1 (reference state) and 0 (very poor state). The Nature Index can be calculated to reflect state in municipalities, counties , major ecosystems and taxonomic groups. See Certain & Skarpaas (2010) for more details.

1.2.1 The state and area of Norwegian ecosystems

Figure 1.1 shows the area and state of the major ecosystems. Coastal waters, forest and mountain areas make up the largest areas, while fresh water, open lowland and mire-wetlands each amount to less than 7 % of the total area. Urban and built-up areas and industry together amount to less than 1 % of the total area, while arable land comprises 2 %. Note that when the proportion of the area is

calculated, coastal waters out to 1 nautical mile beyond the baseline are included. This means that the proportion of each land area unit is less than if we had just taken the land area of Norway as the basis, which is often the case. The area figures here are derived from official N50 maps and GIS modelling (Blumentrath & Hanssen 2010), and can be found on the Nature Index web site (www.dirnat.no/naturindeks).

The state of coastal waters, the sea, fresh water and mountain areas is relatively good (NI = 0.69-0.80) in 2010. Of all the major ecosystems, open lowland and forest are, overall, in the poorest state (NI = 0.43-0.44), whereas mire-wetlands has a somewhat better state (NI = 0.55) (Fig. 1.1). Overall, the conditions in open lowland are most worrying since this ecosystem covers only a small area and is in a poor state. Open lowland mainly consists of formerly cultivated land, that is, areas which are strongly influenced by human activities like haymaking, livestock grazing and heather burning. Many of these areas are now becoming overgrown, and both their extent and the state of the remaining areas are declining. Although there is a lack of farming and management to maintain the biodiversity in open lowland, it is the scale of current or former human utilisation of forest and mire-wetlands that is the main reason why the state is poor here. Small populations of wolves, brown bears and lynx, together with excessively large populations of elk and red deer in some areas, reflect a forest ecosystem that is severely modified by the human management of these species. Forestry, moreover, has a serious impact on the biodiversity. In the case of mire-wetlands, former usage has mainly caused the poor state. Extensive peat cutting, new cultivation and ditching have led to great changes in the ecosystem. Nowadays, little conversion of mire to arable land or forest is taking place through ditching, but the former impacts are in reality irreversible in a 100-year perspective. Moreover, some types of mire are vulnerable to input of far-transported nitrogen and to climate change

The state of mountain areas in Norway is relatively good (Fig. 1.1), but threats here are increasing. Species inhabiting the mountains are adapted to extreme climatic conditions and may therefore be especially vulnerable if they are exposed to additional impacts. Climate change, and more roads and buildings, pose growing threats to biological diversity in the mountains. The state of fresh water is comparatively good and has improved appreciably since 1990. Coastal waters are for the most part in a good state, but the important kelp forest, where fish and other species grow up, has changed in several areas.

1.2.2 Variations in the Nature Index within Norway

The above section described the state of biological diversity in Norway in general terms. However, we know that there are great variations within the country and have therefore calculated the state and area of major ecosystems regionally (Fig. 1.2).

Figure 1.3 depicts this variation in broad outline for both the extent and the state of the area out to 1 nautical mile beyond the baseline, and figure 1.4 shows the state of the sea beyond there. Finally, the

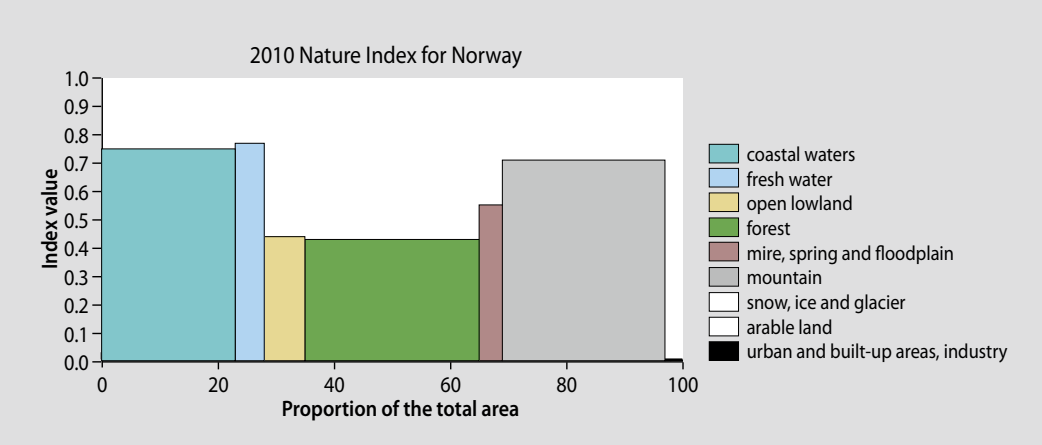


Figure 1.1 *The state of biological diversity in the major ecosystems, as measured by the Nature Index (y axis) and the proportion of the area taken up by the major ecosystems (x axis). The total area includes coastal waters out to 1 nautical mile beyond the baseline, fresh water and the entire land area.*

same results are presented as maps (Fig. 1.5). These maps do not show the extent of the ecosystems, just variations in their state in 2010.

Figure 1.3 shows that the proportion of coastal waters is largest in northern Norway and decreases southwards. The state of the pelagic biodiversity in coastal waters is good everywhere, but for benthic (bottom-dwelling) species it is poorest in central and northern Norway. This is because the kelp forest has been excessively grazed from the Trøndelag counties north to Lofoten.

The proportion of fresh water is fairly similar in all the five regions, approximately 5 % (Fig. 1.3). On the whole, the state of fresh water is good, with an average index of 0.77. It is poorest in southern Norway (NI = 0.67).

Western and central Norway have the largest proportions of open lowland; 11 and 9 % of the total area, respectively. The proportion is lowest in south-eastern Norway (4 %). The area of open lowland shown here includes all open land below the tree line which is not farmed or taken up by industry, infrastructure or urban and built-up areas. Coastal heathlands and grass- and herb-rich pastures are included in open lowland, and it is mainly the state of these units that has been assessed. The state is generally poor in all the regions (≤ 0.52), and poorest in south-eastern Norway (NI = 0.36). Overgrowing is taking place more slowly in the north due to the cold climate, and the state is consequently somewhat better there (NI = 0.52) (Figs. 1.3 and 1.5).

Figure 1.3, moreover, shows that the proportion of forest is smallest in northern Norway and increases southwards. It is 18 % in northern Norway and 53 % in southern Norway. The state of forest is poorest in central Norway (NI = 0.37).

Central and south-eastern Norway have the highest proportion of mire-wetlands (7 %), whereas this is only 1 % in western Norway. The state of mire-wetlands varies more within the regions than is the case with the other ecosystems (Fig. 1.5). In general, the poorest state is found in south-eastern and southern Norway (NI = 0.51 for both regions).

Northern and western Norway have the highest proportion of mountain areas in all the regions, 34 % in both cases (Fig. 1.3). The figure in south-eastern and central Norway is 23 %, and in southern Norway 18 %. There are small differences in the state of the mountain areas between the regions.

Norway has a small proportion of arable land, a mere 2 % when the area of coastal waters is included in the calculations (3 % of the land area). South-eastern Norway has the highest proportion of arable land (5 %), followed by southern and central Norway (3 %), western Norway (2 %) and northern Norway (1 %). The Nature Index has not been calculated for these areas. The Norwegian Institute for Forestry and Landscape is currently exploring the possibilities for an indicator set for the farm landscape (arable land). This will provide a basis for considering whether to extend the Nature Index to this type of environment. Urban and built-up areas, along with industry, take up 1 % of the area in south-eastern and southern Norway, and less in the other regions.

Large areas of sea are within the Norwegian Exclusive Economic Zone, all told 870 000 km^2 from the baseline out to 200 nautical miles. The marine area that is included in coastal waters amounts to 94 000 km^2 (landwards from 1 nautical mile outside

Figure 1.2 *Regional divisions used in the Nature Index. Regional divisions (counties in brackets): Northern Norway (Finnmark, Troms, Nordland), Central Norway (Nord-Trøndelag, Sør-Trøndelag, Møre & Romsdal), Western Norway (Sogn & Fjordane, Hordaland, Rogaland), Southern Norway (Vest-Agder, Aust-Agder, Telemark, Vestfold), South-eastern Norway (Hedmark, Oppland, Østfold, Oslo & Akershus, Buskerud).*

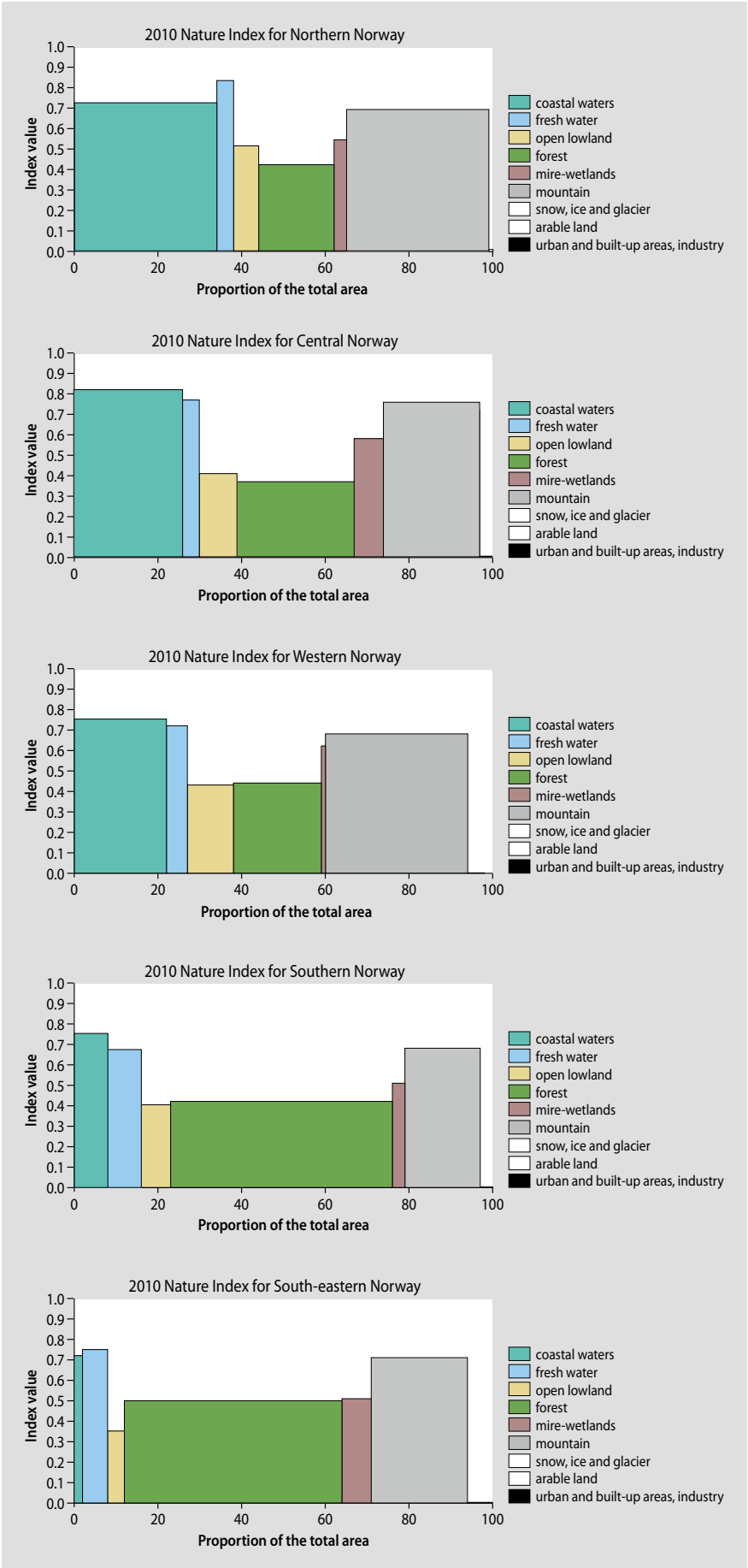


Figure 1.3 *The state of the biodiversity in the major ecosystems in various regions of Norway (y axis) and the proportion of the area taken up by the various ecosystems (x axis). The total area includes coastal waters out to 1 nautical mile beyond the baseline, fresh water and all areas of land.*

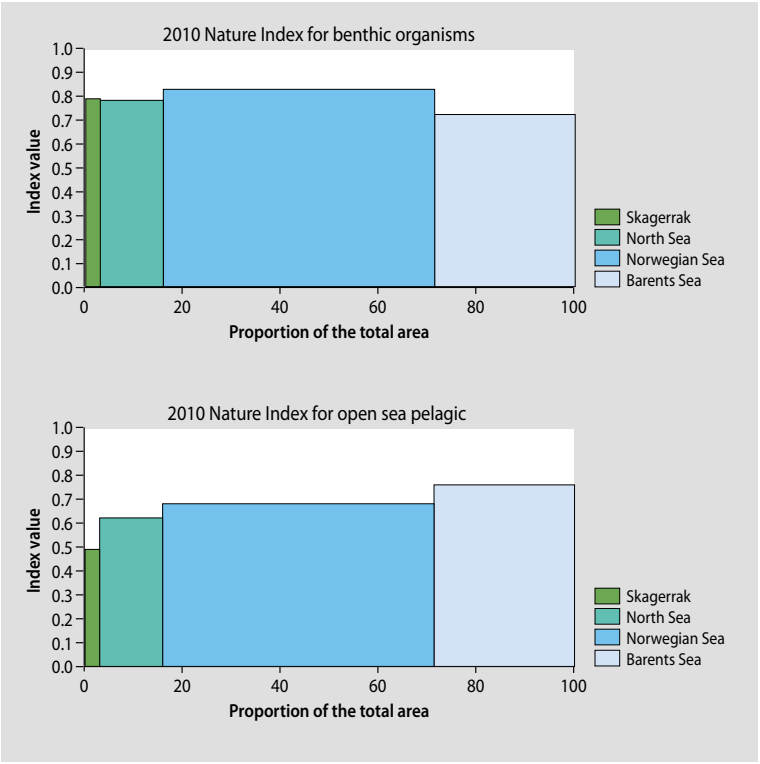


Figure 1.4 *The state of the biodiversity in the large areas of sea around Norway, measured with the Nature Index (y axis) and the proportion of the area of the individual sea area relative to the total area (x axis). The total area comprises the Norwegian Exclusive Economic Zone up to the baseline, but excludes the waters around Svalbard and Jan Mayen, and the Antarctic Ocean; uppermost: the Nature Index for benthic (bottom-dwelling) organisms; lowermost: the Nature Index for organisms living within the water body (pelagic).*

the baseline). This total area of sea amounts to nearly 3 times the land area of Norway, which covers 324 000 km^2. The Norwegian Sea is by far the largest area, comprising more than half of it, 56 % (Fig. 1.4), followed by the Barents Sea (29 %), the North Sea (13 %) and the Skagerrak (3 %).

The Nature Index has been calculated for the biodiversity associated with the water body (pelagic species) and the bottom-dwelling (benthic) species in the sea. Considerably less is known about the benthic species than the pelagic ones because it is difficult and expensive to investigate the state of the seabed. The Nature Index indicates that in 2010 the state of the seabed is very good (NI = 0.79) when the seas are considered as a whole, and better than for the water bodies (NI = 0.69) (Fig. 1.4). The seabed conditions are better in the deep Norwegian Sea than in the more shallow areas of the Barents Sea, the North Sea and the Skagerrak (see also Fig. 1.5). The major fisheries in the sea take place in the water bodies and affect all the species living there, both directly via the fishing and indirectly via changes in the food chains. The state of the water body is best in the Barents Sea (NI = 0.76), somewhat poorer in the Norwegian Sea (NI = 0.68) and the North Sea (NI = 0.62), and poorest in the Skagerrak (NI = 0.49).

Figure 1.5 gives an overall overview of the state of the biodiversity in the various ecosystems that have been investigated. The maps show that there are different regional patterns for the ecosystems. They also clearly show that the biodiversity is poorest in forest and open lowland.

The Nature Index has been calculated for all Norway for 1990, 2000 and 2010. Furthermore change in NI from 1990 to 2010 has been calculated (Fig. 1.6). The index has declined by 12 % in open lowlands during this period and increased by 8% in seabed, and 10 % in both open sea-pelagic and fresh water. For the other major ecosystems the development are somewhat below 0 %, but for these ecosystems no clear conlusions on trends can be drawn. For forest the NI was not calculated for 1990 due to lack of data on the five key indicators.

1.2.3 The biological diversity of Norway in a global perspective

What is taking place with species and habitats around the world is depressing. Butchart *et al.* (2010) compiled all the data for the indicators used by the Convention on Biological Diversity. None of the 10 indicators which measure changes in the state of biological diversity show any improvement on a global perspective since 1970, but there are some

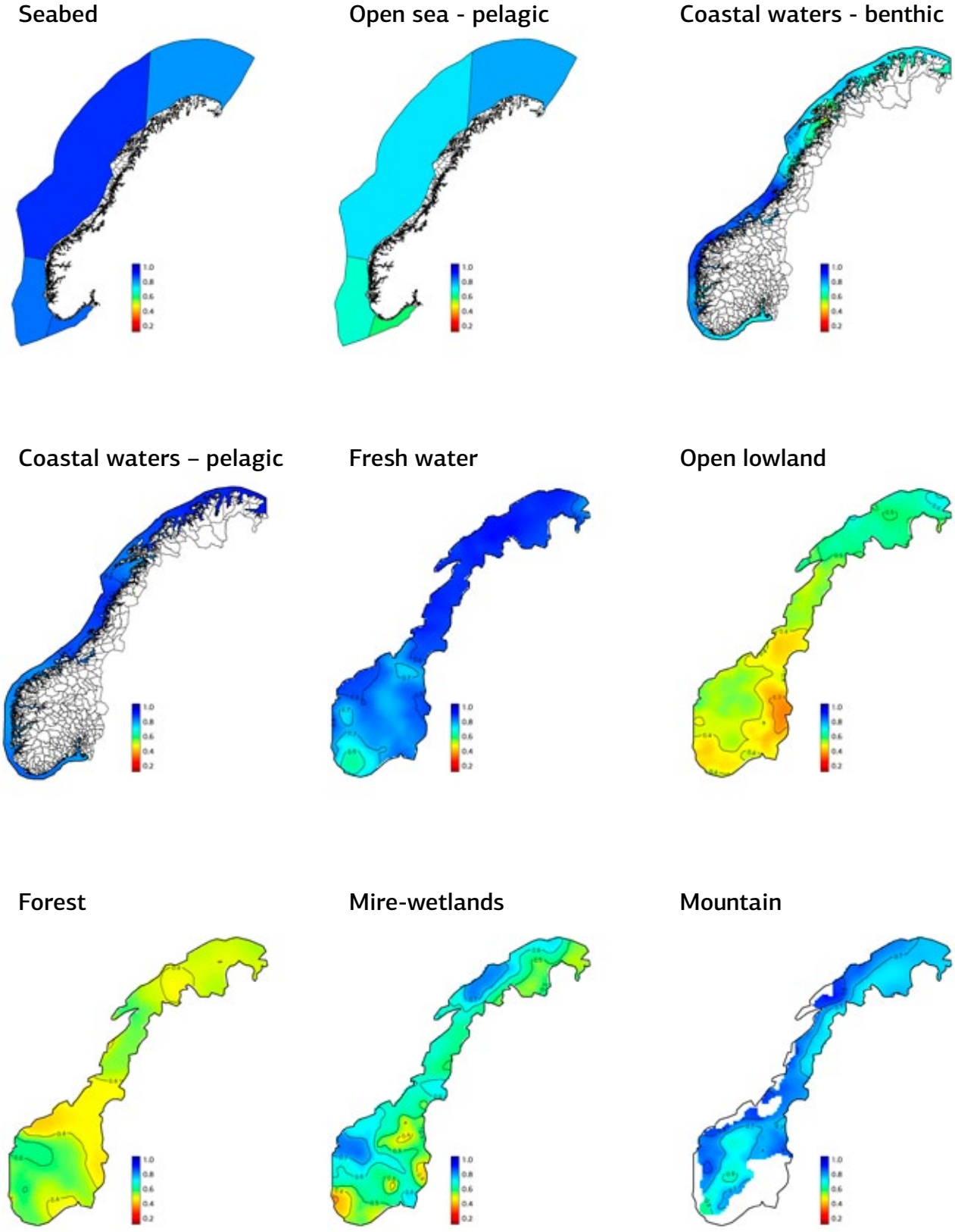


Figure 1.5 *The state of the biodiversity in the major ecosystems in 2010, as measured by the Nature Index.*

positive signs. Some groups of species are showing improvement in a few areas. One example is that the abundance of aquatic birds has increased by an average of 44 % in North America and Europe since 1980. Moreover, all the negative impact factors are increasing, especially the consumption of resources or the ecological footprint (Butchart *et al.* 2010). The ecological footprint shows that Europe, for example, is consuming twice as many resources as it produces (Global Footprint Network 2008). It is, however, gratifying that the effort to improve the state of biodiversity has increased considerably (Butchart *et al.* 2010). Nature protection has been reinforced in many countries, the number of protected areas has increased and certification of forestry has increased. Unfortunately, these measures have been inadequate to stabilise the conditions. Corresponding reinforcement of the legislation and increased protection have also been implemented in Norway in recent years, but it is still not possible to discern any positive trend in the Nature Index as a result.

The European Environment Agency (EEA) assesses the state of the environment in Europe. The loss of biological diversity in marine ecosystems in Europe is appreciable and, according to interpretations of the relatively sparse data available, there are no signs of improvement (EEA 2010). As many as 45 % of the commercial fish stocks are outside safe biological limits. That a species of fish is in a "biological safe stock" means that the stock will not decrease over time[1].

Three of the twelve commercial fish stocks in the eastern Arctic (the Barents Sea and adjacent waters) are below safe biological limits (EEA 2010). The greatest threats to biological diversity in the open sea and coastal waters are eutrophication, contamination, pollution, overfishing, alien species, climate change and acidification. The problem of alien species is increasing. Acidification of seawater is a problem for organisms which have a calcareous shell, like corals, crustaceans and some groups of plankton, and it will also reduce the ability of the sea to store CO_2 and counteract climate change (Burkill *et al.* 2009). The rising temperature of the sea has changed the species composition of fish and invertebrates in the North Sea, where more warmth-loving species occur than earlier (EEA 2010). Many measures have been introduced to reduce point emissions of nitrogen and phosphorus, but eutrophication of European waters is still a problem, mainly due to diffuse emissions. It has, moreover, been shown that pollution in the form of waste can directly injure wildlife, including top predators.

Figure 1.6 *Percentage change of the Norwegian Nature Index in different major ecosystems from 1990 til 2010.*

[1] Biologically safe stocks are defined as the spawning stock biomass (SSB) being higher than a biomass defined as the precautionary approach reference point (Bpa) or when the fishing mortality (F), an expression for the proportion of the stock that is removed by fishing, is lower than the fishing mortality precautionary approach reference point (Fpa).

There are examples of albatrosses ingesting so many fragments of plastic that they have died. The EU marine strategy will promote more sustainable management of the seas. The Nature Index shows that the state of Norwegian marine ecosystems are on the whole good (Fig. 1.5) and seem to have improved in every area from 1990 to 2010, although the trend for the Norwegian Sea is not clear.

The ecosystems that depend upon fresh water are the most altered of the major ecosystems in Europe (EEA 2010). Fresh water contains 25 % of the vertebrate species in the world, principally fish (IUCN 2008). More than 75 % of the drainage basins in Europe are threatened by many negative impacts simultaneously, thus causing the biodiversity to be threatened here (EEA 2010). The greatest threats to the freshwater-dependent ecosystems are contamination, habitat destruction, fragmentation, climate change and alien species. However, the degree of contamination has declined since 1992, mainly due to various EU directives (EEA 2010). Fresh water is also regarded as the most vulnerable ecosystem globally (CBD 2010). The Nature Index for fresh water is showing a positive trend in Norway. This improvement is largely a response to active management measures, not least to reduce the effects of acid precipitation. The introduction of the Water Directive in Norway aims to further improve this state. The development in Norway therefore shows that it is possible to reverse the negative trend.

Many species have natural and semi-natural grasslands as their most important habitat. Such areas have often been used for agricultural purposes, generally without being ploughed or cultivated in other ways (natural and semi-natural grasslands (cf. Halvorsen *et al.* 2008). Many of these species have declined since the mechanisation of farming. For instance, in Europe, birds which live in the agricultural landscape have declined by 50 % since 1980 (EEA 2009). This decline particularly results from the mechanisation of farming in eastern Europe accompanied by increasing use of artificial fertilisers and pesticides, whereas in western Europe much land has been left fallow and therefore become overgrown. The habitats have therefore become more unsuitable for birds which live in the agricultural landscape in both eastern and western Europe. In Norway, the sustainability indicator for breeding birds has shown a negative trend in the agricultural landscape in recent years (Brunvoll *et al.* 2009). A similar development is seen in Finland, Denmark and Sweden (Normander *et al.* 2006). The numbers of butterflies on grass- and herb-rich pastures have declined greatly in European countries, by 70 % since 1990 (EEA 2010). This reduction is mainly due to farming having been intensified in flat areas and the abandonment of traditional forms of farming which kept the vegetation low in steep terrain and wet areas. As part of the Nature Index programme, a project has recently started to record butterflies and bumble bees in Norway to find out whether the same trend is present here. As elsewhere in Europe, little remains of open lowland here and the remaining areas are generally in a poor state (Fig. 1.1).

The area of forest in Europe has increased in the past 20 years, and 8 % of it is protected, except for Russia where the proportion of protected forest is lower (EEA 2010). The effort to certify forestry is positive for biological diversity and 37 countries throughout Europe are taking part in acquiring a certification system that is intended to lead to sustainable forestry. Despite many initiatives aimed at preventing the loss of biological diversity in forest, it is difficult for Europe to halt it. Only 21 % of the 73 forest habitats on the EU Habitat List, which are within the protected areas, are in a good state. Moreover, only 15 % of the species on the lists of the Habitat and Bird Directives are considered to be in a good state. Major structural changes have taken place in North American and European forestry since the 1970s. Mechanisation has increased greatly and the work has been leased out to large contractors, resulting in a dramatic drop in the number of forestry workers. Most experts believe that independent contractors ignore the biodiversity (EEA 2010). Habitat destruction, non-sustainable utilisation, alien species, contamination and rising amounts of nutrients are the main threats to European woodlands and forests. Climate change will have an effect, too, in part by changing the incidence of diseases, increasing windthrows and altering the precipitation pattern. The Nature Index for forest shows that the state of the biodiversity is poor in Norway, too. This is also confirmed by the Red List, in that 47 % of the species which are threatened are found in woodland and forest (Kålås *et al.* 2010).

Mire forms where there is less evaporation than seepage of water. Sweden, Finland, Iceland and Norway, which are cold countries where evaporation is low, thus have the largest areas of mire in Europe (excluding Russia) and they have a special

responsibility to take care of these habitats. Owing to its varied landscape, Norway has a large variety of types of mire. Mires are important habitats for insects, amphibians, bryophytes and birds. Ditching is the one single factor that has brought the greatest change to the state and extent of the mires. Mires have been extensively drained in all the Nordic countries. In Finland, 55 % of the mire area has been ditched since 1950, and in Iceland 30 % (Normander *et al.* 2006). A great deal of ditching has also taken place in Norway. Ombrogenous bogs, which acquire all their water supply through precipitation, are especially vulnerable to air pollution, particularly nitrogen input. The state of mires in Norway varies greatly. Mires in the lowlands are in an especially poor state and only small areas are left). The Ramsar Convention protects the mire-spring-floodplain ecosystem, but no EU directive offers protection.

Habitats in the mountain ecosystem are vulnerable to impacts. The species living there are adapted to an extreme climate, and human-induced impacts may mean that they are unable to tackle altered environmental conditions. For instance, warmer autumn weather or nitrogen input may result in mountain plants continuing to grow longer than usual during the autumn, resulting in them being more poorly prepared to withstand the cold in winter – less cold-tolerant (Aarrestad & Stabbetorp 2010). More infrastructure and tourism, abandonment of farming and climate change are regarded as the greatest threats elsewhere in Europe (EEA 2010). 27 % of the land area on the planet is classified as mountain; in Norway the figure is about 37 %, 28 % if coastal waters are included (Fig. 1.1). Habitat destruction, climate change, changes in farming practices, infrastructure, mass tourism and pollution are the most important factors threatening the mountain ecosystem in Europe (EEA 2010). A review of the development of biological diversity in the Nordic countries showed that little was known about the mountain ecosystem (Normander et al. 2006). The Nature Index for mountain areas in Norway shows that their state is relatively good.

Figure 1.7 shows the state of the biological diversity and the area in the Netherlands in 2002. The Nature Index is based on the Dutch methodology, but differs somewhat; the results are, nevertheless, roughly comparable. It is seen that, on the whole, the state of the ecosystems is better in Norway than in the Netherlands. The state of all the ecosystems except forest and open lowland is better than 0.5 in Norway, whereas in the Netherlands the state of all the ecosystems is evaluated as lower than 0.5, except for swamps and sand dunes, which approached 0.6 in 2002 (Fig. 1.7). Figure 1.7, moreover, shows that large parts of the Netherlands are altered from their essentially natural state in that about 60 % of the land area is used for arable farming, industry, urban and built-up places. The corresponding figure for Norway is a mere 2 % (Fig. 1.1).

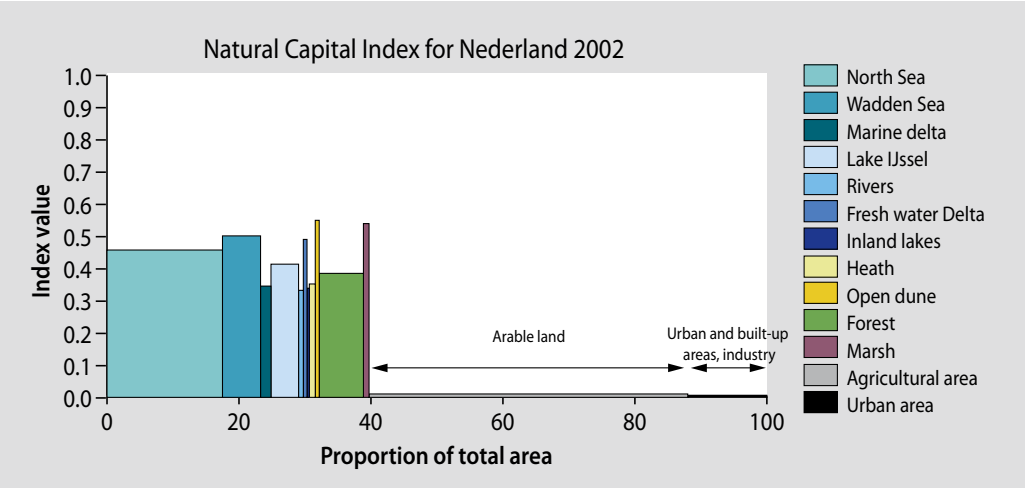


Figure 1.7 *The figure shows the Natural Capital Index for the Netherlands in 2002 (RIVM 2002). The x axis shows the proportion of the area (%) of the large ecosystems in the Netherlands. It comprises all the area out to 12 nautical miles (the territorial boundary), and thus includes a somewhat larger area of coast than the Norwegian figure (Fig. 1.2). The y axis shows the state of the ecosystems calculated using the NCI method. The figure was translated and redrawn by permission of Ben ten Brink.*

2 The possibilities and limitations of the Nature Index

The principal purpose of the Nature Index is to acquire an overview of the state of the biological diversity and to identify gaps in knowledge which require filling to be able to obtain a robust index.

This report presents the results of this work, and we believe that the 2010 Nature Index gives the most up-to-date, overall knowledge we have on the state of the biodiversity in the major ecosystems of Norway in 2010. The Index is based on 309 indicators, and 125 experts have compiled knowledge from monitoring, research and observations about their indicators. All are experts on their indicator and have worked on it for many years. The Nature Index programme has developed a methodology to evaluate this knowledge in context (Certain & Skarpaas 2010). This methodology was developed in cooperation with two teams of experts, one concerned with statistics and the other with biology (Nybø 2010). The Nature Index is thus a compilation of the knowledge of the experts to develop a single set of indicators. At the same time, it documents large gaps in the fundamental knowledge. The 2010 Nature Index must therefore be regarded as an initial step towards improving the level of knowledge about biodiversity so that the task of preserving the diversity will be optimally knowledge based, targeted and cost effective.

Here, we will look in more detail at three key issues in the use and further development of the Nature Index:

1. Does the Nature Index measure the loss of biological diversity as we would wish?

2. How is the relationship between people and the natural world represented in the Nature Index?

3. What is the relationship between the Nature Index and other related indicators?

2.1 Does the Nature Index measure whether we halt the loss of biological diversity?

Through international agreements, Norway has committed itself to halt the loss of biological diversity. On the broad scale, this means that there must not be any negative trend in the Nature Index for any of the major ecosystems or areas in Norway from 2010 onwards. The Nature Index can help to show whether we have achieved this aim (Box 2-1). We will, however, stress that the Nature Index should not be the sole means of measuring biodiversity, but should be evaluated together with other indicators. Red Lists are, for example, useful for evaluating which species and habitats are threatened and require special consideration (Kålås *et al.* 2010).

Local species and land-use management will also require more detailed data than the Nature Index can offer today. As it stands today, the Nature Index is first and foremost a measure of the state and development of biological diversity on an overall level.

If the index is to function as a measurement tool and a basis for decision making, it is essential that we are sure that the changes in it are a consequence of actual changes in the environment and are not due to chance. We have placed emphasis on clarifying uncertainties around the estimates of the Nature Index. In some cases, the trends are strong and clear, with little uncertainty; the indicators for coastal cod

Box 2-1. How does the Nature Index measure that Norway has halted the loss of biological diversity?

The Nature Index must have a positive or stable development for all the major ecosystems and all areas in Norway from 2010 onwards. A loss of biological diversity may be concealed behind a stable or even a rising Nature Index; even though some indicators increase in value, others may drop. It is therefore highly important to study the thematic indices and the data basis in greater detail to understand what is causing the changes in the Nature Index.

If the Nature Index has a negative trend, we are still losing biodiversity.

and herbivores in the mountains are examples of this. In other cases, the trends are weak, but have sufficiently low uncertainty that we regard them as probable, like the ecosystem open lowland as a whole, for example. Here, knowledge is sufficiently good to reveal relatively small differences, both geographical and over time. In yet other cases, the trends are apparently strong, but the uncertainty is high, for filter feeders in coastal waters, for example. In such cases, the knowledge base is currently not good enough to say with certainty whether these trends are real.

In some cases, various measures can be implemented to increase the reliability of the results. This is connected with what lies behind the uncertainty. An increase in the number of indicators will always be benificial as long as they contribute independent information (Certain & Skarpaas 2010), particularly in ecosystems where the number of indicators is low, in coastal waters, for example. In addition, more systematic and long-term monitoring will increase the reliability. In a few ecosystems, we have good monitoring systems which provide data with low uncertainty; an example here is the National Forest Inventory (even though here, too, there are elements which are not well revealed, see Nilsen *et al.* (2010)). The Nature Index is, however, to a large extent based on expert assessments. Even though these are also based on data, there will always be some uncertainty attached to the experience and judgement of the experts. A valuable measure would therefore be to replace expert assessments by monitoring and modelling based on monitoring data. In some cases, it may, however, be very difficult to develop monitoring arrangements that are practicable within realistic economic frameworks or without substantial prior mapping (Sverdrup-Thygeson *et al.* 2008). An alternative measure in such cases might be to increase the number of experts per indicator, i.e. let a group of experts rather than individual persons make the assessments (Garthwaite *et al.* 2005). Expert assessments should in all cases be followed up by a form of field validation.

We have calculated the uncertainty of the index on the basis of uncertainty statements reported by the experts for each individual indicator. This uncertainty may be due to both natural variation (process variation) and observational uncertainty (measurement error) (Clark & Bjørnstad 2004). Today, we do not differentiate these two types of uncertainty. Systematic and well-designed monitoring, and routines to document this in the Nature Index database, are required to obtain good estimates of natural variation and observational uncertainty. To be able to target management measures, the types of natural variation that are present should be investigated; environmental and demographic variations act in different ways and may have different significance for the survival of species (Engen *et al.* 1998).

When the uncertainty is aggregated from individual indicators to the overall Nature Index, the dependence between observations of individual indicators at the municipal level will result in greater uncertainty. Such dependence is partly a result of the indicators covering large, continuous areas (for example, large predators and birds) and partly due to interpolation and extrapolation of estimates (in modelling or expert assessments) in cases where there are few observations (for example, indicators for some vascular plants and coastal waters). This last type of dependence between observations does not only reduce precision in the estimates, but also to generates bias (Bhattacharyya & Johnson 1977), i.e. the estimates deviate systematically (not only fortuitously) from the true value. In many cases, this has resulted in the experts having refrained from estimating the state in boroughs situated far from observation points. One way of reducing both the absence of values and the dependence resulting from interpolation or extrapolation is to develop monitoring that gives good coverage in all the boroughs.

Two other types of bias are linked with the selection of indicators and the selection of observations for the individual indicator. As the Nature Index, for the time being, is based on data gathered for other purposes, for some indicators there is an excess of observations in problem areas (Nybø *et al.* 2008, Nybø 2010). An attempt has been made to compensate for this through expert assessment, but it would be desirable to have a better selection of observations in these cases. As regards the selection of indicators, biases exist in relation to ecosystem function, for example Certain & Skarpaas 2010). For instance, predators are over-represented, whereas degraders are under-represented. This is compensated for by weighting. Direct representation of all relevant ecosystem functions is obviously desirable, but difficult in practice. We will probably continue

to be dependent upon weighting to give a balanced picture. It is therefore important to discuss and perhaps further develop the weighting system used for this version of the Nature Index (Nybø 2010).

The majority of indicators in the 2010 Nature Index are species (see the list of indicators on the Nature Index home page, www.dirnat.no/naturindeks). In principle, there is no reason not to include several other elements such as the state of habitats, genetic diversity and ecosystem functions of the diversity (as long as a reference state can be estimated; see Certain & Skarpaas 2010), but for the moment such elements are mostly only indirectly represented in the index through other indicators. Previous studies have shown that the knowledge base for habitats (as they are defined in a handbook of the Directorate of Nature Management) is so poor that it is indvisable to use these as indicators of state in the Nature Index, for example as indirect indicators for rare species which are only found in these habitats. We do not have good enough data for either 2010 or back in time (Nybø *et al.* 2008). With increased focus being placed on selected habitats in the Nature Diversity Act, knowledge about their area and state may in time become suficcient. Data for genetic variation within species are largely absent and in practice exist for only a few species, such as salmon. In view of their usefulness for people, a Nature Index focusing on ecosystem services would be valuable. The value of the ecosystem services can be calculated as in the TEEB report (ten Brink *et al.* 2009). However, in Norway and the rest of the world, we have very few data that could form a basis for an index for ecosystem services.

As the Nature Index currently does not measure genes or ecosystem functions directly, and only to a slight extent directly reflects habitats that are particularly important for biodiversity (with a few exceptions like coastal heathlands and grass- and herb-rich pastures), it does not give the complete picture of biological diversity. Changes in indicators for the Nature Index (species, for instance) would, however, often be capable of indicating changes in genetic diversity. Moreover, the state of habitats is measured basically using indicators which can be included in the Nature Index (Halvorsen *et al.* 2009), and ecosystem services are linked to many of the same elements (pollinators and harvestable species, for example; ten Brink *et al.* 2009). The Nature Index therefore gives an overview of the state of biological diversity and can be used as a targeted measure towards areas or ecosystems whose state is poor, and to find out whether measures have led to an improvement in the ecosystems. With better data, the Nature Index could be improved further as a basis for decision making.

2.2 Where are human beings in the Nature Index?

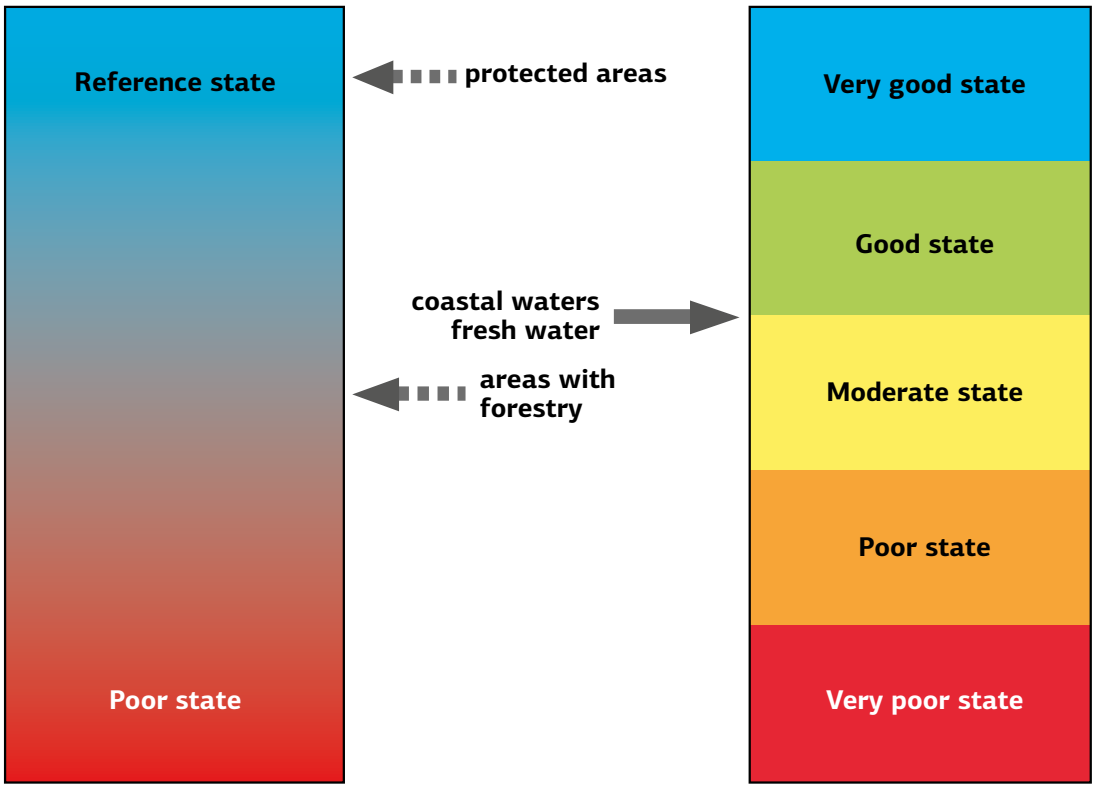
The Nature Index is linked to human activity in several ways, through the definition of the reference state, through possible political targets based on the index and through human impacts on various indicators.

The reference state reflects an ecologically sustainable state for the indicator. The reference value is the numerical value for the indicator in the reference state which minimises the probability that the indicator disappears in the natural habitat, maximises the biodiversity in the habitat to which it is related, or at least does not threaten other species in that or other habitats (Certain & Skarpaas 2010).

In practice, the reference values for most indicators are set equal to the population in virtually undisturbed environments, known historical states or populations in assumed sustainable use (Certain & Skarpaas 2010). It is therefore easy to misunderstand and believe that the aim is to have an undisturbed environment, i.e. a Nature Index of 1. The function of the reference value is firstly that it is used to scale the various indicators into the same calculation model with the aim of comparing the development of different indicators, also in completely different ecosystems. Furthermore, the reference values give a fixed point with which it is possible to measure the development over time in relation to. It is therefore not strictly speaking essential that the reference values are completely correct, but they must always indicate a very good state for the indicator. The indicators measure various aspects of the biodiversity in an ecosystem, for instance threatened and non-threatened species, key species and different trophic levels are included. Furthermore, it is important that the entire set of indicators for an ecosystem is sensitive to different types of impacts. The indicators within one and the same ecosystem may therefore reflect different reference states, and it will not always be possible to attain a maximum value for all indicators in the ecosystem simultaneously.

Because of human activities the reference values cannot be attained everywhere for many indicators. The Water Directive solves this by placing the political targets lower than the reference values (Fig. 2.1). In the same way, it may be envisaged that different political targets could be established depending on the designated use of an area. There is a long way to go before such political targets are in place for other ecosystems than fresh water and coastal waters; discussions have barely started. There has been some discussion in the media concerning whether we want open lowland to become overgrown, or whether we should clear the entire area or only parts of it. When we choose which activities are to take place in an area, they must be balanced against the damage to biological diversity. For a given type and level of activity we must decide the minimum value the Nature Index should attain (Fig. 2.1).

Information has been gathered in the Nature Index database on how the various indicators are affected by human activity like land use, harvesting and pollution. This information has been used to interpret trends in the major ecosystems. In a management context, the information can be used to assess realistic targets for state in the Nature Index in areas with different impacts. Human activities are often the reason why the index declines, but natural impacts may also bring about a drop in the index. Grazing of the kelp forest in northern Norway is an example of a process which reduces the Nature Index, but for which we do not know the reasons.



Figur 2.1 *An example of how different political targets can be set for areas with different use. For instance, the target for a coniferous forest reserve can be near to the reference state, i.e. virtually undisturbed countryside, whereas that for an area where forestry is taking place can be lower. The state in both areas can therefore be measured with the help of the Nature Index, even though the political targets differ. The precondition for the Nature Index being able to measure this is that the reference state is identical in both cases. The broken arrow gives an example of how political targets can be set for coniferous forest, while the solid line shows where political targets for coastal waters and fresh water may be placed (cf. the EU Water Directive). If the state deteriorates, measures must be introduced to improve it. (The figure is reproduced from Nybø* et al. *(2008), with permission).*

2.3 The relationship between the Nature Index, the Red List and other indicators for biological diversity and sustainability

The Nature Index is intended to give an overview of how the Norwegian environment is faring, whereas other indicators and the Red List have more detailed information which is intended to provide guidelines for the management of individual species and habitats. The Nature Index "recycles" data collected for these purposes. In addition, it has a need for data that are not covered through other processes. To acquire the best possible data basis for the Nature Index, it is therefore essential that gathering of information attached to these other tasks continues.

The Nature Index measures the state of the natural biodiversity in the major ecosystems, whereas the Red List gives an overview of all the known species that are threatened by extinction in Norway (Kålås *et al.* 2010). This means that species which are at the margin of their range and can be found in larger populations in other countries may also be on the Red List. This problem is avoided in the Nature Index because the starting point here is the population sizes that would have been natural in an area if there had been little human impact. This means that species which are naturally rare in Norway, or live on the margin of their range, and therefore have a small population in Norway, do not reduce the values in the Nature Index (unless their populations show a decline). For instance, several freshwater fish which are included in the Nature Index have stable populations and have had so for a long time. These species are thus given the value of 1 in the Nature Index (= the reference state). At the same time, several of these species are recorded as threatened on the Red List.

In addition to securing the basis for the Nature Index through the Red List work and other processes, it is important to establish an awareness about the relationship between the Nature Index and other indicators as a basis for management. The index covers elements that are common in the natural environment, in addition to rare and threatened ones, and is therefore better suited than the Red List to give an overall picture of the state of the environment. This also makes it suitable for replacing the limited indicators for biological diversity in the Norwegian set of sustainability indicators (breeding birds and aquatic systems in fresh water and coastal waters with good ecological status – see section 1.1). Even though the Nature Index has a much broader coverage than the existing sustainability indicators, it is not complete. It first and foremost measures state. This means that biodiversity exists that is not revealed by the Nature Index. If management measures were to be solely focused on indicators in the Nature Index, there would be a strong risk that a great deal of other biodiversity would be lost without this being visible in the accounts. As mentioned previously, the Red List contains specific information on many threatened species that are not included in the Nature Index, but which are important for their management and, hence, for the target of halting the loss of biological diversity.

To ensure international comparability, it is important that future work on the Nature Index is carried out in dialogue with international bodies (UN, EEA, Nordic Council). The Nature Index has many features in common with international indices like the Biological Intactness Index (BII; Scholes & Biggs 2005), the Natural Capital Index (NCI; RIVM 2002) and GLOBIO (Alkemade *et al.* 2009) (for comparisons of these and several other indices, see Mace *et al.* 2005, Nybø *et al.* 2008, Certain & Skarpaas 2010). We hope that the Nature Index can be a valuable contribution to an agreed global framework for biological diversity.

3 Conclusions and the way ahead

The Nature Index shows the trend in the ecological state of the major ecosystems in Norway. It indicates that there has been a negative trend for some ecosystems and a more positive one for others. The results show that it is possible to reverse a negative trend for biological diversity. Norway has seen a positive development in both fresh water and the sea. It is well worth noting that in both these ecosystems the improvements are a result of desired policy and great effort on the part of several bodies. Knowledge, funding and the ability to carry through measures are all essential to achieve an improvement. In Norway, it is probably the introduction of measures to preserve open lowland that is most urgently needed.

Developing the Nature Index for Norway has given us new insight into the overall development of Norwegian biodiversity and an opportunity to compare the state of different ecosystems in a quantitative manner. At the same time, the Nature Index has brought different branches of biology together: forest scientists and marine researchers came together to discuss calculation methods and indicators. In addition, the approach has been discussed with social scientists to get an idea of how the work should be presented so that the message will be understood in the community. The process of establishing the Nature Index has been demanding. Many scientists have been sceptical about their data being used in a context over which they had no control. Very many have, nevertheless, contributed data and expert assessments. At the same time, the Nature Index has brought different branches of biology together: forest scientists and marine researchers came together to discuss calculation methods and indicators how certain they were concerning their assessment and data meant that they felt more comfortable in vouching for what they had contributed. If they were uncertain about the figures, the calculation method took this into account.

The framework for the Nature Index is now set up and the index is well suited to be regularly updated. In the same way as the Red List has undergone a development in methodology and form of presentation since the first national Red List in 1998, some adjustments in methodology may well appear in the next revision. The way we regard the work today, we nevertheless believe that the effort made to develop the framework was so thorough that the adjustments will only be minor. However, the set of indicators should be reviewed again for a revised version; for instance, it is necessary to improve the knowledge base by including more indicators from lower trophic levels. In addition the data must be better for indicators that are already in the index. The Nature Index is dependent upon long time series to be able to describe the development over time. Moreover, it is important to have sufficiently detailed geographical coverage to become aware of the variation in the indicators in different parts of the country.

In this first version of the Norwegian Nature Index, we have made a great deal of effort to gather, prepare and quality assure data. This often feels unnecessarily time consuming and exhausting. It is an aim that the scientists who contribute data or expert assessments in a future index get easy access to the data that exist. A great deal of effort goes into acquiring good databases in research institutions and management agencies, and this makes data more easily available. We nevertheless wish to point out that it is very cost ineffective to pay for investigations whose data remain on paper in a drawer or on the PC of an individual person. In practice, it is very rare to have the capacity to digitalise these data before their use in new calculations. In an ideal world, we envisage that the Nature Index database will acquire data online from the databases where they are stored. The experts can then spend their time assessing which data will be used and their quality before they are imported into the Nature Index database.

Owing to the amount of work associated with the gathering and interpretation of data, we recommend that the Nature Index is updated in 5-year cycles. In the intervening years, various thematic indices can be presented based on the data that are collected. There are many possibilities here, such as investigating the quantitative relationship between various impacts and changes in the Nature Index or in individual indicators. Work has also begun to develop an index for areas where there is a great deal of arable land (the farming landscape) and it would be desirable to begin a similar effort for urban and built-up areas. Should this development work be successful, it would be feasible to present maps of the state of biological diversity where many people live.

4 References

Alkemade, R., M. van Oorschot, *et al.* (2009). «GLOBIO3.» Ecosystems 12: 374-390.

Bhattacharyya GK, Johnson RA. 1977. Statistical concepts and methods. New York: Wiley.

Blumentrath, S. and F. Hanssen (2010). Calculation of area. In: Nybø, S. (ed). Data sources of the Nature Index 2010 (in Norwegian). DN-utredning 2010-4.

Brunvoll, F., M. Bergh, et al. (2009). Viktige signaler om samfunnet. Indikatorer for bærekraftig utvikling 2009. Rapporter. S. Sentralbyrå. 2009/26.

Brunvoll, F. and T. Smith, Eds. (2010). På rett vei? Indikatorer for bærekraftig utvikling 2010. Statistiske analyser 114, Statistisk sentralbyrå.

Burkill, P., I. Tyrell, *et al.* (2009). European time series of calceraous organisms and carbvonate chemistry. European Project on Ocean Acidification (EPOCA). J.-P. Gattuso, I. Hansson and EPOCA Consortium, Oceanography. 22: 195.

Butchart, S. H. M., M. Walpole, *et al.* (2010). «Global Biodiversity: Indicators of Recent Declines.» Scienceexpress.org 29 April 2010.

CBD. (2010). «The Convention on Biological Diversity:Year in Reviw 2009.» from http://www.cbd.int/doc/reports/cbd-report-2009-en.pdf.

Certain, G. and O. Skarpaas (2010). Nature Index: General framework, statistical method and data collection for Norway: NINA report 542.

Certain, G., O. Skarpaas, et al. (2010). «The nature index: A general framework to synthezise konwledge on the state of biodiversity.» Submitted PLOS One.

Clark JS, Bjørnstad ON. 2004. Population time series: process variability, observation errors, missing values, lags and hidden states. Ecology 85: 3140-3150.

EEA (2009). Progress towards the European 2010 biodiversity target. Copenhagen, European Environmental Agency.

EEA (2010). Assessing biodiversity in Europe - the 2010 report. E. E. Agency. Copenhagen.

Engen S, Bakke Ø, Islam A. 1998. Demographic and environmental stochasticity - Concepts and definitions. Biometrics 54: 840-846.

Garthwaite PH, Kadane JB, O'HAgan A. 2005. Statistical methods for eliciting probability distributions. Journal of the American Statistical Association. 100(470): 680-701.

Global Footprint Network (2008). Accounts 2008.

Halvorsen, R., T. Andersen, *et al.* (2008). Inndeling i økosystem- hovedtyper. Naturtyper i Norge. Bakgrunnsdokument, Artsdatabanken, Norge: 1-86.

Halvorsen, R., T. Anderssen, et al. (2009) «Tilstandsvariasjon (tistandsøkokliner og objektinnhold), versjon 0.1.»

IUCN (2008). WCC Freshwater Factsheet: Freshwater Biodiversity - A hidden resource under threat. IUCN. Gland.

Kålås, J. A., Viken, Å., Henriksen, S. & Skjelseth, S. (eds) (2010) Norwegian red list for species 2010. Artsdatabanken, Trondheim.

Leadley, P., H. M. Pereira, *et al.* (2010). Biodiversity Scenarios: Projections of 21st century change in biodiversity and associated ecosystem services. Technical Series no. 50. S. o. t. C. o. B. Diversity: 132.

Millennium Ecosystem Assessment (2005). Current state & trend assessment.

Nilsen, J. E. Ø., Moum, S.O. *et al.* (2010). Indirect indicators of the Forest Inventory. In: Nybø, S. (ed), Data sources of the Nature Index 2010, DN-utredning 2010-4.

Normander, B., A. Glimskär, *et al.* (2006). Aggregation of indicators for biological diversity in the Nordic countries: Proceedings and recommendations from the workshop at Tune Landboskole, Denmark, 29-30 March 2006. Copenhagen, Denmark, Nordic Council of Ministers.

Nybø (ed.) (2010). Data sources of the Nature Index 2010, DN Utredning 2010-4.

Nybø (ed.) (2010b). Naturindeks for Norge 2010. DN-utredning 2010-3.

Nybø, S., O. Skarpaas, et al. (2008). Nature Index of Norway, suggestions for a conceptual framework (in Norwegian). NINA-report: 68 s.

RIVM (2002). Nature Outlook. Bilthoven, The Netherlands.

Scholes, R. J. and R. Biggs (2005). «A biodiversity intactness index.» Nature 434(7029): 45-49.

State of World Population Report. (2009). «Indicators.» from www.unfpa.org.

Sverdrup-Thygeson A, Brandrud TE, Bratli H, Framstad E, Gjershaug JO, Halvorsen G, Pedersen O, Stabbetorp OE, Ødegaard F. 2008. Truete arter og ansvarsarter: kriterier for prioritering i kartlegging og overvåking. Trondheim: NINA. Report no. NINA Rapport 317.

ten Brink, P., A. Berghöfer, et al. (2009). TEEB – The Economics of Ecosystems and Biodiversity for National and International Policy Makers – Summary: Responding to the Value of Nature 2009. Wesseling, Germany.

World comission for environment and development (1987). Our common future. Aarrestad, P. A. and O. E. Stabbetorp (2010). Bruk av bioindikatorer til overvåking av effekter av atmosfærisk nitrogen i naturtyper med lav nitrogentålegrense. Pilotprosjekt for Naturindeks for Norge 567.

DN-reports

2011

1-2011: The Norwegian Nature Index 2010

2010

9-2010: Evaluering av «Program for terrestrisk naturovervåking» (TOV 2000-2010)
8-2010: *Overvåking av fjellvegetasjon på Stortussen/Snøtind* - et pilotprosjekt innenfor GLORIA Norge
7-2010: Etablering av nye laksestammer på Sørlandet. Erfaringer fra arbeidet i Mandalselva og Tovdalselva etter kalking
6-2010: Supplerende kartlegging av biologisk mangfold i jordbrukets kulturlandskap, inn og utmark i Oslo og Akershus, med en vurdering av kunnskapsstatus
5-2010: Supplerende kartlegging av biologisk mangfold i jordbrukets kulturlandskap, inn- og utmark i Vestfold, med en vurdering av kunnskapsstatus
4-2010: Datagrunnlag for Naturindeks 2010
3-2010: Naturindeks for Norge 2010
2-2010: Spredning av fremmede karplanter fra veganlegg – kartlegging og metodeutvikling
1-2010: Mulige effekter av etablering av stillehavsøsters (*Crassostrea gigas*) i Norge

2009

6-2009: Overvåkning av fjellvegetasjon sommeren 2008 (GLORIA-prosjketet)
5-2009: Bleka i Byglandsfjorden – bestandsstatus og tiltak for økt naturlig rekruttering 1999-2008
4-2009: Moderne hjorteviltforvaltning med ny virkemiddelbruk mot 2015
3-2009: Utvikling av tradisjonelle kulturlandskaper i Barentregionen – KNP-modellen
2-2009: GMO Assessment in Norway as Compared to EU Procedures: Societal Utility and Sustainable Development
1-2009: Supplerande kartlegging av biologisk mangfald i jordbrukets kulturlandskap, inn- og utmark, i Hordaland med en vurdering av kunnskapsstatus
Nasjonalt program for kartlegging og overvaking av biologisk mangfald

2008

10-2008: Klima og effekter på økosystemer og biologisk mangfold -scenario stølslandskapet i Valdres
9-2008: Nå eller aldri for Vossolaksen - anbefalte tiltak med bakgrunn i bestandsutvikling og trusselfaktorer
8-2008: Reetablering av laks på Sørlandet. Årsrapport fra reetableringsprosjektet 2007
7-2008: Evaluering av bekjempelsesmetoder for *Gyrodactylus salaris*. – Rapport fra ekspertgruppe
6-2008: Supplerande kartlegging av biologisk mangfald i jordbrukets kulturlandskap, inn- og utmark, i Sogn og Fjordane
Nasjonalt program for kartlegging og overvaking av biologisk mangfald
5-2008: Bestandsstatus for laks i Norge. Prognoser for 2008. Rapport fra arbeidsgruppe
4-2008: Supplerende kartlegging av biologisk mangfold i jordbrukets kulturlandskap, inn- og utmark, i Vest- og Aust-Agder, med en vurdering av kunnskapsstatus
3-2008: Supplerende kartlegging av biologisk mangfold i jordbrukets kulturlandskap, inn- og utmark, i Buskerud med en vurdering av kunnskapsstatus
Nasjonalt program for kartlegging og overvåking av biologisk mangfold
2-2008: Nasjonal overvåking av marint biologisk mangfold i havområder og Arktis – Forslag til overvåkingselementer, lokalisering og kostnadsoverslag
1-2008: Supplerende kartlegging av biologisk mangfold i jordbrukets kulturlandskap, inn- og utmark, i Midt-Norge; Møre og Romsdal og Oppdal, med en vurdering av kunnskapsstatus
Nasjonalt program for kartlegging og overvåking av biologisk mangfold

2007

4-2007: Supplerende kartlegging av biologisk mangfold i jordbrukets kulturlandskap, inn- og utmark, i Rogaland med en vurdering av kunnskapsstatus -
Nasjonalt program for kartlegging og overvåking av biologisk mangfold
3-2007: Reetablering av laks på Sørlandet. Årsrapport fra reetableringsprosjektet 2006
2-2007: Bestandsstatus for laks 2007. Rapport fra arbeidsgruppe
1-2007: Den norske våtmarksarven. Styrket forvaltning og utvidelse av nettverket av Ramsarområder og andre vernede våtmarker i Norge. Tiltaksplan 2007-2010

CONTACT INFORMATION
The Norwegian Directorate for Nature Management. Visiting Address: Tungasletta 2.
Postal Address: PO BOX 5672 Sluppen, N-7485 Trondheim.
Tel: +47 73 58 05 00, Fax: +47 73 58 05 01, e-mail: postmottak@dirnat.no, www.dirnat.no

The Norwegian Directorate for Nature Management has central, national tasks and responsibilities in managing the natural environment of Norway. These entail preserving biodiversity and paving the way for outdoor recreation and the use of resources provided by nature.

The Directorate is an advisory and executive agency under the Norwegian Ministry of the Environment. We are authorised to manage natural resources through various Acts and Regulations adopted by the Norwegian Parliament.

In addition to tasks fixed by law, the Directorate for Nature Management is also responsible for identifying, preventing and solving environmental problems. It works together with other authorities, and gives advice and information to the general public.