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Nature Index for Norway 2015

Ecological framework, computational methods, database and information systems

Edited by
Bård Pedersen, Signe Nybø and Stein Are Sæther

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Nature Index for Norway 2015

Ecological framework, computational methods, database and information systems

Bård Pedersen
Signe Nybø
Stein Are Sæther
(eds.)

ARTSDATABANKEN
Nasjonal kunnskapskilde for biologisk mangfold

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Spiny dogfish (*Squalus acanthias)*
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CONTACT DETAILS

NINA head office
Postboks 5685 Sluppen
NO-7485 Trondheim
Norway
Phone: +47 73 80 14 00

NINA Oslo
Gaustadalléen 21
NO-0349 Oslo
Norway
Phone: +47 73 80 14 00

NINA Tromsø
Framsenteret
NO-9296 Tromsø
Norway
Phone: +47 77 75 04 00

NINA Lillehammer
Fakkelgården
NO-2624 Lillehammer
Norway
Phone: +47 73 80 14 00

www.nina.no

Abstract

Pedersen, B., Nybø, S., Sæther, S. A. (eds.) 2016. Nature Index for Norway 2015. Ecological framework, computational methods, database and information systems. – NINA Report 1226. 84 pp.

The Nature Index is a framework for condensed reporting of the state of nature. The composite index synthesizes and communicates knowledge about states and trends in nature to policymakers and the public, who have an intuitive rather than scientific understanding of concepts such as biodiversity and the state of nature.

The Nature Index does this by summarizing measurements and assessments made by experts of the state of indicators, which, together, represent biodiversity. The current (2015) version focuses on species as indicators, because these also partly reflect genetic diversity and the state of ecosystems. However, the Nature Index framework also facilitates the construction of an index that use the state of habitats as indicators. To meet the objectives, the set of indicators should ideally be a representative sample reflecting taxonomic / genetic variation, ecological functions (trophic levels), human pressures, ecosystems, habitats and phases in natural ecological successions. The indicator set should not include alien species.

The Nature Index is calculated for a major ecosystem in a delimited geographical area and a given year. The major ecosystems included in the current version are: *ocean bottom*, *ocean pelagic*, *coast bottom*, *coast pelagic*, *open lowland, mires and wetland*, *freshwater*, *forest*, and *mountain*. The index does not account for changes in the areal extent of major ecosystems.

Mathematically, the Nature Index is a weighted average of scaled indicators. Fifty per cent of the weightings per spatial unit are assigned to key or extra-representative indicators. The criteria for selecting an indicator as an extra-representative indicator are that the indicator has significance for populations of one hundred or more species, that it occurs over a large area, and that there are good data for it. The other indicators are weighted so that trophic groups contribute equally per spatial unit to the Nature Index value.

Non-linear scaling functions are used to transform indicators measured on different scales to a common one, before taking the average. The common scale ranges from zero to one. The scaling functions have only one parameter, which defines a base line called the reference value. Reference values serve two aims; first, they act as scaling factors that determine which values of the various indicators correspond to the same state, and second, they set limits for how much an increase in one indicator may compensate for a decrease in another when combined in a composite index.

The Nature Index framework includes a common conceptual basis for setting reference values for indicators belonging to the same major ecosystem, the so-called reference state. For "natural" major ecosystems (i.e. all major ecosystems except *open lowland*), reference values are estimated relative to a common reference state that represents intact ecosystems with little or no human impact. A little impacted state means that species richness, the state of the various populations, and the system's ecological functions are intact. The corresponding reference state for semi-natural systems (i.e. *open lowland*) is defined as a system that is "in good condition" relative to the species diversity normally associated with the type of semi-natural habitat in question (resulting from the application of traditional practices for a long time). The current report further elaborates and specifies reference states for each of the nine major ecosystems. This approach to setting reference values together with the shapes of scaling functions means that scaled indicators measure the indicators' negative deviance from the reference state, and that the Nature Index and thematic indices are averages of such deviations. The difference between the index value and the reference state value (=1) may be interpreted as the total negative effect on biodiversity resulting from human activity. Simulations based on real and artificial data suggest that

the Nature Index is robust to adjustments in the reference concept. Such adjustments will not result in significantly different descriptions of the state of Norwegian nature than those given by the Nature Index today.

Experts provide the estimates (observations) of indicator values. These observations are associated with measurement error. When estimating the Nature Index, each observation is modelled as a statistical distribution. The dispersion (measured as the interquartile range) measures the uncertainty of the observations and the location along the number line (the expected value) represent the observations' magnitude. The corresponding sampling distribution for the Nature Index is simulated using Monte Carlo methods. The median in this simulated distribution provides an estimate of the index.

The data behind the Nature Index for Norway comprise 301 indicators for the nine major ecosystems. The Norwegian Institute for Agricultural and Environmental Research (Bioforsk), Institute of Marine Research (IMR), Norwegian Institute for Nature Research (NINA), Norwegian Forest and Landscape Institute, Norwegian Institute for Water Research (NIVA), and NTNU University Museum provide data. The state of each major ecosystem is described using between 29 and 37 indicators, with the exception of the forest major ecosystem, which is characterized by 87 indicators. The data comprise monitoring data, model-based estimates of state and estimates based on expert assessments. Expert assessments are subjective judgements based on data and information that are not collected systematically as in a designed monitoring programme. Expert assessments constitute 46% of the available data for calculating the Nature Index for Norway, model-based estimates 19%, and estimates from monitoring programmes constitute 35%.

We have developed a web-based information system for recording, storage and presentation of data used for calculating the Nature Index and the results from the calculations. The system consists of an SQL relational database for storing indicator observations and other data as well as results from index calculations done in R. It further includes a web interface for entering data to the database where the individual expert can update information for the indicators they are responsible for, and a set of R scripts that calculate the Nature Index and analyse raw data and results. In addition, a web portal (www.naturindeks.no) has been constructed to present results and information to the public.

Bård Pedersen (bard.pedersen@nina.no), Signe Nybø (signe.nybo@nina.no),
Stein Are Sæther (stein.sather@nina.no),
Norwegian Institute for Nature Research (NINA), Postboks 5685 Sluppen, NO-7485 Trondheim, Norway

Sammendrag

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Naturindeksens formål er å gi en kortfattet beskrivelse av naturens tilstand. Den sammenfatter og formidler tilgjengelig kunnskap om naturens tilstand og utvikling til beslutningstakere og allmennheten, som har en intuitiv snarere enn en vitenskapelig forståelse av begrepene biologisk mangfold og naturens tilstand. Naturindeksen gjør dette med utgangspunkt i et utvalg av indikatorer, som til sammen representerer det biologiske mangfoldet. I dagens implementering av naturindeksen, velger man å legge vekt på arter som indikatorer, fordi disse også til en viss grad gjenspeiler genetisk mangfold og økosystemenes tilstand. Rammeverket for naturindeksen legger også til rette for etableringen av en indeks som måler tilstanden til naturtyper. For å oppfylle formålet, bør utvalget av indikatorer ideelt representere taksonomi eller genetisk variasjon, økologiske funksjoner (trofiske nivåer), menneskelig påvirkning, økosystemer, habitater og faser i naturlige økologiske suksesjoner så homogent som mulig. Indikatorutvalget bør ikke inneholde fremmede arter.

Naturindeksen beregnes for et hoved-økosystem i et avgrenset geografisk område og for et gitt år. Hoved-økosystemene som inngår i analysene er hav bunn, hav pelagisk, kyst bunn, kyst pelagisk, åpent lavland, våtmark, ferskvann, skog og fjell. Indeksen reflekterer imidlertid ikke endringer i arealmessig utbredelse av de terrestriske hoved-økosystemene.

Naturindeksen er et veid middel av skalerte indikatorer. Femti prosent av vektene per geografiske enhet tilordnes nøkkelelementer. Kriteriene for at en indikator er et nøkkelelement, er at den skal ha utsagnskraft om bestander til mange arter, den skal forekomme i et større område og den skal være dokumentert med gode data. De andre indikatorene veies slik at trofiske grupper bidrar likt per geografiske enhet til naturindeksverdien.

Indikatorene skaleres til en felles skala ved hjelp av ikke-lineære skaleringsfunksjoner. Skalaen går fra 0 til 1. Skaleringsfunksjonene har bare en parameter som kalles referanseverdi. Referanseverdiene definerer skaleringskonstanter for hver indikator som avgjør hvilke verdier for de ulike indikatorene som representerer samme tilstand. Referanseverdien setter i tillegg en grense for hvor mye en forbedring i en indikator som i utgangspunktet er i en god tilstand, kan kompensere for negativ utvikling i andre indikatorer.

Referanseverdier for enkeltindikatorer fastsettes med utgangspunkt i en referansetilstand som defineres for et helt hoved-økosystem, dvs. en tilstand som i teorien skal kunne være oppnåelig for alle indikatorer samtidig. For naturlige økosystemer (omfatter alle hoved-økosystemene bortsett fra åpent lavland), fastsettes indikatorenes referanseverdier ut fra økosystemer der påvirkningen fra menneskelig aktivitet er, eller har vært, så begrenset at den har minimal påvirkning på det biologiske mangfoldet. Artssammensetningen, de ulike populasjonenes størrelse og tilstand og de økologiske funksjoner er intakte, dvs. ikke vesentlig påvirket av menneskelig aktivitet. Referansetilstanden for semi-naturlig mark (hoved-økosystemet åpent lavland) defineres som et system i «god hevd» relativt til artsmangfoldet en tradisjonelt forbinder med den aktuelle naturtypen og som har blitt formet gjennom den tradisjonelle hevden over lang tid. I denne rapporten utdypes referansekonseptet videre med hensyn til blant annet klimatiske forutsetninger, potensiell artssammensetning og naturlig forekommende suksesjoner, og konseptet presiseres for det enkelte hoved-økosystem. Forskjellen mellom naturindeksens verdi og referanseverdien (=1) kan ses på som et mål på den samlede belastningen fra all den menneskeskapte aktiviteten som har negativ innvirkning på det biologiske mangfoldet. Simuleringsstudier basert på reelle og konstruerte datasett tilsier at naturindeksen er robust overfor justeringer av referansekonseptet, og at slike justeringer ikke vil gi vesentlig forskjellige beskrivelser av tilstanden i norsk natur enn de naturindeksen gir i dag.

Indikatorverdiene er forbundet med usikkerhet. Verdiene blir derfor i naturindeks-sammenheng angitt som sannsynlighetsfordelinger der fordelingens spredning representerer denne usikkerheten, mens fordelingens plassering på tallinja representerer indikatorverdiens størrelse. Den tilsvarende fordelinga til naturindeksen simuleres ved hjelp av Monte Carlo simuleringsmetoder. Vanligvis oppgis medianen i den simulerte fordelingen som et punktestimat for naturindeksen.

Datagrunnlaget bak naturindeks for Norge omfatter 301 ulike indikatorer fordelt på de ni hoved-økosystemene. Forskningsinstitusjonene Bioforsk, Havforskningsinstituttet, Norsk institutt for naturforskning (NINA), Norsk institutt for skog og landskap, Norsk institutt for vannforskning (NIVA) og NTNU Vitenskapsmuseet bidrar med grunnlagsdata. Tilstanden for hoved-økosystemet skog beskrives ved hjelp av 87 indikatorer. For de andre hoved-økosystemene utgjøres datagrunnlaget av mellom 29 og 37 indikatorer. Datagrunnlaget omfatter overvåkningsdata, modellbaserte estimat av tilstand og estimater basert på ekspertvurderinger. Ekspertvurderinger er subjektive vurderinger basert på data og informasjon som ikke er samlet inn etter en helhetlig design eller på en systematisk måte slik som i et overvåkningsprogram. Ekspertvurderinger utgjør 46% av det totale datagrunnlaget for beregning av naturindeks for Norge, modellbasert estimat utgjør 19% og overvåkingsdata 35%.

For flere hoved-økosystem er den geografiske dekningen av indikatorene ujevn. Dataene har en gjennomgående lav romlig oppløsning. En gjennomgang av datagrunnlaget viser at det er behov for mye, ytterligere informasjon om naturens tilstand før en oppnår en jevn geografisk representasjon innenfor alle hoved-økosystemene, og med en tilstrekkelig geografisk oppløsning som tillater kommunevise sammenfatninger av tilstand. Det anbefales derfor ikke å beregne naturindeks med en finere geografisk oppløsning enn landsdeler. Det er tilsvarende et behov for å inkludere ytterligere indikatorer i datagrunnlaget før kriteriene for et balansert utvalg av indikatorer er oppfylt. Videre viser gjennomgangen av datagrunnlaget at det er stor spredning i indikatorenes tilstander innenfor de fleste hoved-økosystemene. Så selv om det er variasjon mellom naturindeksen beregnet for de ulike systemene, så er det innenfor hvert enkelt hoved-økosystem både indikatorer som er i en god til svært god tilstand, og indikatorer som er i en dårlig til svært dårlig tilstand. I forbindelse med gjennomgangen av dataene har en imidlertid ikke funnet opplagte forhold som tilsier at de er misvisende mht. det biologiske mangfoldets tilstand.

Det er utviklet et internettbasert informasjonssystem for innlesing, lagring og presentasjon av de data som benyttes som grunnlag for beregning av naturindeksen. Systemet består av en SQL relasjonsdatabase for lagring av indikatorobservasjoner og andre grunnlagsdata for beregning og presentasjon av naturindeksen, samt resultater fra naturindeksberegninger gjort i R. Videre inngår et nettsted for innlesing av data til basen hvor den enkelte ekspert kan oppdatere opplysningene for de indikatorer vedkommende er ansvarlig for, og ett sett av rutiner for å beregne naturindeks og analysere grunnlagsdata og resultater. I tillegg er det utviklet en webportal for presentasjon av resultatene og informasjon om bakgrunnsdata (www.naturindeks.no).

Bård Pedersen (bard.pedersen@nina.no), Signe Nybø (signe.nybo@nina.no),
Stein Are Sæther (stein.sather@nina.no),
Norsk Institutt for Naturforskning (NINA), Postboks 5685 Sluppen, 7485 Trondheim

Contents

Foreword

This report describes the ecological and mathematical framework and the data that provide the basis for calculating the Nature Index for Norway. It also describes the overall status of additional development that has occurred after the Nature Index for Norway was first launched in 2010 (Nybø 2010b, English summary by Nybø et al. 2011). The report was prepared on behalf of the Norwegian Environment Agency, and originally published in Norwegian as NINA report 1130 (Pedersen & Nybø 2015). The present report is a slightly modified and adapted English version.

The Norwegian Environment Agency is the project owner and is responsible for developing and updating the Nature Index for Norway. The Agency has signed a framework agreement with the Norwegian Institute for Nature Research (NINA) from 2011 to 2015, which gives NINA the main responsibility for developing a comprehensive framework with the aim of establishing a common basis for the various ecosystems. NINA has also had the primary responsibility for developing, updating and maintaining the database and other IT systems that are related to the Nature Index for Norway.

NINA has relied on an expert group for the Nature Index for Norway that has been appointed by the Norwegian Environment Agency. The expert group discusses and provides advice on both the ecological framework and the knowledge needed to update the index. The following persons and institutions are represented on the expert group as of 2014: the Norwegian Institute for Agricultural and Environmental Research (Knut Anders Hovstad, Ann Norderhaug), the Norwegian Institute for Water Research (NIVA, Hege Gundersen, Hanne Edvartsen, Eivind Oug), the Norwegian Forest and Landscape Institute (Ken Olaf Storaunet, Aksel Granhus), the Institute of Marine Research (Gro van der Meeren, Anders Jelmert, Margaret McBride), Statistics Norway (Iulie Aslaksen, Per Arild Garnåsjordet), the Norwegian Biodiversity Information Centre (Snorre Henriksen), NINA (Hans Christian Pedersen, Ann Kristin Schartau, Jarle Werner Bjerke, Erik Framstad). NINA was also represented by Bård Pedersen, Signe Nybø and Olav Skarpaas, whose main involvement related to the development of the ecological and mathematical framework. The expert group has met several times a year. The Norwegian Environment Agency leads the group.

In addition to the expert group, a statistics group was created to discuss issues related to the mathematical framework. NINA (Erlend Nilsen, Bård Pedersen, Olav Skarpaas), Statistics Norway (Per Arild Garnåsjordet), NTNU/NINA (Steinar Engen), UiT – The Arctic University of Norway/NINA (Nigel Gilles Yoccoz) and the Institute of Marine Research (Geir Ottersen) are represented in this group. The statistics group has held meetings as needed.

The report and work for the Nature Index for Norway has generally been financed through the Norwegian Environment Agency.

We would like to thank all our partners in the Norwegian Environment Agency, the Nature Index for Norway expert group and statistics group and all those who provided data for the Nature Index for Norway for their good cooperation and the great amount of work done by many. Furthermore, we thank all of the co-authors of the various chapters and those who have participated in their quality assurance. Thanks also to the Norwegian Agriculture Agency's senior advisor Berit Haga Vikanes for comments on a preliminary version of the original Norwegian report. The translation to English was done by Nancy Reney Bazilchuk and Stein Are Sæther.

Bård Pedersen & Signe Nybø, January 2016

1 Introduction

The work to establish a Nature Index for Norway were included in the Government Declaration of Trust from the First Stoltenberg Government (2005-2009). The nature index shall "... obtain an impression of how nature, including the cultural landscape, is developing" (Stoltenberg et al. 2005). The establishment of the Nature Index for Norway was confirmed by the Second Stoltenberg Government (2010-2013) (Stoltenberg et al. 2009).

The value and utility of the Nature Index for Norway were clarified in the Ministry of the Environment’s (MD) requisition letters for follow-up on the Government's objectives to the Directorate for Nature Management (now the Norwegian Environment Agency). The Nature Index for Norway shall:

- Have educational value
- Provide early warnings of changes
- Be a benchmark for natural resource management
- Enhance our understanding of the need to map and monitor biodiversity

This clarification has influenced the design of the framework. The goal is thus that people who do not have a thorough technical understanding of biodiversity should be able to interpret the index intuitively. At the same time the index should also be relevant for international reporting on the state and development of biodiversity in Norway (Ministry of the Environment 2006). The Nature Index for Norway is intended to build on our current levels of knowledge, presented in a clear and educational way. The effort will help to identify key knowledge needs as a basis for prioritizing systematic monitoring of biodiversity so as to track future trends and developments.

The efforts to develop the framework for the Nature Index for Norway started in the autumn of 2007 (Nybø et al. 2008). The framework is based on international approaches (RIVM 2002, Loh & Wackernagel 2004, Scholes & Biggs 2005) but there has been significant work for further development both before and after 2010, when the first edition was published (Nybø 2010b).

This report describes the ecological and mathematical framework as used in the Nature Index for Norway 2015 (Framstad 2015). The report addresses the ecological framework (Chapter 2), and provides a more detailed description of the characteristics of the reference states for the various major ecosystems (Chapter 3). Chapter 4 describes how pressure factors are treated in the Nature Index for Norway, while Chapters 6, 7 and Appendix 1 provide an overview of the data and indicators included in the work. The mathematical framework, which is an operationalization of the ecological framework, is discussed in Chapter 5. This report also describes the website for data entry and the web portal that visualizes results (Chapter 8).

The political objective of developing a nature index has made Norway a frontrunner in the establishment of unified indices for biodiversity, and Norway is, as far as we know, the only country in the world as of 2015 that has established a sustainability indicator showing the development of biological diversity. Several other institutions/regional groups outside of Norway have taken the initiative to test the Nature Index for Norway’s framework (Chapter 9).

After the Nature Index for Norway was established, it became clear that both the framework and the data could be used for more purposes than originaly planned, including the development of thematic indices. Some of these other applications are discussed in the main report that the Norwegian Environment Agency has published (Framstad 2015). In its present form, the Nature Index for Norway mainly represents changes in populations of species and species indices over time. We would like the reader to be aware that the framework and the database can be used for several purposes, such as changes in habitat types and non-native species, among others. Currently, our data for habitat types is judged to be too incomplete for this to be realistic in 2015.

For further information, see English-language scientific articles at the NINA website.

2 Ecological framework

Signe Nybø[1], Bård Pedersen[1], Olav Skarpaas[1], Iulie Aslaksen[2], Jarle Werner Bjerke[1], Grégoire Certain[1], Hanne Edvardsen[3], Erik Framstad[1], Per Arild Garnåsjordet[2], Aksel Granhus[4], Hege Gundersen[3], Snorre Henriksen[5], Knut Anders Hovstad[6], Anders Jelmert[7], Margaret Mary McBride[7], Ann Norderhaug[6], Geir Ottersen[7], Eivind Oug[3], Hans Christian Pedersen[1], Ann Kristin Schartau[1], Ken Olaf Storaunet[4], Gro I. van der Meeren[7]

[1]Norwegian Institute for Nature Research, [2]Statistics Norway, [3]Norwegian Institute for Water Research, [4]Norwegian Forest and Landscape Institute, [5]Norwegian Biodiversity Information Centre, [6]Norwegian Institute for Agricultural and Environmental Research, [7]Institute of Marine Research

2.1 Measuring the state of and changes in biodiversity

Biodiversity is defined by the Convention on biological diversity as "*the variability in living organisms from all sources, including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part: this includes diversity within species, between species and of ecosystems*" (United Nations 1992). The Biological Diversity Act defines biodiversity as "*the diversity of ecosystems, species and genetic variations within species, and the ecological relationships between these components*". Natural diversity is a broader term and comprises "*biological diversity, geological diversity and landscape diversity, which essentially are not the result of human influence*".

The definition in the Convention contains several items. It identifies biological *variation* as the central element of the concept of biodiversity. It emphasizes variation at three different levels, *within species* (which includes genetic variation within and between populations), *between species* (such as species richness) and *between ecosystems* (including habitat and landscape variations). The definition also includes ecological interactions that occur as a result of the interplay among individuals, populations and species (Mace et al. 2012). The definitions, however, are not explicit regarding how far they refer to the *extent* of the biological variation or biological variation *per se*, or how the concept of biodiversity relates to spatial variation (Mace et al. 2012). The definitions do not include measurements and amounts that are solely based on quantity or abundance (cf. Balmford et al. 2003, Mace 2005).

In order to evaluate progress towards the 2010 target to reduce the loss of biodiversity, the Convention on Biological Diversity defined the concept of "biodiversity loss" as encompassing "*the long-term or permanent qualitative or quantitative reduction in components of biodiversity and their potential to provide goods and services, to be measured at global, regional and national levels*" (Convention on Biological Diversity 2004). Examples of these kinds of components of biodiversity are the individual species/population or habitat/ecosystem (ref. Millennium Ecosystem Assessment 2005). But the term is often used in a much broader sense (Certain et al. 2011, McDonald 2011). Accounting for changes in the state and development of biodiversity can therefore be addressed in various ways (McDonald 2011), such as by measuring the size of the biological variation in the form of different measures of genetic diversity, species richness, or species diversity (i.e., the relationship between species richness and abundance of each species), and then using these different measures to describe how diversity is changing over time (as in Fleishman et al. 2006). Alternatively, it is possible to measure the state /vitality of the components that together make up biodiversity and summarize these in one or more component-based composite indices (e.g. Noss 1990).

Data on the size of the overall biological variation, such as the species diversity in different ecosystems and at different times, are not currently available and are unlikely to be able to be obtained in the foreseeable future. This is because there is insufficient scientific and financial capacity to provide these numbers.

Well-known international indices for biodiversity such as the Natural Capital Index (RIVM 2002), the Living Planet Index (Loh & Wackernagel 2004, McLellan 2014) and the Biodiversity Intactness Index (Scholes & Biggs 2005) are based on changes in populations of species and /or species indices and measure whether the state of the biological diversity in question is changing in a positive or negative way. The Nature Index for Norway builds on this approach, in that it focuses on changes in the quantity of the indicators over time. The indicators in the Nature Index for Norway are species and indirect indicators that measure changes in populations of species, or species indices (Figure 2.1).

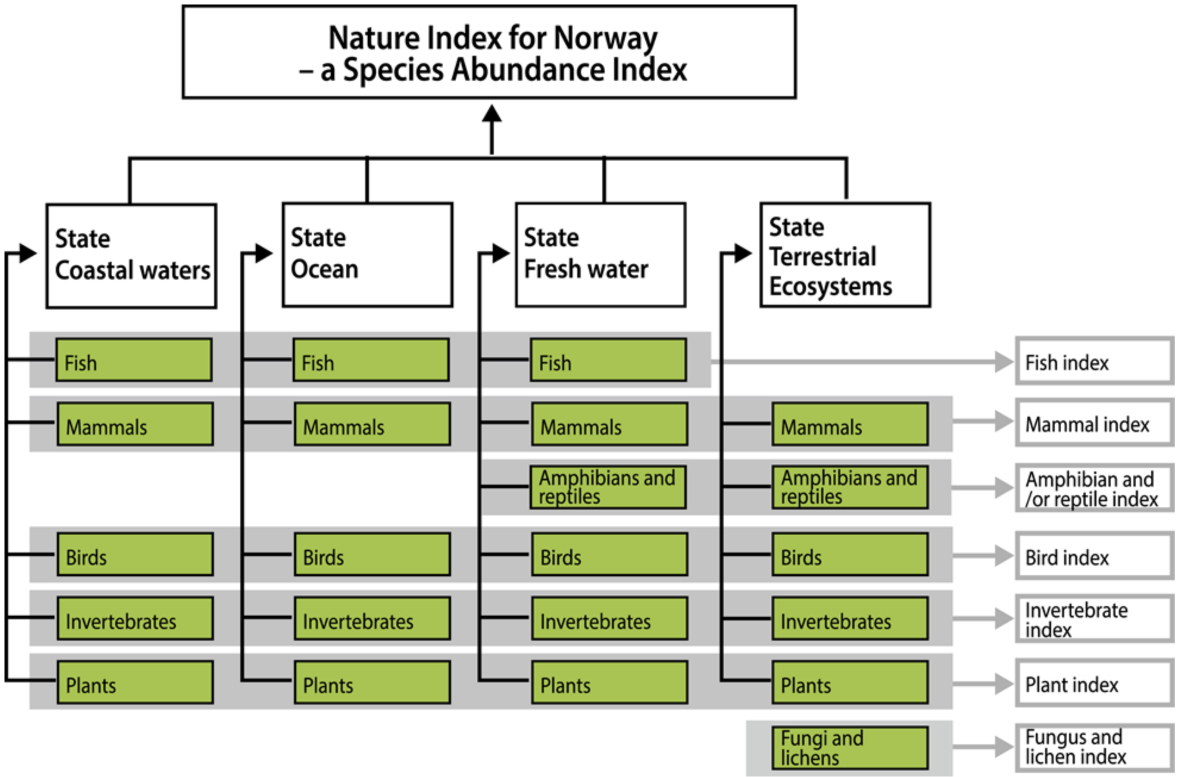

Figure 2.1. *Schematic view of how different indicators are combined into a Nature Index for each major ecosystem.*

In order to compare and combine values from different indicators, all values must be converted to the same scale (0-1) before they are combined in a total index (Chapter 5). To achieve this, a reference value has to be defined against which the measured values are evaluated. The Nature Index for Norway uses an approach that is similar to that used in a number of international indicators and indices (Chapter 2.4 and Chapter 3).

The Nature Index for Norway measures the state and change of biodiversity in ecosystems in accordance with the principles summarised in Box 2.1.

The framework for the Nature Index for Norway also allows for the creation of an index based on the state and changes in habitat types as indicators. In 2007, the data was considered to be too poor for this to be realistic (Nybø et al. 2008), and there is still a lack of comprehensive surveying and systematic monitoring of the state of habitat types. As of 2015, we therefore do not have sufficient data to use the framework to establish a nature index for habitats.

Box 2.1. *The Nature Index for Norway measures the state and development of biodiversity in the major ecosystems*

- The state is measured as a weighted average of populations of species/species indices/indirect indicators in relation to the reference state. Key indicators/key species, i.e., indicators that are of great importance for populations of other species are given greater importance (weight) than other indicators.
- A Nature Index value of 0.7 means that populations of species / species indices/indirect indicators are on average 70% of what is found in an intact natural environment.
- The Nature Index value reflects a cumulative effect, the total pressure of multiple influences; land-use changes, harvesting, pollution, alien species and climate change.

2.2 Criteria for indicators and for the set of indicators

The Nature Index for Norway is a composite index that includes many individual indicators. These are assembled in such a way that the index should become recognized as a useful tool for evaluating and formulating policy strategies and communicating with the public from a wide range of society sectors, including environmental protection and environmental management and economics (Bandura 2006, Saltelli 2007). Other well-known composite indices are the gross domestic product and the consumer price index.

To ensure that the Nature Index for Norway reflects the biodiversity in different ecosystems, a set of criteria has been developed so that the indicators reflect different aspects of biodiversity (Pedersen et al. 2013). The criteria set has been created to be very similar to the approach used in the first framework and for the Nature Index for Norway 2010 (Nybø et al. 2008, Nybø 2010b).

The selected indicators should:

- Be taxonomically representative, meaning that invertebrates, plants and vertebrates shall all be included as indicators.
- In total represent the different ecological functions of the species. Different trophic levels and functional groups should be represented.
- Include both common and rare species.
- Include key species. The populations of key species have great significance for the occurrence of a number of other species.
- Contain indicators that collectively are sensitive to different types of environmental pressures. This is to ensure that the Nature Index does not solely reflect one influence, such as harvesting or climate, but all pressures.
- Represent different habitats and natural succession stages within the various major ecosystems.
- Represent different major types of microhabitats found in the various major ecosystems.
- Not include alien species (these are considered as pressure factors).

It is challenging to create a balanced set of indicators that reflect the different aspects of biological diversity. The list above will nevertheless serve as a starting point to identify gaps and imbalances in the Nature Index for Norway data. Alien species are not included as a biodiversity component in the Nature Index but are considered here as a pressure factor, meaning that they are expected to affect the indigenous biodiversity of Norway (see Chapter 4 on environmental pressures). There is, however, a report describing how the Nature Index's framework can be developed to provide an index of the potential harm caused by alien species (Van Dijk et al. 2012).

In addition to criteria to ensure a balanced set of indicators, each indicator also has some properties that must be met:

- The indicator should only be measured in the natural environment.
- Measurements should only be linked to defined, demarcated areas.
- It must be possible to estimate a reference value.
- The indicator must be linked to one or more major ecosystems.
- For each of the major ecosystems, the indicator should be able to maintain a persistent population when the ecosystem is in its reference state.
- The data is good enough that trends in the indicator can be estimated.
- The indicator should preferably be a population trait.
- It should respond to environmental changes.

2.3 Key indicators and weighting with respect to ecological function

The set of indicators was selected by the institutions in accordance with the criteria and in discussions in the expert groups for the different ecosystems. The indicators used may change over time as a result of improved data for relevant indicators or because monitoring and updating of the data has been discontinued. If the indicator set changes between two releases of the Nature Index for Norway, the earlier Nature Index will be recalculated using the new indicator set. This ensures comparability over time. Appendix 1 lists the indicators currently included in the Nature Index for Norway.

In a review of the indicator set, it was found that there is a predominance of vertebrates, especially birds. The criteria for the indicator set state that the set should be a representative sample with respect to taxonomic groups and ecological functions. The expert group for the Nature Index therefore agreed on a weighting system that corrects for this (Figure 2.2). For more information, see Chapter 5.3.

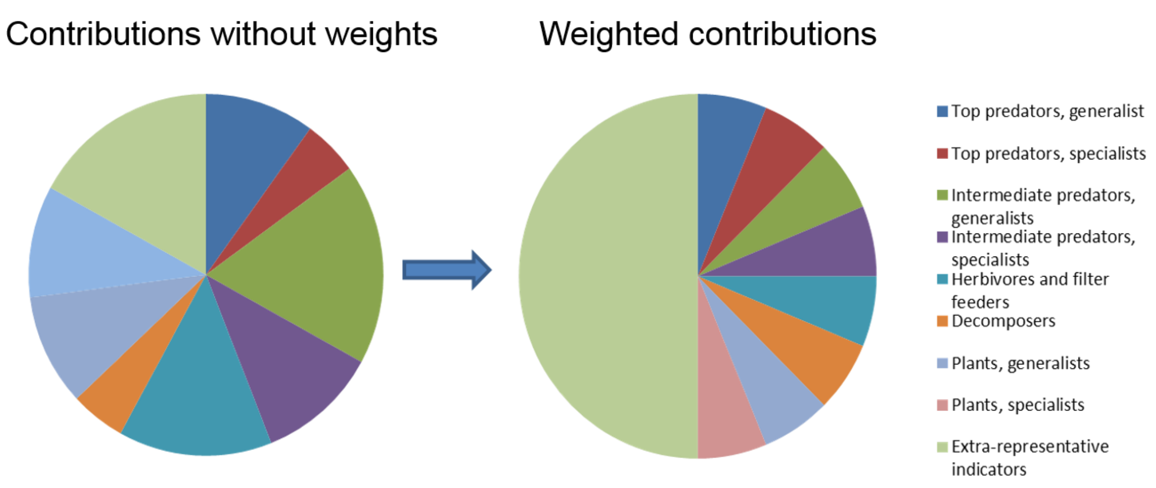

Figure 2.2. *Schematic overview of weighting the functional groups*

The weighting system is based on assigning indicators to functional groups. The functional groups are: *top predator specialists*, *top predator generalists*, *intermediate predator specialists*, *intermediate predator generalists*, *primary consumers and filter feeders*, *decomposers*, *primary producer specialists* and *primary producer generalists*. All the functional groups are to be given the same weight in the aggregate Nature Index (Figure 2.2). At the same time, some indicators have particular importance for the occurrence/populations of a number of other species. These key indicators (also called “extra-representative” indicators; see definition below) are given half the total weight.

A key indicator could be a key species or an indirect indicator. An indirect indicator is a variable that is measured and believed to be of great importance for the population of one or more species. An example of an indirect indicator is dead wood in *forest*.

For an indicator to be defined as a key indicator it must (Certain et al. 2011):

- Be representative of populations of a hundred species or more
- Occur in a large area
- Be well documented with good data in the index

Species such as capelin, herring, rodents and blueberries are examples of key species of great importance for other species, and these are emphasized as key indicators (Appendix 1). Certain et al. (2011) tested the significance of weighting in all major ecosystems, with the exception of the ocean. The analysis showed that the effect of weighting varied for the major ecosystems. For *mountain* and *coast bottom* ecosystems, weighting increased the contrast between areas where the state of biodiversity was good or bad, whereas the opposite effect was observed for the *coast pelagic* ecosystem. Weighting also resulted in a reduction in the index values for the majority of ecosystems. This suggests that the state values of the key indicators are worse than for the majority of the other indicators (Certain et al. 2011).

The principles for weighting and aggregation can be adjusted to new needs by developing new thematic indices. An indicator can be characterized on the basis of the ecosystem and habitat type(s) to which it belongs, its ecological function, microhabitat, taxon, which pressure factors it is sensitive to, and so forth. This paves the way for constructing various thematic indices and analyses that can shed light on cause-and-effect relationships. By employing other principles for weighting and the composition of the indicator set, the Nature Index data and framework can be used to answer other questions. For example, Framstad et al. (2015) analysed trends in index values for indicators affected by different pressure factors.

2.4 Reference state and management objectives

The Nature Index for Norway (NI) measures the state and development of biodiversity. In order to compare values from different indicators, all values are converted to the same scale before they are put together into an aggregate index (Chapter 5). To achieve this, a reference value must be defined that the measured indicator values (populations) can be related to. The Nature Index uses approaches that are similar to the Water Framework Directive (VD) (Climate and Environment Ministry 2007), the Biodiversity Intactness Index (BII) (Scholes & Biggs 2005), the Natural Capital Index (NCI) (RIVM 2002), GLOBIO (Alkemade et al. 2009) and the "Natural Forests Index" (Bastrup-Birk 2014) to define the reference state. GLOBIO is the model that the Convention on Biological Diversity uses to assess the condition of the Earth's biological diversity (www.globio.info).

All of the above-mentioned efforts use “intact natural environment with little human activity” or “naturalness” as the basis for determining reference values. This is in contrast to indices that simply use the state in a particular year as the reference value. For example, the "Living Planet Index" uses 1970 as the reference year (Loh and Wackernagel 2004). The definition of the reference state for the Nature Index is given in Box 2, while the operationalization of this is described in Chapter 3.

Based on the knowledge of the reference state, a numerical value can be determined as a reference value for each indicator. The reference values for all the indicators should ideally be set so that they are consistent with each other, and it should be theoretically possible for the ecosystem in question to obtain the state that is collectively described by the reference values. Consideration should be given to natural variation when the indicator value is determined. The reference value is used to scale all indicators to a value between 0 and 1, where the value 1 is the indicator's value in the reference state (see chapter 5.2). In this way it is possible to compare and combine data for different indicators and thus estimate the impact human activity has on the state of biodiversity.

BOX 2.2. *Reference State – intact nature*

- For natural ecosystems, the reference state is defined as an ecosystem that is little affected by human activity, while for semi-natural ecosystems, the reference state is defined as nature in good condition, i.e. under the land use customs that define the habitat type. Pressures other than those from traditional uses are minimal.
- In the reference state, the ecosystem contains the species composition and population sizes that would have been found in an intact ecosystem in the period 1961–1990.
- In the reference state, the climate is that which was found in the period 1961–1990, which is an often used climate normal.

Some ecosystems require continued human traditional use to be maintained, so-called semi-natural systems, which have been extensively used for agricultural operations (grazing and mowing, but not ploughing or fertilization). In these ecosystems, terminating this traditional use will negatively affect biodiversity. In the 2015 version of the Nature Index, ecosystems that rely on such management were only included in *open lowland*. A low Nature Index value here may therefore reflect the termination of traditional management.

The difference between the value of the Nature Index and the reference value can primarily be seen as a measure of the cumulative environmental effect of all human activity that has a negative impact on biodiversity. The lower the Nature Index value, the higher the overall impact on biodiversity. Management measures that improve the condition of biological diversity in the ecosystems could increase the Nature Index value.

The advantage of this approach is that it can specify at a coarse scale the extent of the impact that the sum of human activities has on biodiversity. This avoids mixing arguments about what humans need in terms of goods and services from nature with the state of biodiversity. With this as the starting point, society can make trade-offs between maintaining biodiversity, resource use and other impacts, and set management objectives (Figure 2.3).

Implicit in all nature management is the assumption that management is undertaken in relation to a management goal – a realistic desired state for a population, a species or an ecosystem. For example, there are **population goals** for large carnivores and commercial fish stocks. These kinds of management objectives involve making a trade-off between society interests, business interests and maintaining the populations of these individual species over time.

For ecosystems, balancing between commercial interests, public interests and biodiversity is usually not based on quantified management objectives, but instead by using guidelines and regulations (management). The environmental objective of the Water Framework Directive is the closest we get to quantified management objectives for ecosystems. The environmental objective of the Water Framework Directive is good ecological condition. The definition of good ecological condition is that "… *the values of the relevant biological quality elements for the surface water body show low levels of distortion resulting from human activity, but deviate only slightly from those normally associated with the surface water body type under undisturbed conditions*" (WFD CIS Guidance Document No. 13 2005). For freshwater and coastal waters, good ecological condition means that the ecosystem is only slightly changed as a result of human activities. All other ecosystems lack specific quantified management objectives (Figure 2.3).

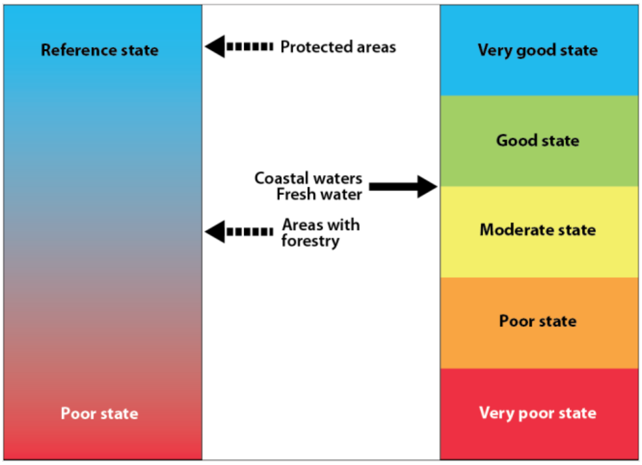

Figure 2.3. *Illustration of the difference between management objectives (arrows) and reference states for ecosystems managed under the EU's Water Framework Directive (right) and other ecosystems and geographical areas where similar legislation does not exist (left). For coastal waters and freshwater, the EU's Water Framework Directive has set management objectives, which means that all water bodies should be in minimum good condition. The condition should also not be deteriorating. The water directive's management objectives are shown by the solid arrow. As of 2014, the directive did not set specific management objectives for terrestrial ecosystems. Any government targets for biodiversity should probably vary depending on how the site is used. A nature reserve is likely to have management goals for biodiversity that are closer to the reference state than a forest operation. The dotted arrows illustrate possible management objectives for biodiversity in terrestrial ecosystems from the perspective of the Nature Index framework. A prerequisite for being able to differentiate between management objectives for areas with different management approaches (such as within and outside protected areas) is that the Nature Index is divided into corresponding areal categories.*

In practice, one would only very rarely set a management goal as an intact natural environment with very limited impact from human activity. In all assessments of the state of species or ecosystems, there is consideration of what represents good condition, and similarly what is a detrimental condition, even though what underlies these assessments is often not quantified. The Nature Index builds on a broad knowledge base and provides a basis for developing broad-based management goals that reflect society's overall balance between the different needs associated with the use of natural resources, other uses of nature and the desire to safeguard biodiversity. This is described in NOU (2013, their Box 4.6).

Metaphorically, we can think of the reference state in the Nature Index as analogous to the magnetic North Pole, which serves as a reference in planning the correct route. The North Pole (reference state) is not the objective, but you must know where the North Pole is to arrive at where you want to go (management goal). The reference state is thus different from the management goal, perhaps with the exception of certain protected areas where the goal is for the state to be as unaffected by human activity as possible. Knowing the reference state is therefore important for knowing whether a change is positive or not. When the Nature Index shows increasing values over time, this indicates a positive development for biodiversity. Conversely, decreasing Nature Index values over time indicate a negative development for biodiversity.

2.5 Basic principles for the determination of reference values

Reference values for individual indicators are determined based on a reference state that is defined for an entire major ecosystem, i.e., a condition that in theory should be achievable for all indicators simultaneously. The individual indicator's reference value is determined based on this common reference, which applies to all indicators for the ecosystem. This means that the reference values are linked to a reference state, not to a certain year (Box 2.2). The definitions of major ecosystems generally follow the Nature Types in Norway (NiN 2.0) system, with a distinction between how natural and semi-natural ecosystems are handled (Halvorsen et al. 2015) (see Chapter 3 for additional information).

One advantage of a shared reference state definition for all indicators in an ecosystem is that the Nature Index is sensitive to any negative departure from the reference state. Another advantage is that the Nature Index value of 1 is given concrete meaning. This meaning is described in relation to the discussion of each individual ecosystem (see Chapter 3). A Nature Index state with a value of 1 for a major ecosystem means that all indicators and therefore also the major ecosystem are in a reference state (Pedersen et al. 2013). It is worth noting here that the indicators can have higher numerical values than their reference value, while still having the scaled value of 1. Any further "improvements" of the indicator value above the reference value are counted as neither positive nor negative in the index (see Pedersen et al. 2013 and chapter 5.2 for more information). A value of 0 means that all indicators have a value of 0, and the original ecosystem has lost its biodiversity and the ecological functions that were part of the intact system.

For **natural ecosystems** (including aquatic systems) the indicators' reference values are set relative to a common reference state that represents ecosystems where the impact of human activity is, or has been, so limited that it has minimal impact on biodiversity. The species composition, the different populations' sizes and states and the ecological functions are intact, meaning they have not been significantly affected by human activity. The reference state for semi-natural land is defined as a system in "good condition" relative to species diversity traditionally associated with the appropriate habitat (Pedersen et al. 2013) and which has been shaped through traditional uses over a long time. See the discussion of semi-natural ecosystems in Chapter 2.6.

An ecosystem that is described as little impacted means that the species richness, the state of various populations and the ecological functions are intact. In practice, the reference value is set based on the populations in what would have been an intact ecosystem today, given a climate at a set time (for example, the climate normal for 1961-1990 used by the Norwegian Meteorological Institute), and with a species composition that would represent intact nature (Box 2.2).

2.6 Special conditions associated with semi-natural ecosystems

The Norwegian Government ordered the preparation of the Nature Index for Norway in 2005, and wanted semi-natural land (culturally dependent ecosystems) to be included in the work. This has presented some challenges since semi-natural land requires human traditional use to be maintained. The reference state for semi-natural land must therefore assume that this traditional management and associated biodiversity are maintained over time. Cessation of traditional management is considered negative, and will result in a lower Nature Index.

Semi-natural land is found in all terrestrial ecosystems, but semi-natural land dominates the *open lowland* defined in the Nature Index. *Open lowland* also contains natural ecosystems, i.e. habitats that do not require traditional management to be maintained. *Forest*, *mountain* and *mires and wetland* consist mainly of natural ecosystems, but there is semi-natural land in these ecosystems as well, such as forest pasture. To avoid confusion in how a nature index value should be interpreted, we emphasize here that **the Nature Index for *open lowland* reflects the state of semi-natural land (Box 2.3). The Nature Index for the other ecosystems reflects the state of natural ecosystems**. However, it is desirable to develop thematic indices for natural ecosystems in *open lowland* and semi-natural land in other ecosystems (*forest*, *mountain* and *mires and wetland*), such as for example forest pasture, because it is possible to identify distinctive biodiversity in these habitats. The Nature Index framework has been created to facilitate this, but currently there are no indicators for natural ecosystems in *open lowland*, or for semi-natural land in the other ecosystems.

> ***Box 2.3.*** *Open lowland*
>
> The Nature Index for open lowland shows the state and development of semi-natural ecosystems (culturally dependent ecosystems). The development of natural open ecosystems in the lowlands can be shown as a separate thematic index, provided that the necessary data for such an index have been put in place.

Since the reference state is defined differently for semi-natural land and natural ecosystems, the same indicator cannot be used in semi-natural land (*open lowland*) as in natural ecosystems (*forest*, *mountain*, *mires and wetland*). Indicators for semi-natural land should be exclusive to this land type, and characteristic indicators must be selected. If a species/group of species nevertheless must be represented in both semi-natural land and natural ecosystems, two different indicators must be established. These would use different data sources/expert assessments, and different reference values. For example, there must be independent assessments of bumblebees in semi-natural land (*open lowland*), and for bumblebees in natural ecosystems in *mires and wetland*.

2.7 The Nature Index measures the state in a given area

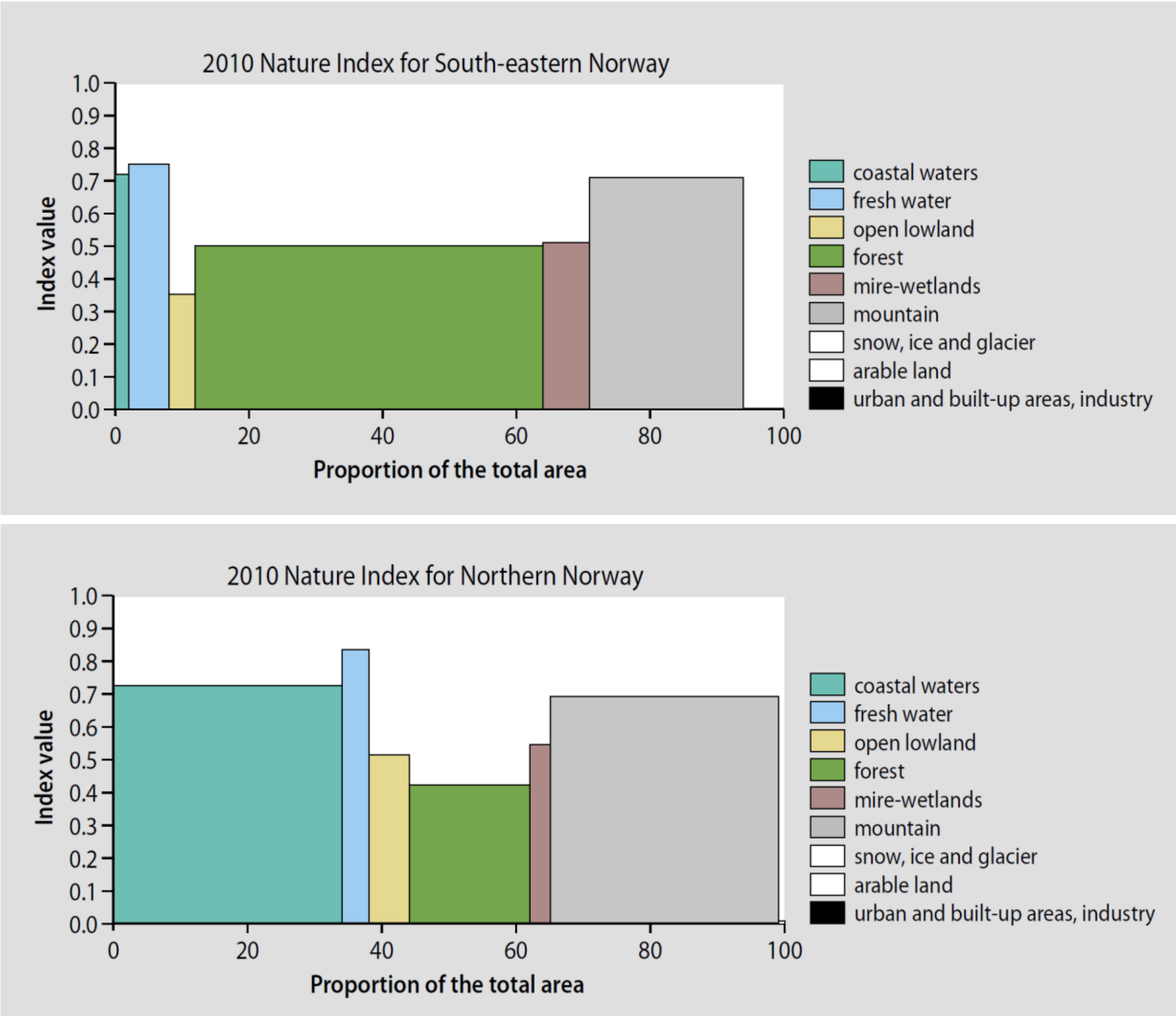

Figure 2.4. *Terrestrial area covered by different major ecosystems (proportion) and their Nature Index values, in two regions (Østlandet and Northern Norway) in 2010 (Nybø 2010b).*

The Nature Index measures the ecosystems' state for biodiversity in the areas covered by a given ecosystem at a given time. In terrestrial environments, the spatial extent of major ecosystems may change over time.This means that when the values of an indicator are to be quantified, the state of the indicator should be evaluated based on the areal extent of the ecosystem at that time. This is because the goal is to estimate the state of biodiversity in that specific area.

This is illustrated in Figure 2.4 (in two different regions at the same time). If numbers are available to show the changes in areal extent, these can be illustrated by changing the size of the x-axis, while changes in the value of the Nature Index can be displayed on the y-axis. In practice, changes in land area over a 5-year perspective are relatively small.

For marine environments, the above does not apply. These ecosystem have instead a fixed areal extent, covering the entire geographical unit in question.

3 Description of the major ecosystems and their reference states

Signe Nybø[1], Bård Pedersen[1], Olav Skarpaas[1], Iulie Aslaksen[2], Jarle Werner Bjerke[1], Grégoire Certain[1], Hanne Edvardsen[3], Erik Framstad[1], Per Arild Garnåsjordet[2], Aksel Granhus[4], Hege Gundersen[3], Snorre Henriksen[5], Knut Anders Hovstad[6], Anders Jelmert[7], Margaret Mary McBride[7], Ann Norderhaug[6], Geir Ottersen[7], Eivind Oug[3], Hans Christian Pedersen[1], Ann Kristin Schartau[1], Ken Olaf Storaunet[4], Gro I. van der Meeren[7]

[1]Norwegian Institute for Nature Research, [2]Statistics Norway, [3]Norwegian Institute for Water Research, [4]Norwegian Forest and Landscape Institute, [5]Norwegian Biodiversity Information Centre, [6]Norwegian Institute for Agricultural and Environmental Research, [7]Institute of Marine Research

The reference state is defined as an ecosystem where human activity is/has been so limited that it has had a minimal impact on biodiversity. The basic principles for describing reference states are given above. The text below provides examples of important anthropogenic influences in the various ecosystems. For semi-natural land, the reference state is set as the condition of an ecosystem under traditional management, i.e. the management that define the habitat as a result of human use over a long period (see Chapter 2.6).

A specification of this approach means that the reference value for the individual indicators should be based on the following criteria:

Absence of anthropogenic influences

- Absence of anthropogenic inputs of **environmental pollutants, acid rain and eutrophic substances**. Natural background levels of these compounds can be found in intact ecosystems.
- A limited degree of **fragmentation** from human activity, for example by roads, power lines and conversion of one habitat to another.
- Limited impacts from **land use** by human activity, such as trawling, forestry, overgrazing by reindeer or other animals, dumping of mine tailings.
- **Hydrological conditions** not affected by man-made facilities and installations.
- Limited pressure from **harvesting/hunting and trapping/bycatch.** The reference values for harvested species are seen as the commonly occurring population sizes/density without such harvesting. For example, predator populations (marine, freshwater and terrestrial) should be within natural variations.
- The absence of population effects by **non-native species** on naturally occurring species. In this context, the assessment is based on species lists and risk assessments in the last report on non-native species in Norway (Gederaas et al. 2012). This list mainly includes species that have come to Norway after 1800.

Climate, natural disturbances and species composition

- A climate that is equivalent to **the 1961–1990 climate normal.** If a species increases in prevalence or numbers due to climate change, the species' indicator value will go towards 1, but the scaling model ensures that the value will never be greater than 1, even if productivity continues to increase beyond the reference state. Climate change that further favours this species will consequently not affect the Nature Index value. Conversely, an indicator that reflects depleted populations due to climate change will be given a lower value than 1 when populations are lower than in intact nature. This will thus provide a negative contribution to the Nature Index.
- Species that move without being planted, sown or displaced by manmade vectors are considered to be naturally dynamic.
- **The presence of natural disturbance factors and subsequent succession factors**, such as forest fires, disease outbreaks and felling of trees by storms.

- The ecosystems’ potential indigenous **species composition** is what it would be in an intact ecosystem without significant human impact, assuming climatic conditions as in the climate normal from 1961 to1990. This involves a hypothetical reference state where the species composition is what it would have been, assuming natural immigration and extinction, not because of deliberate releases or planting. Releases or planting before 1800 are considered indigenous (cf. information on alien species). For indicators that have a negative population trend because of previous anthropogenic pressures, the reference value is set as if these influences have not happened. For example, salmon and trout are assumed to be present in the reference state in Sørlandet, even though stocks were wiped out or severely reduced in many localities before the mid-1950s. Non-native tree species planted outside of their natural range are not counted as part of the indigenous species composition. Nevertheless, it is a given state and species composition in an ecosystem that defines the reference state, not a particular year. This means that the starting point for an assessment is contemporary ecosystems with their species diversity and population sizes, not as they were 500 or 1,000 years ago.
- Specifically for semi-natural land, for example in *open lowland*, traditional uses are considered to be positive for the characteristic biodiversity and a prerequisite for the maintenance of the ecosystem. Cessation of traditional use is considered negative for the biodiversity that is characteristic of the ecosystem (see Chapter 2.6). Regrowth (encroachment by trees and bushes) is therefore a threat to semi-natural land, despite the fact that this is natural succession.

3.1 Forest

Includes all forests, including northern boreal deciduous forests, which are often montane birch forests. Forest lands are areas where forests are growing and areas which have been in the recent past or are expected in the future to be forest (ref. NiN 2.0). The Nature Index includes floodplain woodland in the *forest* major ecosystem. Just over one-third of Norway’s land area is covered by forests, but there is considerable geographical variation. A part of this area consists of forests that are not used commercially, such as northern boreal deciduous forests and wooded swamps. The productive forest area comprises about a quarter of the land area.

The reference state for *forest* is defined as a hypothetical state where all of the forested area consists of natural forests and where natural disturbance processes (e.g. forest fires, epidemic outbreaks and wind falls) with subsequent succession stages are present, assuming a climate corresponding to the climate normal (1961–1990). Habitats, species composition and population sizes of all species groups are about as they would have been in such a natural forest landscape. The forest is not exposed to nitrogen, phosphorus, acidifying compounds or contaminants, beyond what would have been natural. In other words, tree species composition, the population sizes of vascular plants, lichens, fungi and mosses and the amount of dead wood are like what would be found in a natural forest landscape. Moreover, populations of wild deer are at a level adapted to a natural density of carnivores, and wild deer and small game populations are not significantly affected by hunting.

3.2 Mires and wetland

Mires and wetland include bogs and springs (see NiN 2.0) both above and below the treeline. A mire and wetland massive is a natural hydromorphological unit where the different parts are interdependent on the groundwater table being maintained near the land surface (see. NiN 2.0). This is a prerequisite for a functioning wetland system. The *mires and wetland* massive also includes all other peat lands (including springs with deep peat) and other natural wetlands. Bogs have a peat layer deeper than 30 cm. Statistics Norway’s official land statistics show that 5.8% of the land area is bog. Bogs also include areas with shallow peat where the vegetation is dominated by bog species. The Nature Index for *mires and wetland* reflects the state of wetlands with freshwater inflow, both those above and below treeline.

The reference state for *mires and wetland* is characterized by the absence of human activities affecting hydrological conditions, for example by draining, ditching, cultivation, reduction or fragmentation. They are not exposed to nutrients through rainfall, fertilizers or liming. Manmade acidification of *mires and wetland* and environmental pollution are absent. Hydrological conditions are natural and not altered by human intervention. The reference state for *mires and wetland* is characterized by population sizes found in intact habitats in this ecosystem.

3.3 Mountain

Mountain includes all areas above treeline, except glaciers and other snow or ice-covered ground. Landslides and avalanche areas above treeline are included in the *mountain* major ecosystem. *Mires and wetland* and *freshwater* are defined as separate ecosystems and are not included in the *mountain* ecosystem.

The reference state for *mountain* is areas that are characterized by natural disturbances from frost, ice, snow, wind and water, and natural population fluctuations of dominant species (e.g. small rodents, insects) and the resulting vegetational succession. Further, in the reference state the *mountain* ecosystem is not heavily influenced by infrastructure, settlements and other land use or grazing livestock. The *mountain* has a natural population size of predators, wild reindeer and other naturally occurring species. The populations of wild reindeer and domesticated reindeer are at a level that reflects a natural predator density. The populations of carnivores, birds of prey, reindeer and small game are not significantly affected by hunting and the populations of domesticated reindeer are assumed to be under natural regulation.

The *mountain* is not exposed to nitrogen, phosphorus, acidifying compounds or contaminants, beyond what is natural. This also means that inputs of anthropogenic compounds from the atmosphere are so low that they do not affect vegetation or fauna. Radioactive substances and heavy metals are found at background levels.

3.4 Open lowland

This includes all open land area below treeline with natural and semi-natural vegetation, i.e. excluding agricultural land, human settlements and infrastructure, and other areas with artificial ecosystems. *Open lowland* thus consists mainly of semi-natural ecosystems (boreal heath, coastal heath, semi-natural beach meadows and semi-natural pastures, ref. NiN 2.0) where the habitat’s character is shaped by extensive ("traditional") use (pasture and haying, possibly burned) for a long time, often hundreds of years. The areas can be cleared of stones, but not ploughed, sprayed, fertilized or seeded, or with only insignificant traces of such influence (ref. NiN 2.0, Halvorsen et al. 2015). Boreal health is a culturally dependent treeless heath below treeline. Crowberry, heather, juniper and dwarf birch are characteristic species. Boreal heaths are typically found around summer mountain pastures. Also included are naturally open natural ecosystems, such as rock fall and avalanches areas and other natural open areas below treeline. As of 2015 indicators for natural ecosystems are not included. **The Nature Index for *open lowland* therefore reflects the state of biodiversity in semi-natural ecosystems in the lowland.** If good indicators for natural open areas in lowlands can be obtained, this will be presented as a separate thematic index. It is therefore not appropriate to present one overall Nature Index for semi-natural systems and natural ecosystems in *open lowland*. Built-up areas, infrastructure, farmland and the like, such as artificial and constructed fields (terminology according to NiN 1.0, Halvorsen et al. 2009) are not included in the habitat type. If these areas are to be included in a new area type, more development work must be undertaken.

The reference state for *open lowland* is defined as habitat types in good condition. This means that semi-natural systems are managed in such a way as to provide light, open areas with good growing conditions for grasses, herbs and mushrooms and which also provide good conditions for insects and other fauna. The management regimes that represent "good condition" vary across the country, but mainly consist of livestock grazing, mowing and/or heath burning. These were often farming methods that were common until World War II. Areas that are in "good condition" and that are in the reference state, cannot be overgrazed by livestock and manure has not been used on the area, or has only been used in insignificant amounts. The plant communities in semi-natural lands in good condition have a characteristic element of plant species that retreat and eventually will disappear if fertilized. Pesticides have not been used to limit insect populations or alter the composition of the plant community on land that is in good condition.

Inputs of nitrogen, phosphorus, acidifying compounds and contaminants from air pollution or other human activities are so limited that they do not substantially affect biodiversity. Environmental pollutants above natural background levels are absent.

3.5 Freshwater

Freshwater includes both open water and bottom areas, flowing water (streams and rivers), stagnant water (lakes, ponds, lakes) and their associated systems. *Freshwater* is found both above and below treeline. Springs are included in *mires and wetland*, see Section 3.2.

The reference state for *freshwater* is characterized by natural variations in rainfall, flooding and fluvial transport. The only source of nutrients is via precipitation and runoff from natural processes. There are no inputs of nutrients originating from sewage or other contaminants via runoff or precipitation, or any anthropogenic supply of acidifying or neutralizing compounds (such as lime). Any alien species are found at such low numbers that they do not affect populations of native flora or fauna. Environmental pollutants are absent, but natural background levels are acceptable. Hydrological conditions are natural and not changed due to manmade interventions. Physical intervention is absent or is so limited that it has not led to changes in the bottom area.

The species composition and population sizes of different species are the same as are found in an intact natural environment. For use in accordance with the Water Framework Directive, values have been established representing a natural state (the reference values and upper/lower limit) for a range of indicators and water types in *freshwater*, see www.vannportalen.no.

The Nature Index does not account for modified and artificial water bodies, in contrast to the Water Framework Directive. Instead, the reference values for indicators in such water bodies are what the indicator values would have been without these interventions.

3.6 Coastal waters

Coastal waters include all internal waters and coastal waters out to one nautical mile (1,852 m) off the coast baseline, which is drawn between the coastal (low-tide) extremes. This definition that distinguishes coastal waters from the ocean is the same as is used in the Water Framework Directive and is a practical limit that will be used in future environmental monitoring of Norwegian coastal waters. Coastal waters include habitats in all saltwater and brackish water and can be divided into two major ecosystems: *coast bottom* and *coast pelagic*. Norway has a coastline of approximately 2500 km measured along the baseline from the Swedish border in the south to Grense Jakobselv in the north, with the marine area in the coastal waters covering 94 000 km^2.

The reference state for the coast is characterized by natural ecosystem dynamics with variations in ocean currents, salinity and temperature and where populations of marine mammals, seabirds, marine fish species and other organisms show natural conditions. Habitats, species compositions and population sizes of all species groups are about as they would have been in the absence of effects from anthropogenic activity. Alien species are at such low numbers that they do not affect populations of native flora and fauna. Pollutants, oil compounds and radioactive substances are at background levels. Harvesting of commercial species and bycatch affects populations of marine species to a limited extent. There is an absence of effects from the use of bottom trawls and other activities that result in reduced habitat quality. Boat traffic and other sources of noise (such as seismic surveys) result in limited damage or disturbance of birds, mammals and fish. Additionally, the reference state is characterized by a lack of added nutrients from anthropogenic activities such as sewage wastewater discharges, fertilizer runoff or long-range transport. Atmospheric CO_2 levels are so low that they do not cause ocean acidification.

The Water Framework Directive contains examples of values that individual indicators have in the reference state.

3.7 Ocean

Includes waters in the Norwegian Exclusive Economic Zone and is defined as the area between 1 and 200 nautical miles beyond the baseline, excluding the Norwegian economic zone around Svalbard and Jan Mayen. The ocean is divided into two major ecosystems, *ocean bottom* and *ocean pelagic*. Norway has a large area within its Exclusive Economic Zone, a total of 870,000 km^2 (from the baseline out to 200 nautical miles). The marine area included in coastal waters is 94 000 km^2 (1 nautical mile outside the baseline and landwards). For comparison, Norway’s land area is 324 000 km^2, which means the marine area is roughly 3 times as large as the land area. The Norwegian Sea is by far the largest ocean area and constitutes more than half of the ocean area (56%), followed by the Barents Sea (29%), the North Sea (13%) and Skagerrak (3%). The Nature Index for ocean contains the area from 1 nautical mile outside the baseline (the scope of the Water Framework Directive) and out to 200 nautical miles, meaning the Norwegian Exclusive Economic Zone.

Many populations of species in the ocean vary rapidly over a short time, while others may fluctuate in cycles of decades, 50 years and more. Thus, the interaction between external influences, between species and within species independent of human influence is quite complex and results in significant variations. Ocean life is characterized by very strong competition for resources with subsequent short- and long-term mutual interactions between the organisms and the environment. There is never and has never been "balance" in the marine ecosystem. There is a lack of understanding of the complex and dynamic interaction between species and life stages in the ocean and the coast since people do not have a natural place in these ecosystems. This makes it challenging to establish reference values based on the idea that these can be achieved by all indicators in the sea simultaneously. As much as possible, reference values must be consistent with the intent of the Nature Index (the biological diversity in the ocean, given little or no impact from human activity). At the same time they must be scientifically justified, based on the best available information that can be obtained, from monitoring data and recruitment/population models.

Reference values for indicators in the ocean are therefore established in relation to the best scientific knowledge available about each indicator’s reproduction, life cycle and ecology. The selected reference values shall be justified through a scientifically strong statistical calculation based on the selected species' specific requirements and ecology.

The text describing the reference state for coastal waters also applies to the ocean, except for the discussion of values defined for individual indicators in the Water Framework Directive: The reference state for oceans is characterized by natural ecosystem dynamics with variations in ocean currents, salinity and temperature and where populations of marine mammals, seabirds, marine fish species and other organisms are characterized by natural conditions. Habitats, species composition and population sizes of all species groups are about as they would have been with negligible influence from anthropogenic activity. Alien species are at such low numbers that they do not affect populations of native flora and fauna. Pollutants, oil compounds and radioactive substances are at background levels. Harvesting of commercial species and bycatch affects populations of marine species to a limited extent. There is an absence of effects from the use of bottom trawls and other activities that result in reduced habitat quality. Boat traffic and other sources of noise (such as seismic surveys) result in limited damage or disturbance of birds, mammals and fish. Additionally, the reference state is characterized by a lack of added nutrients from anthropogenic activities such as sewage wastewater discharges, fertilizer runoff or long-range transport. Atmospheric CO_2 levels are so low that they do not cause ocean acidification.

3.8 Examples of how reference values are determined

The public website for the Nature Index for Norway (www.naturindeks.no) was made available in the autumn of 2015. This includes descriptions of how reference states are established for each indicator. Below are examples of how the reference values for three different indicators can be determined.

3.8.1 Roe deer

The reference values for roe deer (*Capreolus capreolus*) are model-supported expert assessments based on a hypothetical condition where hunting is absent, the climate is as it was until recently (1961–1990), forestry is of little significance in affecting grazing areas, and the number of predators is limited by factors other than hunting (predominantly limited by the availability of prey). High predation from wolves, bears and lynx, in combination with severe winters, would then cause roe deer to be absent or occur at very low densities in the snowy parts of the country, while coastal lowlands, and in particular predator-free islands, may have relatively high densities of roe deer.

3.8.2 Small mountain rodents

The reference state is based on considerations that assume the ecosystem is governed by natural processes. This creates a pattern in rodent population dynamics characterized by regular population peaks that are approximately 5 to 10 times higher than the abundance in years where populations are low. This is especially true in northern ecosystems (mountains, boreal forest) with regular snow cover that lasts for several months. In practice, the reference state is based on an expert assessment that assumes that small rodent dynamics in the period 1950–1980 were almost natural. In this respect, the reference state is generally similar to conditions in 1950.

3.8.3 Sugar kelp

Reference values for the kelp known as Devil's apron or sugar kelp (*Saccharina latissima*) have been determined using prediction models based on available data on the species' occurrence, collected through a series of major and minor monitoring and survey projects from 1990 to 2012 (Gundersen et al. 2012). The statistical models have been transferred to GIS and predict the natural range for sugar kelp, meaning where it would be found if sites were in a natural state. The models contain environment variables that previous studies have shown to be important for sugar kelp, such as depth, slope, wave exposure and the terrain variables depth of basin and curvature. A detailed map can thus be generated of the probability of presence of sugar kelp along the Norwegian coast through Skagerrak, the North Sea and the southern region of the Norwegian Sea. These in turn are used to calculate the total area which is suitable as habitat for sugar kelp within each municipality, defined in this context as areas with a probability of presence of greater than 0.5. However, this method for setting reference values is not currently used for Nature Index calculations since it would require a corresponding area-based approach for the indicator values, which is so far lacking.

4 Pressure factors

Signe Nybø
Norwegian Institute for Nature Research

For each indicator, experts have specified the 2–3 negative pressure factors to which the indicator is most sensitive and which may occur where the indicator is found. Only the most aggregated level from Table 4.1 is used. The details on the indicator's sensitivity to pressure can be considered along with the actual pressure in different areas and indicate whether the pressure actually has an effect.

Table 4.1. *Negative pressure facors. The classification is based on the revised proposal for the Norwegian standard (NS 9452: 2012, Collection of environmental data - Factors affecting Norwegian biodiversity and cultural environments). The first column shows the terms used in the Nature Index base. The second column shows what is included in the categories, and the last column gives the ID number and the designation given in the standard's level 2. Not all categories in the standard level 2 are relevant, and thus are not included in the table.*

Acronym	Category	Subcategories
BE	Controlled reduction and harvest	[101] fishing [102] hunting and trapping [103] collection, gathering, picking
FR	Alien species	[201] amensalism [202] competition [203] antagonism [204] ecological facilitation [205] mutualism
EU	Eutrophication	[301] addition of nutrients that cause eutrophication
FO	Acidification	[309] addition of acidifying substances from the air [310] addition of acidifying substances to water
AF	Other pollution	[302] addition of oxygen demanding substances [303] addition of health or environmentally damaging substances [304] addition of radioactive substance [305] addition of oil [306] addition of ozone-depleting gases [307] effects from ground-level ozone [311] addition of particles [313] addition from polluted soil, sediment or masses [314] leakage from shipwrecks and the like
KL	Climate change	[401] weather and climate conditions (temperature, precipitation, drought, moisture, humidity, wind, currents) [402] climate processes and consequences (sea level, snow cover, ice cover (land and freshwater), sea ice cover, permafrost, drainage, growing season, fires, lightning strikes)

AB	Land use / habitat quality	A result of land use can be reduced habitat quality [506] ditching and draining [511] silviculture and logging [516] grazing and other activities related to grazing (from livestock) [xxx] harvest that affects bottom conditions in freshwater and the sea, such as trawling
OP	Cessation of traditional uses	A result of the cessation of use can be loss of habitat quality or area [515] Cessation of use (haying, burning, pollarding, livestock grazing, etc.)
FY	Physical encroachment	A result of physical encroachment can be fragmentation or loss of habitat (area): [501] planting [509] levelling [514] fences [521] digging and drilling [522] material deposition and erosion control [523] building activities [524] construction and development, including aquaculture [525] transport infrastructure and technical infrastructure [526] facilitation of hiking and other outdoors activities
FE	Disturbance from human activity	[601] wilderness travel (non-motorized transport, motorized transport, military transport, other outdoor sports and outdoors activities) [602] traffic and transport via the transport infrastructure [312] Emissions of noise and pressure waves
AN	Other	[701] shooting or blasting [702] collisions [703] fire [704] fire suppression [705] environmental improvement measures (liming, restoration after natural events, restoration, construction of fish ladders, game control measures, culling of nuisance animals) [706] removal or destruction of cultural sites [707] research and mapping
NN	Unknown or natural processes	[403] geophysical processes (processes on the surface of the earth that happen independent of any agent, such as volcanic eruptions, earthquakes, flood waves, tsunamis, landslides, avalanches, erosion) [404] chemical processes (acidification, alkalization, saponification [xxx] unknown
HY	Hydrologic changes	[xxx] changes in hydrology related to hydropower installations, embankments or other anthropogenic interventions

Alien species

The establishment of alien species (which based on current knowledge do not represent a threat to the established indigenous diversity), will locally increase biodiversity in Norway – if the number of species is used as a measure of biodiversity. But if seen from a wider geographical perspective than the country, the spread of invasive species represents homogenization, and thus a reduction of biodiversity.To clarify the goal of maintaining native and endemic biodiversity, the Nature Index uses "species abundance" instead of "species richness" as a measure of biodiversity, as do numerous other international biodiversity measures. Alien species are not included as indicators.

The Nature Index treats alien species in a manner similar to the Water Framework Directive. The Nature Index includes alien species that pose a risk of significantly affecting the expansion or populations of indigenous species only as a pressure factor. If a population is reduced because of introduced populations/species, this is recorded as a pressure. For example, farmed salmon are recorded as a pressure factor in rivers, because they are believed to have a negative impact on wild salmon stocks. The Norwegian Black List can be a basis for assessing which species represent a risk (Gederaas et al. 2012) and consequently can be expected to have a negative effect on one or more indicators.

A study has been conducted that describes how to use the Nature Index framework and databases, and that builds on the Norwegian Black List's risk assessment to create a separate index indicating the potential impact of alien species on biodiversity at a spatial scale – i.e., portrayed as a map (Van Dijk et al. 2012). The proposed method has not been adopted.

5 Mathematical framework and calculation of the Nature Index

Bård Pedersen and Olav Skarpaas
Norwegian Institute for Nature Research

5.1 The Nature Index is a weighted mean of scaled indicator states

The Nature Index is a weighted average of the state of a sample of biodiversity indicators in which the indicators' states are scaled to a common measurement scale that has 0 as the minimum value and 1 as the maximum value (Certain et al. 2011, Skarpaas et al. 2012). The Nature Index (NI) is calculated for a major ecosystem (j) in a specified geographical area (k) for a given time (t).

(1) $$NI_{jkt} = \sum_{i=1}^{n} S_{ikt} w_{ijk},$$

where $S_{ikt}, i = 1,..,n$ are the n scaled indicator states included in the calculation. The weights (w_i) must conform to

(2) $$\sum_{i=1}^{n} w_{ijk} = 1$$

(Certain & Skarpaas 2010, Certain et al. 2011, Skarpaas et al. 2012).

In a weighted average, the state values used to calculate the average are weighted in relation to each other. Some indicator observations are given more weight than others. There are two motives for doing this in the context of the Nature Index. One motive is to correct for biases in the data from which the index is calculated. The second motive relates to the meaning of the index. In calculating the Nature Index, additional weight is given to key indicators, meaning indicators that represent many species and/or represent key functions in their ecosystem. Moreover, the different trophic levels (= level in the food chain) that are a natural part of the ecosystem are given the same weight (Certain & Skarpaas 2010). This is regardless of how many indicators the different levels are represented by. In other words, equal weight is given to primary producers as a group, as to for example decomposers and herbivores. Thus, the Nature Index summarizes the state of biological diversity based on the state of ecologically defined, functional groups of indicators. The weighting system is discussed further in Chapter 5.4.

The indicators are measured or observed using measurement scales that are specific to the individual indicator. The scaling of observations to a common scale is necessary to calculate a meaningful average. The observations are scaled relative to the indicators' reference values (Chapter 2) for the relevant geographic area (Certain & Skarpaas 2010, Certain et al. 2011). The scaling functions that are used are discussed further in Chapter 5.3.

Since all the indicators after scaling are measured on a scale between 0 and 1, and the sum of the weights is 1, then the Nature Index also varies between 0 and 1, where 0 represents a completely degraded state where none of the system's initial components are present, and 1 represents the reference state (Certain et al. 2011).

5.2 Scaling the indicator values

Scaling the indicator values to a common scale is done using non-linear scaling functions (Figure 5.1). The scaling functions contain only one parameter, the so-called reference value (Chapter 2, Certain & Skarpaas 2010, Certain et al. 2011). Reference values are specified for each geographical area in which an indicator is observed. The scaling functions values are, as described, over the interval [0,1].

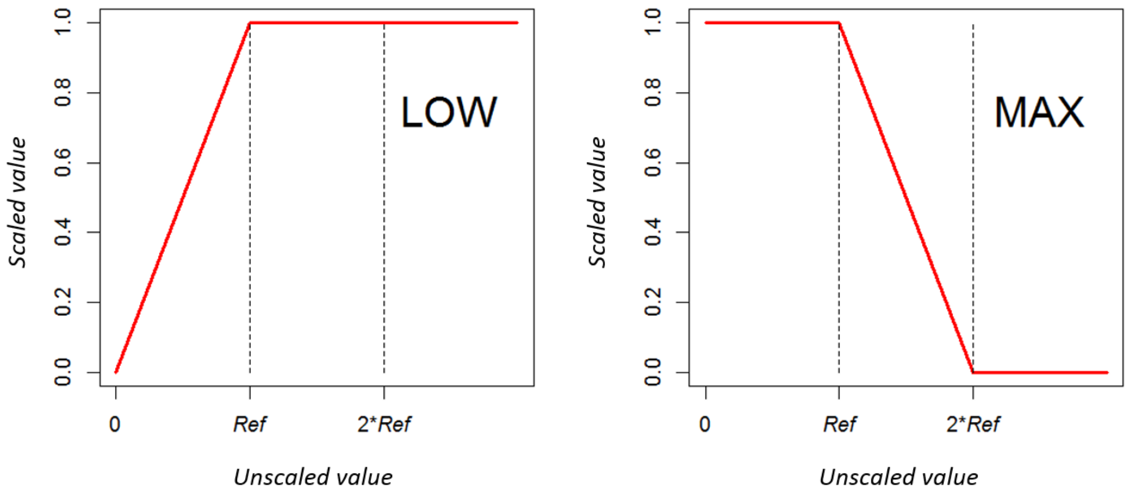

Figure 5.1. *The scaling models LOW and MAX.*

The scaling functions and reference values are key elements of the mathematical implementation of the ecological framework presented in Chapter 3.

From a purely mathematical standpoint, reference values serve several "roles". The parameter corresponds to the maximum value 1, which an indicator value can have after scaling. The reference values simultaneously define scaling constants for each indicator. The scaling constants are the inverse reference values ($\frac{1}{U^{ref}}$). These determine the values that represent the same state for the different indicators.

The reference value also defines the indicator intervals where the Nature Index is influenced by changes in the indicator and intervals where the index is not sensitive to these changes. In this way, the reference value sets a limit on how much an improvement in an indicator which is basically in a good state, can compensate for negative developments in other indicators. This mechanism is a prerequisite for the Nature Index to function as an index of biodiversity.

There are two types of scaling functions, LOW and MAX (Figure 5.1). The choice of a scaling function is determined by whether the indicator correlates positively or negatively with the aspect of biodiversity that the indicator represents.

$$(3a)\qquad LOW: \quad S_{ikt} = S_{ik}(U_{ikt}) = \begin{cases} \frac{U_{ikt}}{U_{ik}^{ref}}, & 0 \le U_{ikt} \le U_{ik}^{ref} \\ 1, & U_{ikt} > U_{ik}^{ref} \end{cases},$$

$$(3b)\qquad MAX: \quad S_{ikt} = S_{ik}(U_{ikt}) = \begin{cases} 1, & 0 \le U_{ikt} \le U_{ik}^{ref} \\ 2 - \frac{U_{ikt}}{U_{ik}^{ref}}, & U_{i}^{ref} < U_{ikt} \le 2U_{ik}^{ref} \\ 0, & U_{ikt} > 2U_{ik}^{ref} \end{cases},$$

where U is the indicator value before scaling, $U^{ref}$is the reference value, and S is the indicator value after scaling.

The LOW model (also denoted as MIN in Certain & Skarpaas 2010) is used when there is a positive correlation between the indicator and biodiversity. This holds true for most indicators. The reference value in this model divides the indicator axis into two intervals. In the interval between 0 and the reference value, S_{LOW} is an increasing function of *U* with a constant slope of $\frac{1}{U^{ref}}$. For indicator values greater than U^{ref}, S_{LOW} is set to 1 and the Nature Index is not sensitive to changes in the indicator.

The MAX model is used when there is a negative correlation between the indicator and biodiversity. This applies only to certain indirect indicators that represent a negative effect that the measured indicator has other components of biodiversity. One example is the negative effect that high densities of wavy hair grass (*Avenelles flexuosa*) have on the incidence of other plants in areas where there is a great deal of added nitrogen. The reference value in this model divides the indicator's definition area into three intervals. In the interval between U^{ref} and $2U^{ref}$, S_{MAX} is a decreasing function with a constant slope $\frac{-1}{U^{ref}}$. For values less than the reference value, the scaled indicator is equal to 1, and for values greater than $2U^{ref}$, the scaled value is 0.

In 2010, a third scaling model, OPT, was used in calculating the Nature Index (Certain et al. 2011). The model is no longer in use, in part because it has unfortunate statistical properties when used on uncertain data. The OPT model is discussed by Pedersen and Skarpaas (2012).

The experts have chosen the scaling function based on their knowledge of the indicators. Of the 303 indicators that formed the basis for the calculation of the Nature Index in the winter of 2014 (www.ssb.no), seven were scaled using the MAX model, and the remainder with the LOW model.

5.3 Weighting indicator values

The weights assigned to the individual indicator values for the calculation of the Nature Index take into account the indicators' specificity to the respective major ecosystem and the indicators' ecological function (Chapter 2.3, Certain et al. 2011). The weights can be written as a product of two factors, a trophic weight ($w^{trophic\ group}$) and a specificity weight ($w^{specificity}$)

$$(4)\qquad w_{ijk} = w_{ijk}^{trophic\ group} w_{ijk}^{specificity}$$

The indicators' specificities (φ) are determined by the individual expert based on the degree to which the underlying data for the indicator reflect the state of one or more major ecosystems (Certain et al. 2011). An indicator's total specificity is 100%. Many indicators belong to only one of the major ecosystems; for example, mussels are only an indicator for the *coast bottom* major ecosystem and have a specificity of 100% to the *coast bottom*, with a specificity of 0% to the other major ecosystems. Conversely, marine fish species will often belong to two or more of the marine major ecosystems, *ocean pelagic* and *ocean bottom*, *coast pelagic* and *coast bottom*. In these situations (unless ecosystem-specific data are available), the specificity is divided over several major ecosystems based on the extent to which the data for the indicators are affected by conditions in the different systems. The effect of this is that indicators that belong to several major ecosystems will be included in the basis for calculating the Nature Index for all of these systems. But their weight is then reduced in each of these metrics compared with indicators that have a 100% specificity to one system. In some cases, ecosystem-specific data is available for a species, and then separate indicators with 100% specificity can be used. The specificity weight of an indicator belonging to trophic group g is given by

$$(5) \qquad w_{ijk}^{specificity} = \frac{\varphi_{ij}}{\sum_{m \in g} \varphi_{mj}},$$

where the sum in the denominator is over all indicators within the trophic group observed in the geographical unit k. The same holds for key indicators that are treated as a separate group in this context.

Trophic weight, $w^{trophic\ group}$, is equal to $\frac{1}{2}$ of the key indicators and equal to $\frac{1}{2r_{jk}}$ for other indicators. r_{jk} is the number of functional groups represented by indicator observations in a geographical unit k. The consequences of these allocations are first, that the sum of the weights of the key indicators is $\frac{1}{2}$, so these count for 50% when calculating the Nature Index for a municipality. Second, the different trophic groups represented in the relevant geographical unit are counted equally, regardless of the number of indicators represented within each group (Certain et al. 2011).

5.4 Aggregated indices

Municipalities represent the basic geographical unit for the calculation of the Nature Index for the terrestrial major ecosystems and *freshwater*, and the index could in principle be calculated for individual municipalities. However, we do not yet have sufficient data to calculate the index with such a fine geographical resolution (Chapter 7). In practice, aggregated indices were calculated for five regions (north and central Norway, western, southern and eastern Norway) and the whole country was assembled as weighted averages of municipal index values:

$$(6) \qquad NI_{agg,jt} = \sum_{k \in agg} NI_{jkt} w_{jk}^{area},$$

where $w_{kj}^{area} = \frac{a_{jk}}{\sum_{m \in agg} a_{jm}}$, a_{jk} is the area that the major ecosystem j covers in municipality k and $\sum_{k \in agg} w_{jk}^{area} = 1$.

The same applies for the calculation of the Nature Index for pelagic and bottom ecosystems along the coast, while the Nature Index for the marine ecosystems is calculated for ocean areas (the Barents Sea, Norwegian Sea, North Sea and Skagerrak) individually or collectively.

5.5 Uncertainty in the indicator values

Indicator values may be associated with errors and are therefore uncertain. These uncertainties arise for many reasons, including: Because the values are based on measurements from a sample of possible localities; because of the possibility of measurement error; because the indicator values are generated from models where parameters are estimated with some uncertainty; because expert judgements are subject to uncertainties; etc. Thus, in the context of the Nature Index, the indicator values are specified as probability distributions where the dispersion of the distribution represents this uncertainty, and the central tendency of the distribution represents the size of the indicator value. Each index value is thus regarded as a stochastic variable. This presupposes that all input values used to calculate the index are provided with an estimate of how uncertain the values are. This estimate is provided by each expert in terms of the interquartile distance in the distribution, while the central tendency is given as an expected value.

Elicitation is the term for the process that generates probability distributions for uncertain quantities based on experts' knowledge and beliefs about them (Garthwaite et al. 2005). In the context of the Nature Index, this is a two-step process (Certain et al. 2011). For all indicator values, experts estimate the distribution's expected value and its lower and upper quartiles. Using this, a probability distribution is fitted from a number of model distributions for each indicator value. The fitting is based on a least squares criterion. All the indicators are non-negative variables. Hence, the model distributions are non-negative, univariate distributions. These are truncated normal, log-normal, Weibull, “zero-inflated” exponential and gamma distributions (Johnson et al. 1994). The relevant truncated normal distributions are left-truncated at zero. All model distributions thus have two parameters.

The reference values are also associated with uncertainties and treated in the same way.

5.6 Calculating the Nature Index

Since the Nature Index is calculated from indicator values that are considered stochastic variables, the index itself is also treated as a stochastic variable with an associated probability distribution. Parametric bootstrapping (Manly 2007) is used to simulate this distribution from the distributions of indicator values. An observation from the index’s distribution is generated by randomly drawing one observation from each of the the distributions of indicator values used in the calculation. The Nature Index value is then calculated based on this, using equations (1) – (6). The index’s distribution is simulated by repeating this procedure 1000 times, for example. Normally, the median of the simulated distribution is given as a point estimate for the Nature Index, while the 95% confidence interval given by the 2.5% and 97.5% quantiles of the distribution is used as a measure of uncertainty for the index value.

5.7 The sensitivity of the index to changes in reference values

The reference state, as defined in Chapter 2, represent only one of several conceivable alternative references. The definition is the result of discussions that have been ongoing for several years in the Nature Index expert group. The reference concept has also been criticized in the public debate surrounding the Nature Index (see Krange et al. 2013). It is therefore appropriate to examine the effect a systematic change in all reference values will have on the index values. There are also challenges related to methods, data, knowledge and concepts (Figari 2012) when deriving reference values for each indicator based on this reference concept (see Framstad & Storaunet 2014). Thus, there will be uncertainty related to the reference values.

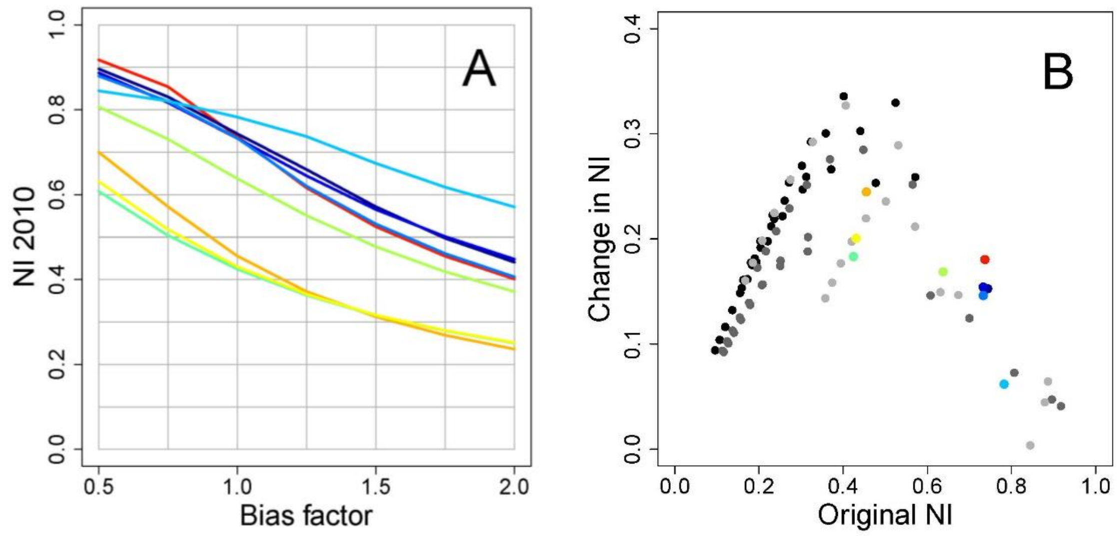

Figure 5.2. *Systematic errors in reference values.* ***a)*** *The Nature Index for Norway for 2010 calculated for 9 major ecosystems where all reference values are multiplied by the same factor (Bias factor): freshwater (red), mires and wetland (orange), open lowland (yellow), forest (green), mountain (light green). The four lines that range from dark to light blue represent ocean bottom, ocean pelagic, coast bottom and coast pelagic, respectively. The figure shows the NI 2010 when the bias factor ranges from 0.5 to 2, corresponding to a halving to a doubling of all reference values. The calculations are based on data from the Nature Index base as of 1 April 2014. Uncertainties in the indicator observations have not been accounted for in these calculations.* ***b)*** *The change in the Nature Index resulting from halving all reference values. Simulated and real (NI 2010, colours) data sets. Change in NI = NI after values were halved – NI before values were halved. The colour codes are as described in A. Black, grey and light grey dots represent data sets where the weighted coefficient of variation of the scaled indicator observations is less than 1, between 1 and 3 and over 3, respectively. The observations are scaled by dividing each observation by the associated reference value. The percentage of indicators that are scaled with the LOW model and the variation in the indicators' condition are similar to real data sets.*

Figure 5.2a shows the effect on the Nature Index of **systematic** changes in the reference values within each major ecosystem. All reference values have been multiplied by the same factor, and index values are calculated when this factor varies from 0.5 to 2, corresponding to a four-fold increase in all reference values from left to right in the figure. A halving of all reference values for *forest*, which is equivalent to a dramatic change in the reference concept, represents a change in the index value of 0.18, while the corresponding change for *coast pelagic* is 0.06. This suggests that the Nature Index is robust with respect to adjustments in the reference concept, and that these adjustments will not result in significantly different descriptions of the state of Norwegian nature than the Nature Index provides today.

Figure 5.2b shows the effect of halving all reference values based on data sets with properties similar to those underlying the calculation of the Nature Index. The simulations show that the effect of these systematic changes for this type of data set is greatest when the original index value is between 0.4 and 0.6, and when the variation in the scaled indicator values used in the calculation is small (Figure 5.2.B). The effect decreases with increasing variation in the indicator value and when the index values approach 1 or 0. These relationships are due to the properties of the LOW model, which is used for scaling most indicators (Chapter 5.2). In this model, the effect of reducing the reference values of the scaled indicator values is small or non-existent for the indicator values close to or greater than the reference value, and the effect decreases with decreasing indicator values less than the reference value. The percentage of observations in the data set that are slightly or are not affected by changes in the reference values will increase with increasing variation in the indicators' states, and when the average state approaches zero or the reference state.

The effect of **random** errors in the reference values on uncertainty in the Nature Index values are presented in Figure 5.3 (see also Pedersen & Skarpaas 2012). The effect depends on how many pairs of indicator observations and reference values are included in the calculation of the Nature Index (Ex: ocean bottom, 59 observations; *forest*, 627 observations) and how they are weighted, and how uncertain the reference states are (Figure 5.3). The Nature Index is generally robust to errors in the reference values. For the data sets that were used for the Nature Index for Norway, the standard deviation of the index error distribution was for the most part less than 1/10 of the reference value’s coefficient of variation (Figure 5.3).

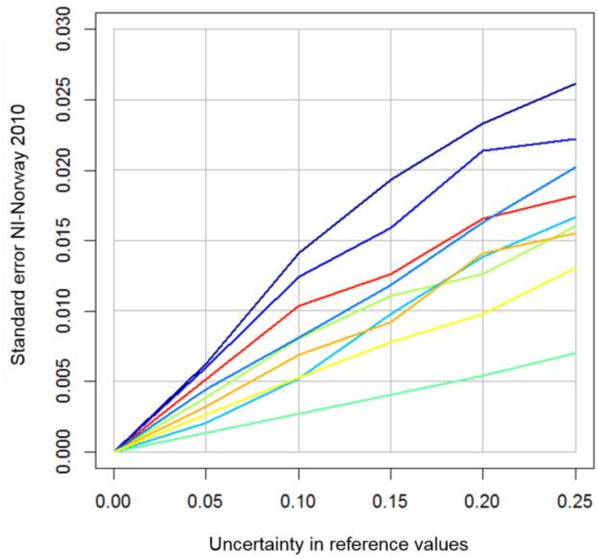

Figure 5.3. *Random errors in reference values. A simulation of standard errors of the estimates for the Nature Index for Norway for 2010 was calculated for 9 major ecosystems. The colour codes are as in Figure 5.2. Standard errors are presented as a function of the uncertainty (coefficient of variation in the distribution) in the reference values. Estimates of the Nature Index’s standard error are based on 200 simulations of the Nature Index for each combination of uncertainty (with corresponding variation coefficients of 0.05, 0.1, 0.15, 0.20 and 0.25 respectively) and ecosystem. In each simulation, the reference values are multiplied by random observations from a normal distribution with an expected value of 1 and a standard deviation equal to the relevant coefficient of variation. The calculations are based on data from the Nature Index base as of 1 April 2014. The uncertainty in the indicator observations has not been accounted for.*

5.8 The sensitivity of the Nature Index to a general change in the state of biodiversity.

The Nature Index's sensitivity with respect to general changes in the state of biodiversity has also been studied by Pedersen and Skarpaas (2012). They studied data sets where all indicator observations were identical, had the same uncertainty, were scaled with the same model and all changed the same amount. They compared the sensitivity with data sets without uncertainty indicator observations. For these data sets, they found that uncertain indicator values reduced the sensitivity in the Nature Index with respect to general changes in the state when the indicators' expected values approached the reference value and when the uncertainty in the data increased. As values come close to the reference value, the sensitivity under the LOW and MAX models is roughly half as large with uncertainty in the data as in data without uncertainty. The reason for this is that the Nature Index's median (Chapter 5.6) is dependent on the uncertainty in the data. For a more detailed description of this phenomenon and its causes, see Pedersen and Skarpaas (2012). This effect was called location displacement and can be calculated for each data set (Figure 5.4a).

The real data sets that underlie the calculation of Nature Index for Norway, however, differ from those studied by Pedersen and Skarpaas (2012). The indicators' states vary between indicators and areas, and the same applies to the uncertainty in the observations. For these data sets, the location displacements are small (Figure 5.4.A) and therefore in most cases have a negligible effect on the sensitivity of the Nature Index. For such data sets, the sensitivity is primarily dependent on the weighted proportion of observations that show a better state than the reference values (Figure 5.4.B).

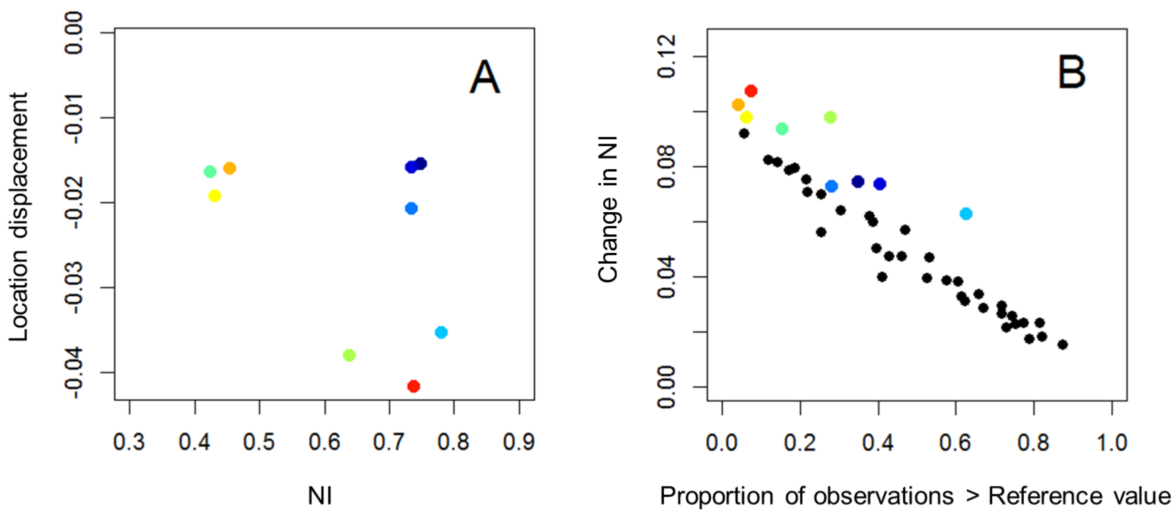

Figure 5.4 a) *Location displacement (cf. Equation 28a in Pedersen and Skarpaas 2012) in Nature Index values for 2010 for 9 major ecosystems. Note the scaling of the second axis.* ***b)*** *Changes in the Nature Index as a result of a general increase in all indicator observations equivalent to 0.1*the reference value for real and simulated data sets. Simulated data sets are constructed by adding a constant value to all observations from one of the real Nature Index data sets. Colour codes as in Figure 5.2b.*

6 Nature Index data sources

Signe Nybø[1], Hege Gundersen[2], Kristian Hassel[3], Knut Anders Hovstad[4], Line Johansen[4], Ken Olaf Storaunet[5], Gro I. van der Meeren[6]

[1]Norwegian Institute for Nature Research, [2]Norwegian Institute for Water Research, [3]NTNU University Museum, [4]Norwegian Institute for Agricultural and Environmental Research, [5]Norwegian Forest and Landscape Institute, [6]Institute of Marine Research

Many different data sources contribute to the knowledge base for the Nature Index. The data for each indicator are presented on the Nature Index's web portal (www.naturindeks.no), including both a textual description of how data and reference values are determined, along with a link to key publications related to this assessment. The percentages of an indicator's values that are made up of expert assessment, models and monitoring data are presented in Appendix 1 under the headings E/M/O respectively. The Nature Index as of 2015 includes a total of 301 indicators (Appendix 1). Chapter 7 provides an overall analysis of the Nature Index data.

This chapter provides a brief description of the main sources for the Nature Index's data, i.e., important monitoring programmes and projects at the individual research institutions that provide data. In addition, data from the Species Map Service have been used to model population changes for some species, especially vascular plants, see below. The Species Map Service assembles observation data for species from museums and scientific institutions with its own web portal (artskart.artsdatabanken.no) linked to the Norwegian Biodiversity Information Centre. Although the main sources of knowledge about species and indirect indicators are included in the Nature Index's data, we see that there may be untapped data sets both among the institutions involved and elsewhere. In the future, additional information can be obtained by compiling and modelling changes in indicators based on existing, untapped data. In addition, many of the established indicators risk being dropped from the Nature Index in the future because new data are not collected. New monitoring, particularly monitoring that is spatially representative is desirable to obtain better knowledge of the general development in biodiversity. In terrestrial as well as marine ecosystems, there is a lack of systematic survey and monitoring of changes in the area of habitats and major ecosystems. This means that the Nature Index cannot report areal changes in ecosystems. Monitoring of biodiversity, where long time series are collected, is also required to assess nature's capacity to deliver a number of important natural resources/ecosystem services.

6.1 Norwegian Institute of Bioeconomy Research (NIBIO) (formerly Norwegian Institute for Agricultural and Environmental Research)

The Norwegian Institute for Agricultural and Environmental Research, now part of Norwegian Institute of Bioeconomy Research (NIBIO), is responsible for two indicators in *open lowland*: "Semi-natural grassland state" and "Coastal heathland state". Both indicators are categorized as key indicators.

Indicator values are set through expert assessments since there are no spatially representative monitoring data for the habitats in question. An expert group was established for each indicator and the experts were responsible for setting indicator values for a geographic area. The expert groups developed a common understanding of the reference state, which was discussed and coordinated with respect to determining indicator values across geographical areas. The indicator values are at the municipal level. The indicators of state are assessed on the basis of various relevant data at national and regional levels as well as the experience and knowledge of experts and other resource persons. Some examples of data sources include the Norwegian Environment Agency's "Naturbase", management plans, various surveys of habitats that were not in the Naturbase and statistics from the action plans for selected habitats. Expert assessments are emphasized when data are inadequate. There is an urgent need for better data on *open lowland*. The Norwegian Institute for Agricultural and Environmental Research has developed data on successional shifts (encroachment by trees and bushes) in coastal heathland areas based on remote sensing that can be included as an important basis for future versions of the Nature Index.

Indicator values were determined following the same template as the initial version of the Nature Index for 2010. Indicator values (0-1) were set based on the proportion of intact areas of semi-natural grassland or coastal heathland. Intact in this context means that the species composition has not been changed because of succession or fertilization. Semi-natural grassland includes semi-natural meadows below treeline and is an umbrella term for several habitats as defined in NiN 2.0 (semi-natural wet meadows, semi-natural meadow, beach meadows) or DN handbook 13 (hayfields, natural pastures, beach meadows, beach marsh). Coastal heathland is defined as in NiN 2.0.

6.2 Institute of Marine Research (IMR)

The Institute of Marine Research reports on 67 indicators for the Nature Index, for the major ecosystems *ocean bottom*, *ocean pelagic*, *coast bottom*, and *coast pelagic*. Several of these indicators are found in more than one ecosystem.

In essence, IMR is responsible for collecting the underlying data for these indicators through its own research cruises and fieldwork, international cooperation including five expert working groups at the International Council for the Exploration of the Sea (ICES), regional monitoring programmes, cooperation with the fishing fleet (catch diaries for crustaceans, plus IMR's ocean reference fleet and coastal reference fleet) and partially through regional and species-specific projects. A large percentage of the data is archived and publicly available at the Norwegian Marine Data Centre as well as at ICES and the Institute of Marine Research itself. Gjertsen (2015) provides an overview of the kinds of research cruises that the data are taken from and the data coverage. The indicators, which are also included in the Norwegian Management Plans for the Marine Environment, are also available under the "Marine and Coastal Waters" tab on the portal environment.no and Barentsportalen.no.

Marine monitoring of pelagic species is undertaken in many ways. Whales and seals are monitored every 5-6 years; counts of population numbers are conducted from aircraft, and from ships at seal breeding grounds on the ice. Pelagic species are monitored to a large extent through international cruises in partnerships with other countries, with Russia in the Barents Sea and with EU countries in the Norwegian Sea and the North Sea / Skagerrak. The research cruises measure fish numbers collected via pelagic trawls and with acoustic methods in which the amount and size of the fish are measured directly in the ocean. ICES calculates population sizes, based on models that are critically reviewed on a regular basis, and if necessary revised as new knowledge warrants. Pelagic species are also evaluated based on the collection of the annual ecosystem cruises in the Barents Sea and the Norwegian Sea and by the ocean reference fleet. Zooplankton are also monitored four times a year through transect surveys.

Marine monitoring of benthic species is conducted via seasonal cruises with bottom trawls in the Barents Sea, the North Sea and Skagerrak. In addition, both bottom trawling and the collection of bottom creatures using scrape and grab sampling have been an important part of the ecosystem survey in the Barents Sea. Mareano, the national surveying programme for benthic species in the Barents Sea, has provided much regional information but is not part of a regular monitoring programme. Individual cruises and the coastal reference fleet also provides the basis for assessment of non-commercial species. The development of stocks of the commercial benthic species is based on population estimates from ICES.

Coastal water monitoring of pelagic species, such as coastal populations of seals, is conducted nationally and regionally with counts roughly every five years at moulting areas when the seals come to shore and replace their fur. Fish stocks are assessed from data from the coastal reference fleet and the annual coastal cruises north of 62 degrees of latitude and from fixed plankton stations, but otherwise only regionally for some indicators. The Flødevigen Research Station provides jellyfish data through its jellyfish counts.

Coastal water monitoring of bottom species is based partly on coastal cruises north of 62 degrees of latitude and on data from the annual beach seine survey, which has been conducted for more than 50 years from Vest Agder to the Swedish border. For lobsters and crabs, the NI indicator relies on catch diaries, while the shellfish indicator is based on experts' field observations.

6.3 Norwegian Institute for Nature Research (NINA)

NINA reports on 180 Nature Index indicators. These comprise 24 in the *mountain* ecosystem, 66 in *forest*, 22 in *freshwater*, 27 in *mires and wetland*, 20 in *open lowland*, 6 in *ocean pelagic*, 3 in *coast bottom* and 12 in *coast pelagic*. Several of the indicators are found in several major ecosystems, but above each indicator is counted only once. The company “Biolog J.B. Jordal AS” has provided a significant contribution for two mushroom indicators in *open lowland*.

NINA is responsible for a variety of monitoring programmes that form the basis for reporting to the Nature Index. All of these monitoring programmes are funded by the Norwegian Environment Agency and several comprise somewhat long time series. Two important programmes monitor terrestrial passerine birds (TOV-E) and butterflies and bumblebees in selected counties. This monitoring is areally representative and is undertaken on a variety of LUCAS routes – a grid network defined by Statistics Norway and the Norwegian Forest and Landscape Institute.

Hunting statistics, the game bird portal (honsefugl.nina.no) and wild deer monitoring provide the basis for assessments of game species stocks. Data from the Programme for Terrestrial Monitoring (TOV) and/or from the Species Map Service were used for terrestrial vascular plants, lichens and moss. Evaluations of fungi and insects other than bumblebees and butterflies are mainly based on individual surveys and action plans where the population trends of these species have been considered. These indicators are particularly at risk being dropped from the Nature Index’s indicator sets because of the lack of new data. Rodent populations are also recorded in TOV, and data from TOV and other time series about rodents are assembled through this programme. Predator monitoring and the monitoring programme for mountain foxes provide a comprehensive basis for evaluations of predator populations. Assessments of otter populations build on modelling based on data collected on trapped animals, the Species Map Service and the wild deer portal. The assessment of amphibian populations is based on monitoring, observations and models. A specific monitoring programme for palsa bogs has also been established.

The assessment of *freshwater* indicators is based on surveys that are essentially funded by the Norwegian Environment Agency. Information about brown trout is based on interview surveys. For most other indicators, data are obtained through national monitoring programmes. This includes population monitoring (wild salmon, noble crayfish and freshwater pearl mussel) and ecosystem monitoring related to Norway's obligations with respect to the Water Framework Directive and the Long Range Transport Convention. For zooplankton and benthic fauna, data have been taken from other monitoring/inventories conducted by NINA and data collected from various publications. Expert assessments and/or modelling, in combination with monitoring data and other systematic information, are used in the assessment of most *freshwater* indicators.

On the marine side, NINA contributes data about seabirds via the monitoring programme called SEAPOP. This monitoring is partially funded by the Ministry for Petroleum and Energy and the Norwegian Oil and Gas Industry Association with additional funding from environmental management authorities.

6.4 Norwegian Institute for Water Research (NIVA)

NIVA reports on 18 Nature Index indicators. Six are in *freshwater*, 1 is in *ocean bottom*, 10 are in *coast bottom* and 1 is in *coast pelagic*.

All of the NIVA *freshwater* indices, except dwarf spike rush (which is based on occasional sightings from various local studies), are taken from surveillance monitoring for the Water Framework Directive. Several of the marine indicators (three indicators for soft-bottom communities, as well as two indicators for hard-bottom vegetation) are also partly based on collections for the Water Framework Directive, but are also supplemented with corresponding data from various projects under NIVA's auspices. The blue mussel indicator relies on data from CEMP monitoring of pollutants in sea areas under the North Atlantic OSPAR program in Norway, which is carried out by the Norwegian Environment Agency. Data on common ditch shrimp are taken from the Species Map Service, after systematic surveys in 1997-2002 and in 2010-2011. Information on kelp and Devil’s apron are based respectively on a coastal monitoring programme (initially KYO, later ØKOKYST) operated by the Norwegian Environment Agency (formerly DN) as well as sugar kelp monitoring and various other NIVA projects. In the north, the kelp indicator and the sand shell indicator are based solely on expert assessments. Data on phytoplankton (Chlorophyll a) are measured continuously by NIVA’s Ferrybox system on the Hurtigruten and other ships that routinely travel along the Norwegian coast.

6.5 NTNU University Museum

The NTNU University Museum reports on 23 Nature Index indicators, of which all are for mosses. Five of these are in the *mountain* ecosystem, 6 in *forest*, 4 *freshwater*, 4 in *mires and wetland* and 4 in *open lowland*.

Mosses are an important part of the vegetation in northern and alpine areas. In Norway, the dominance of mosses is particularly evident in the *mires and wetland* and *mountain* ecosystems. Most mosses contained in the Nature Index are evaluated by expert assessment, with the data basis for these assessments found in the Norwegian Biodiversity Information Centre’s Species Map Service, the University Museum’s scientific collections and relevant literature. Populations of seven of the species are currently being monitored to improve our knowledge for the Nature Index assessments. Five of these species are associated with the *mountain* ecosystem, while one is associated with the *mires and wetland* ecosystem, and the last is associated with the *freshwater* ecosystem.

6.6 Norwegian Institute of Bioeconomy Research (NIBIO) (formerly Norwegian Forest and Landscape Institute)

The Norwegian Forest and Landscape Institute, now part of Norwegian Institute of Bioeconomy Research (NIBIO), reports on 11 *forest* indicators, 5 of which are categorized as key indicators.

The National Forest Inventory by the Norwegian Forests and Landscape Institute is a selective survey of land, resources, and environment data to document the extent of forest resources and environmental components of the forest and how they are developing over time. Previously, the focus of attention was mainly on the forest as a supplier of raw material, while in recent years the focus has also broadened to include monitoring and documenting of environmental conditions such as dead wood (2 indicators), MiS (Environmental Investigations in Forests) habitats (5 indicators), and blueberry coverage (1 indicator). Data from the Programme for Terrestrial Monitoring (TOV) are also used for vascular plants (3 indicators).

7 The data used for the Nature Index

Bård Pedersen
Norwegian Institute for Nature Research

7.1 Indicators

The data behind the Nature Index for Norway comprises 301 different indicators divided into nine major ecosystems as described in Chapter 3. Appendix 1 lists all indicators for each major ecosystem. Some of the indicators characterize two or more systems.

The set of indicators has been revised since the launch of the Nature Index for Norway in 2010. This is especially true for bird indicators and indicators for the marine major ecosystems. The number of indirect indicators (Chapter 2.2) has been reduced. The data for many indicators have also been revised since 2010. The revisions are based on better data series, better models for model-based observations, and/or better information for expert assessments. These revisions also include data from 2010 and earlier. This means that the Nature Index is recalculated for all years whenever the data and/or indicator set changes. This makes the calculations for different years comparable.

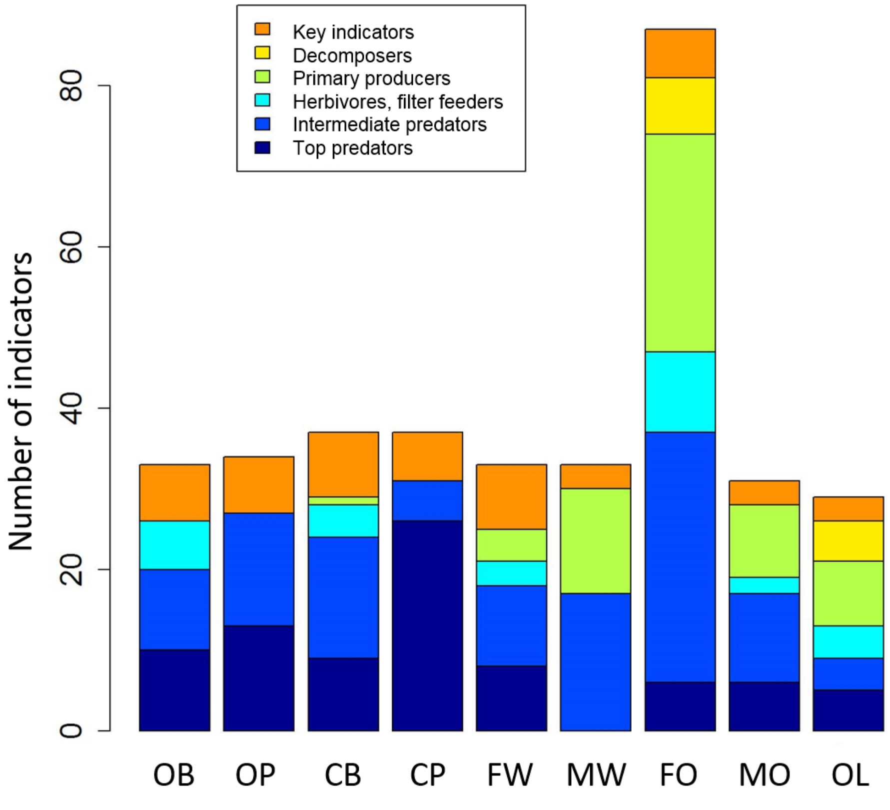

Figure 7.1. *Number of indicators per major ecosystem and trophic group. OB = ocean bottom, OP = ocean pelagic, CB = coast bottom, CP = coast pelagic, FW = freshwater, MW = mires and wetland, FO = forest, MO = mountain, OL = open lowland. The key indicators are depicted as a separate group in the figure. The trophic groups thus only cover indicators that are not key indicators.*

Apart from *forest*, which is represented by 87 indicators, the state of the different major ecosystems is described by between 29 and 37 indicators (Figure 7.1). Top and intermediate predators dominate the indicators for the marine major ecosystems, while the share of primary producers is greater for terrestrial major ecosystems. Figure 7.1 suggests that herbivores and decomposers are especially poorly represented in the data. The same also applies to primary producers in marine systems. However, these groups are represented among key indicators, partly in the form of indices that summarize information about many species, or in the form of surrogates, such as the "dead wood" indicators for *forest* (Appendix 1). These are therefore given extra weight when the Nature Index is calculated (see Chapter 5). Nevertheless, the distribution of indicators over functional groups can be described as biased

This bias is also reflected in the distribution of the indicators over taxonomic groups. Fifty-four per cent of the indicators are vertebrates. Birds alone amount to 33%. At the same time, other groups of organisms in comparison are underrepresented.

The number of key indicators in the major ecosystems varies, with 3 each in *mires and wetland*, *mountains* and *open lowland*, to 8 in *coast bottom* and *freshwater* (Figure 7.1).

The Nature Index's weighting system (Chapter 5) seeks to correct the bias in the data caused by unequal representation of the trophic groups when the index is calculated. The weighting system also corrects for taxonomic bias to some extent, because many indicators within the same taxonomic group also belong to the same trophic group.

7.2 Data types

The data used in the Nature Index include monitoring data, model-based estimates of state and estimates based on expert assessments. Expert assessments are subjective assessments based on data and information that have not been collected according a comprehensive design or in a systematic manner, unlike a monitoring programme. These data come from different types of surveys, environmental impact assessments, smaller monitoring projects and the like. These are combined with other information and knowledge, such as knowledge about the development of important pressure factors and the expert’s own notes and experiences from the field, into an evaluation of the indicator’s state.

Expert assessments are not as repeatable as estimates of state based on statistical and/or dynamic models that can be tested. The data for these models may vary from systematically collected monitoring data to data that have been collected unsystematically on occasion, such as the Species Map Service (e.g. Skarpaas et al. 2014). Many different modelling strategies are used in conjunction with the data for the Nature Index, from simple interpolation to advanced population models.

The three categories of information sources are all heterogeneous with respect to data quality and precision, however. For example, an expert assessment based on a large amount of data that has been unsystematically collected in an area may provide a more precise estimate of an indicator’s state than a designed monitoring programme with a low density of observation points in the same area. Moreover, categories overlap and the category to which an indicator observation belongs is not always obvious. The data for many indicators consist of two or all data types (Appendix 1). Expert assessments and model-based estimates are often necessary to complement data series from monitoring programmes. In general, observations from designed monitoring programmes and population estimates from models based on monitoring data can be considered to be more reliable than expert assessments.

Expert assessments constitute 46% of the total data used to calculate the Nature Index for Norway, while model-based estimates constitute 19% and monitoring data constitute 35%. However, there is considerable variation between the major ecosystems. Monitoring data and model-based estimates together constitute almost 80% of the data for the pelagic systems, while for *ocean bottom*, *freshwater*, *mires and wetland*, *mountain* and *open lowland*, expert assessments constitute more than 50% of the data (Figure 7.2).

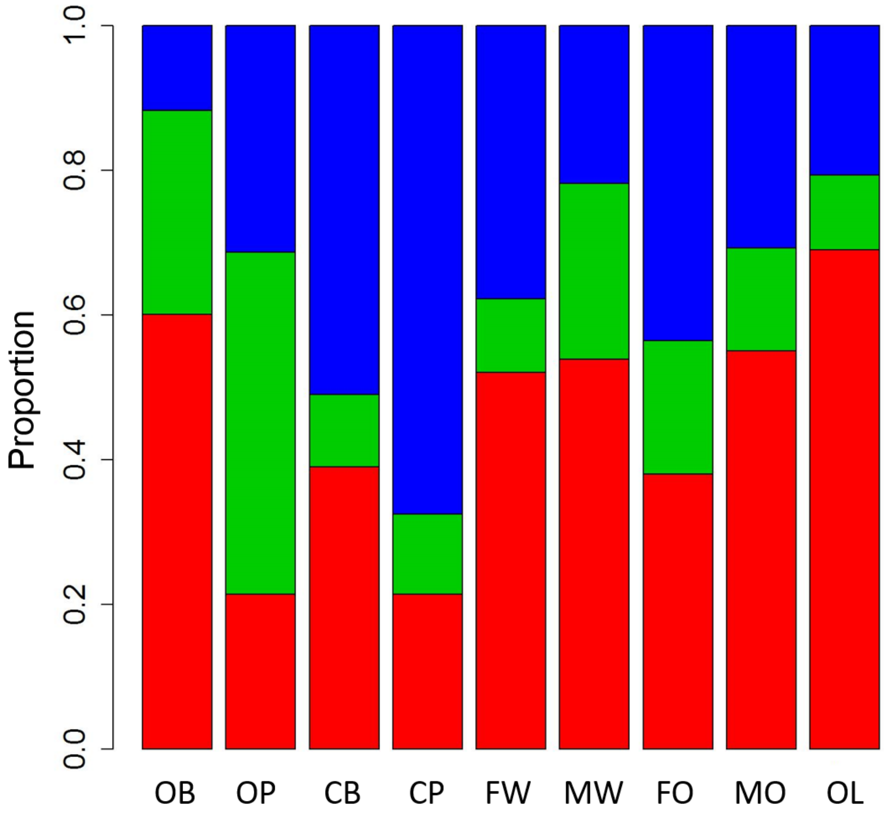

Figure 7.2 *The proportion of data that is monitoring data (blue), model-based estimates (green) and based on expert assessments (red) for each of the major ecosystems OB = ocean bottom, OP = ocean pelagic, CB = coast bottom, CP = coast pelagic, FW = freshwater, MW = mires and wetland, FO = forest, MO = mountain, OL = open lowland. In the figure, each indicator is counts equally regardless of the indicator's geographical coverage and the data's geographical resolution.*

7.3 Geographical coverage and resolution

We calculated a coverage ratio as the proportion of all municipalities (with occurrence of the relevant major ecosystem) where an indicator is documented with data. The coverage ratio for indicators is 0.54 on average, but the ratio varies widely between major ecosystems. While the average coverage ratio for both *forest* and *mountain* indicators is 0.69, the coverage for *coast pelagic* indicators is as low as 0.25 on average.

The geographical distribution of the indicators is shown in Figure 7.3. With the exception of municipalities with breeding colonies of several species of seabirds, there are only a few indicators in each municipality to document the state of pelagic ecosystems. Fjord ecosystems in particular are poorly documented in the Nature Index's data. This also applies to the bottom systems in the fjords and the *coast bottom* from Vesterålen northward. The number of indicators with data is also low for *open lowland* except for coastal areas from Lindesnes to Lofoten, for *ocean bottom* in the Norwegian Sea, the North Sea and Skagerrak, and *mires and wetland* in northern parts of Western Norway.

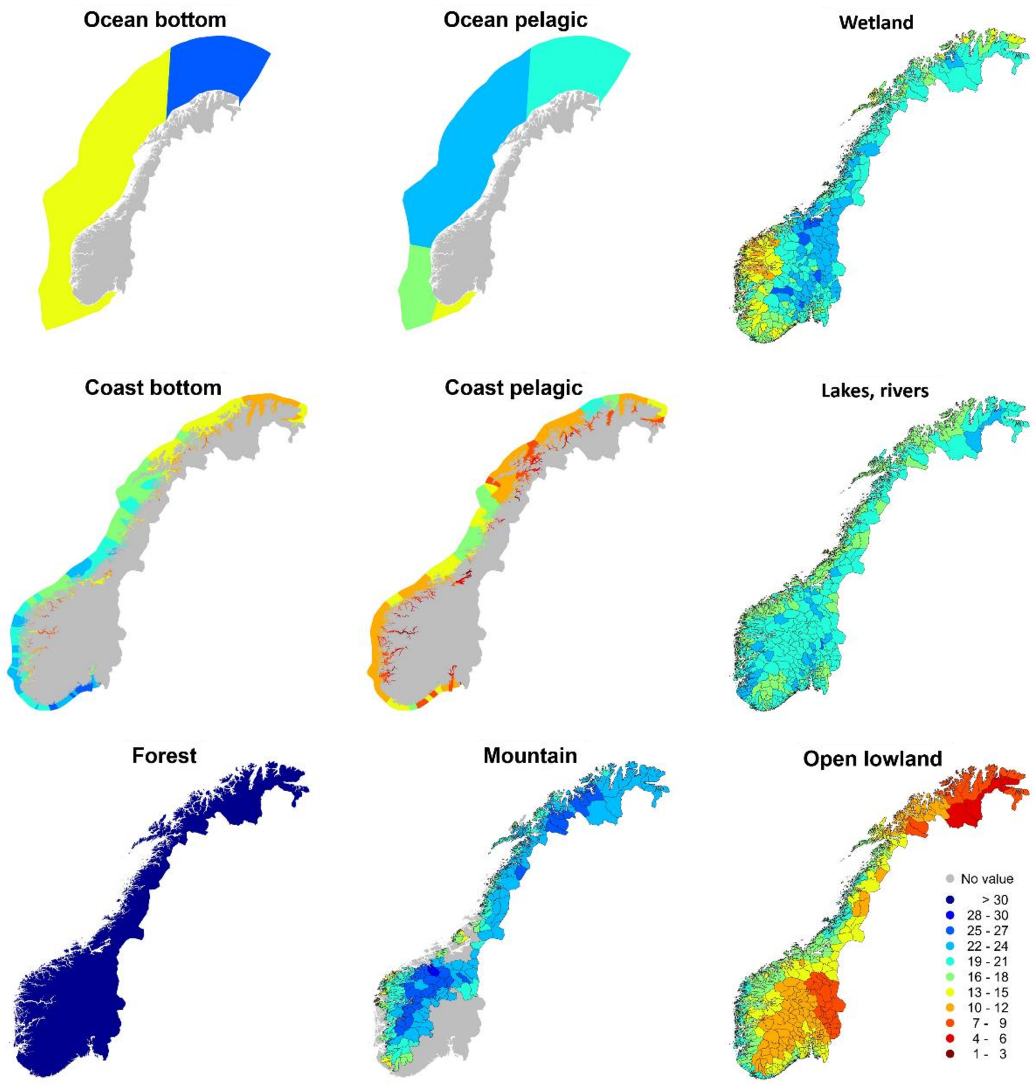

Figure 7.3. *Number of indicators per municipality or per ocean area (ocean bottom and ocean pelagic) for each of the nine major ecosystems.*

The data for the Nature Index generally have low geographic resolution. For 72% of the indicators, data are given by county or with an equivalent or lower resolution (Figure 7.4, Appendix 1). Indicators with model-based values generally have a higher resolution than indicators based on expert assessments and indicators based on monitoring data (Figure 7.5.A). For this last type of indicator, there is a negative relationship between geographic resolution and coverage (which corresponds to a positive correlation between the area size and area coverage as shown in Figure 7.5 B), meaning that the indicators that cover a large part of the country have low resolution, while the high-resolution indicators only cover a small part of the country. The likely reason for this is that monitoring is resource-intensive and costly, so that during planning, coverage must be weighed against the density of observation points. TOV-E (terrestrial birds) (Kålås & Husby 2011) and MiS (Environmental Investigations in Forests), which rely on National Forest Inventory plots (Fencing & Baumann, 2002), are both examples of data for the Nature Index that are based on nationwide monitoring programmes which basically have relatively many observation points.

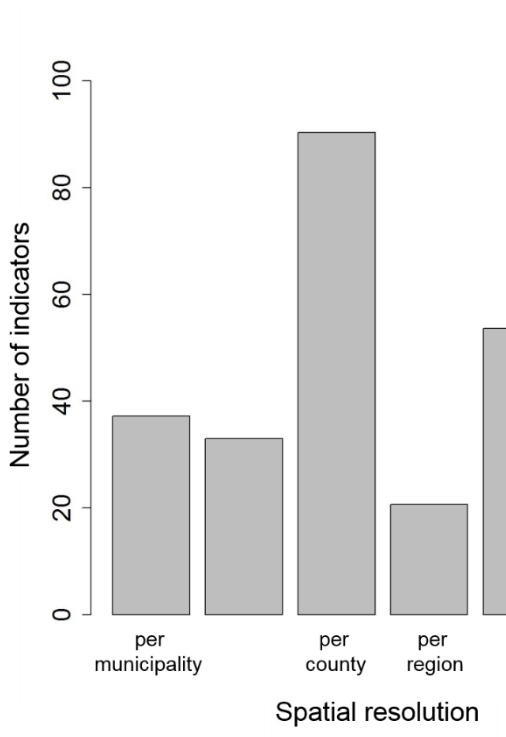

Figure 7.4. *The geographical resolution of indicators. The geographical resolution for each indicator is measured as the average number of municipalities per area. The figure shows the distribution of the indicators over classes that represent different spatial resolutions in their data. The resolution decreases from left to right along the first axis. Municipality = indicators with municipality-level resolution. Region = indicators with county-level or equivalent resolution. Regional = indicators with regional resolution or the equivalent (Northern Norway, Central Norway, Western Norway, Southern Norway, Eastern Norway). The indicators for oceans are not included in the figure. The two columns without names represent indicators with a resolution between the municipality level and county-level specification of values, and indicators with a resolution between regional values and a value for the whole country, respectively. The calculation of the indicators' distribution over these groups has taken into account that a county-level resolution for the coast bottom, coast pelagic and mountain major ecosystems, for example, corresponds to a lower number of municipalities per county than for the other major ecosystems.*

In both cases, however, data are reported to the Nature Index database at a coarse geographic scale to achieve sufficient precision in the indicator values. Programmes that have a high coverage ratio combined with a sufficiently high density of observation points to allow a detailed spatial (in terms of municipality) description of indicator states are not found in the data for the Nature Index. A similar negative correlation is also found between coverage and geographical resolution for indicators based on expert assessment (not shown). This most likely reflects the same balance between high coverage and high density of observation points. The low resolution of some data means that it is more natural to describe some indicators, such as for large carnivores and pelagic fish stocks, based on larger geographical units than single municipalities.

Several model-based indicators have both high resolution and high coverage. This results when an indicator state is modelled as a function of predictors with high spatial resolution (e.g. Van Dijk & May 2012), through interpolation and/or by starting with data that have a high geographic resolution, but that have not been collected in accordance with a formal monitoring design (e.g. Skarpaas et al. 2014).

Uneven geographical coverage of indicators (Figure 7.3) and consistently low spatial precision in the data (Figure 7.4) mean that Nature Indices calculated for each municipality based on these data are not informative and are not suited to comparing the state of biodiversity in the different municipalities. It is recommended that the Nature Index not be calculated using a geographical resolution finer than a region. For some major ecosystems, it should be considered whether there is a sufficient basis to calculate a Nature Index for all regions.

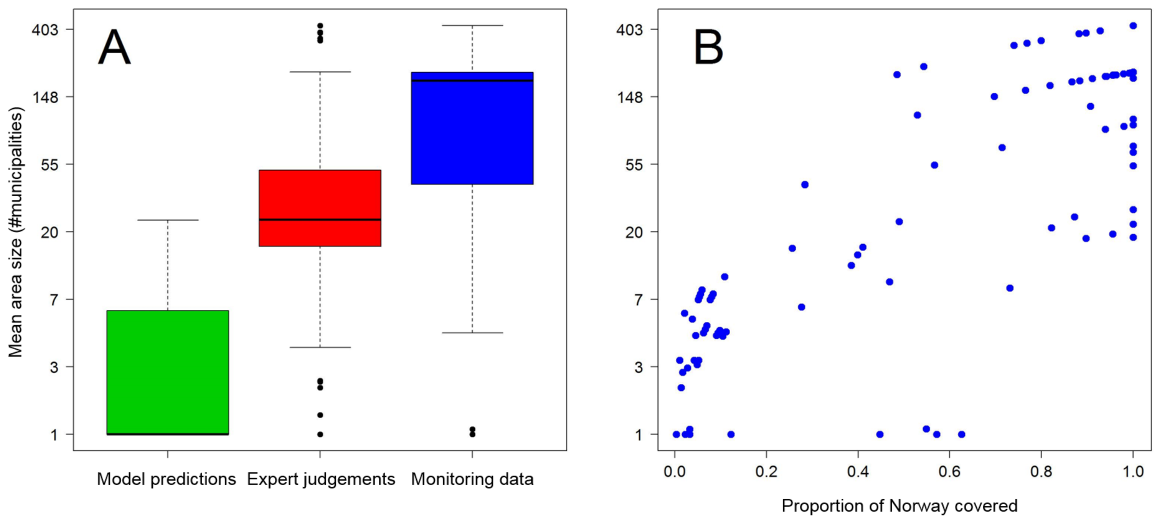

Figure 7.5. a) *Distribution of indicators with respect to their geographical resolution. Note that the y-axis represents the area size, i.e. the geographic resolution decreases upward along the axis. Note also that the y-axis is log scale. The indicators are grouped by the type of data that make up the majority of their observations. The figure includes indicators for the freshwater, mountain, forest, mires and wetland and open lowland major ecosystems. Thirty-six indicators were calculated from models, 90 were based on expert assessments and 81 were based primarily on monitoring data. The boxes represent interquartile distances in the three distributions, while the thick, horizontal lines across boxes are the medians for each distribution. Solid circles represent divergent observations that are at least 1.5 times the interquartile distance from the nearest quartile.* ***b)*** *Correlation between coverage and geographic resolution for indicators that are all primarily based on monitoring data. The y-axis is scaled as in Figure 7.5.A. The figure includes indicators from all major ecosystems except ocean bottom and ocean pelagic.*

7.4 Discussion – precision and representativeness

The Nature Index should be seen as a summary of what we know today about the state of nature in Norway. The database represent an extremely comprehensive compilation of this knowledge. At the same time, as is shown by the description above of the indicator set (Section 7.2), the criteria for a balanced range of indicators as described in Chapter 2.2 are in practice not met. The standard procedure for publishing various indices is a review and assessment of uncertainty and different types of sources of error (cf. overview of indices at Statistics Norway). It is thus natural to ask two questions when examining the data for the Nature Index. The first is whether the indicators included in the calculation of the Nature Index constitute a biased sample with respect to the state of biodiversity. The second is whether the chosen indicators are sufficient to give accurate summaries of the state of biodiversity in the form of index values.

Both questions revolve around so-called sampling error, i.e. how uncertain the results are due to relying on a sample of indicators rather than the entire population of indicator states in Norwegian nature. (Sampling error is a different source of uncertainty in nature index values, in addition to the possibilities for measurement error discussed in Chapter 5.5. Measurement error is addressed when the Nature Index is calculated, as explained in Chapters 5.5 and 5.6.) To quantify the magnitude of the uncertainty caused by sampling error, one must rely on a model of how indicators are chosen for the sample. The most common model that provides the basis for this kind of quantification is that the sampling happens randomly. However, for this data, we do not yet have the kind of control of and oversight over how the information is collected to provide this kind of quantification. In reality, the indicator sample for the Nature Index is determined largely by what data are available, which in turn is largely determined by the information needs identified by management authorities. The data are originally usually not collected with the intention to calculate a nature index, and the indicators have not been chosen at random with such a purpose in mind. This makes it impossible to provide satisfactory or absolute answers to the two questions related to sampling error. However, this is not a situation that is unique to the Nature Index. The quantification of the uncertainty caused when a calculation is based on a sample of measurements is correspondingly problematic and therefore not considered in many other government statistics and indices that are currently used as the basis for management and political decisions (e.g. Statistics Norway 2006, 2015). Thus, the purpose of this chapter is not to come to any conclusions with respect to these questions. Rather, the aim is to present and discuss information that is nevertheless relevant and sheds light on issues related to sampling error, and that provides further insights into the properties of the data used for the Nature Index.

The indicators are measured using non-negative scales. The Log normal distribution is therefore a natural model for comparison when characterizing the distribution of selected indicators. This corresponds to comparing log-transformed indicators with a normal distribution. Figure 7.6 shows the distribution of the indicators' log-transformed average values where the averages are calculated for indicator values that have been scaled against their respective reference values. The distribution is negatively skewed. Compared to a normal distribution, indicators in a very poor state and indicators in a very good state are both overrepresented in the Nature Index's data. The same also applies to indicators around the distribution's centre. Many plausible explanations can be offered to explain why these deviations from a normal distribution are found in the data for the Nature Index. For example, the negative skewness could be caused if a group of indicators, such as those from one of the major ecosystems, is in a worse state than the others. Alternatively, the skewness may occur because indicators that are affected by anthropogenic pressures are more likely to respond in a negative rather than a positive way. A third possibility is that the scientific community and land and resource managers have a greater focus on those indicators whose states deviate negatively from the average than those that deviate positively. Of these three, only the last means that the indicator set is biased compared to the real state of biodiversity.

Monitoring and model-based indicators are overrepresented in the distribution's tails, while indicators based on expert assessments are overrepresented close to the distribution's centre (Fig. 7.6). In other words, the sample of indicators based on expert assessments is no more biased than monitoring and model-based indicators.

There is large variation in the mean values for the scaled indicators. There is also large variation within most major ecosystems. The standard deviation of the distribution of the indicators' mean value (not log-transformed) is as high as 0.91 or larger for the *ocean pelagic*, *forest*, *coast bottom* and *coast pelagic* major ecosystems, 0.69 for *open lowland* and between 0.22 (*freshwater*) and 0.39 (*ocean bottom*) for the remaining major ecosystems. In comparison, the Nature Index is calculated on a scale from 0 to 1. The greater the variation, the less the mean for these states will be representative of the individual indicator's state. So even if there is variation in the calculated Nature Index among the different major ecosystems, there are both indicators that are in good to very good condition, and indicators that are in poor to very poor condition *within* each individual major ecosystem. The ability to describe this variation is of value in itself, and provides a central insight into the state of nature in Norway as well as an important premise for its management.

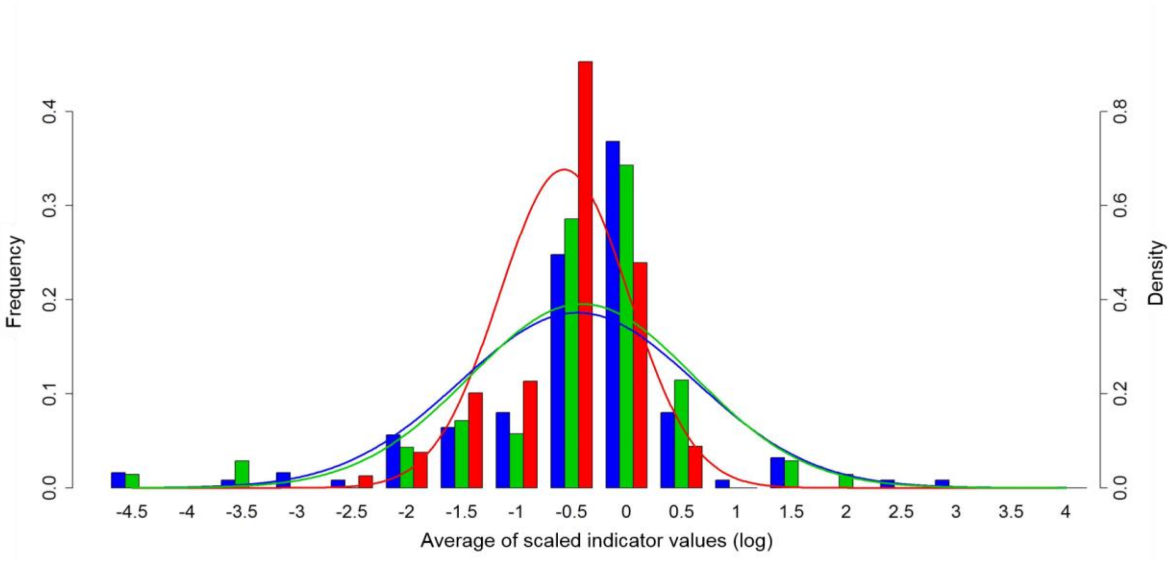

Figure 7.6. *The distribution of the indicators' mean values. Means are calculated from the indicator values that have been re-scaled to a common scale by using the inverse of the associated reference values as scaling factors. The mean values are then log-transformed. The figure shows the distributions of indicators grouped based on the type of data that is dominant in the data: monitoring data (blue), model-based estimates (green) and expert assessments (red). The distribution of indicators based on expert assessments differs from the other two types by having a smaller spread (sd = 0.59 for expert assessments and 1.02 and 1.07 respectively for model-based and monitoring-based indicators) and it is less peaked than the other two (Pearson kurtosis of 4.10, 7.52 and 6.72 respectively). All of the indicator types' distributions have a negative skewness. The coloured lines are the probability densities for normal distributions with the same means and standard deviations as the distributions for the indicator types. The distribution for all the indicators together (not shown) has an average of -0.49 standard deviation equal to 0.88, skewness and -1.02 and kurtosis equal to 8.11. All values refer to the distributions of the log-transformed means.*

The amount of uncertainty in the calculation of the Nature Index with respect to sampling error will depend on how large the dispersion in (the scaled) indicator states is, and how many values are included in the calculation. A measure that can be used with this kind of uncertainty is standard error, which is the standard deviation of the distribution of a statistic when it is calculated from many random samples. Figure 7.7 shows the results of simulations made to estimate the uncertainty for the Nature Index for different major ecosystems with respect to sampling errors. The figure suggests that at a sample size of 30 indicators, the standard error ranges from 0.034 for *mires and wetland* to 0.074 for *coast pelagic* and *coast bottom*, indicating that estimates of the Nature Index for the last two major ecosystems are uncertain at this sample size. The variation in the standard error between the major ecosystems reflects the variation in the indicators' conditions within the various systems (not shown) and the varying degree of coverage among them (cf. Figure 7.3). The results suggest further that a sample with fewer than 15 indicators is too small to provide precise estimates of the Nature Index for most major ecosystems. In this context it is worth noting that indicators based on expert assessments and model-based indicators together constitute 65% of the data, and for many systems, that share is even higher. It therefore appears that the monitoring data alone are not sufficient to calculate a Nature Index for Norway.

However, these analyses are at best only indicative because they are based on a limited number of indicators for these types of simulations, and they assume that the indicators are chosen randomly from an infinitely large population of indicators. That is a model for sampling and weighting of indicators not consistent with how the data for the Nature Index have been chosen or the method for its calculation. For example, the simulations do not take into account the weighting of indicators with respect to trophic group and whether they are key indicators or not. Key indicators are particularly important in this context as they count for 50% when calculating the Nature Index. These are not selected at random, and there are also a limited number of possible key indicators in a major ecosystem. Key indicators have been specifically identified and weighted to increase the precision of estimates for the Nature Index because they are perceived to represent the development of many other indicators that are otherwise not covered by the data. However, we do not have a good model that allows us to simulate how key indicators are identified, how well they represent other indicators and the number of such indicators that occurs in each major ecosystem. We are therefore currently unable to make calculations equivalent to those presented above, which also take into account the Nature Index's weighting system.

The Nature Index should be seen as a summary of what we know about the state of nature in Norway today. The value of the index lies primarily in illustrating trends within each major ecosystem. This review of the data shows that there is a need for much more additional information on the state of nature before it will be possible to have uniform geographical representation within all the major ecosystems and with sufficient resolution to allow summaries of state at a municipal level. Furthermore, the review shows that there is a corresponding need to include additional indicators before the criteria for a balanced set of indicators (Chapter 2.2) are met. But this does not in itself mean that the data constitute a biased sample of states. Although questions concerning sampling error remain unanswered, we have found no obvious indications in this review that suggest that the current data are misleading for calculating a Nature Index at a coarse geographic scale.

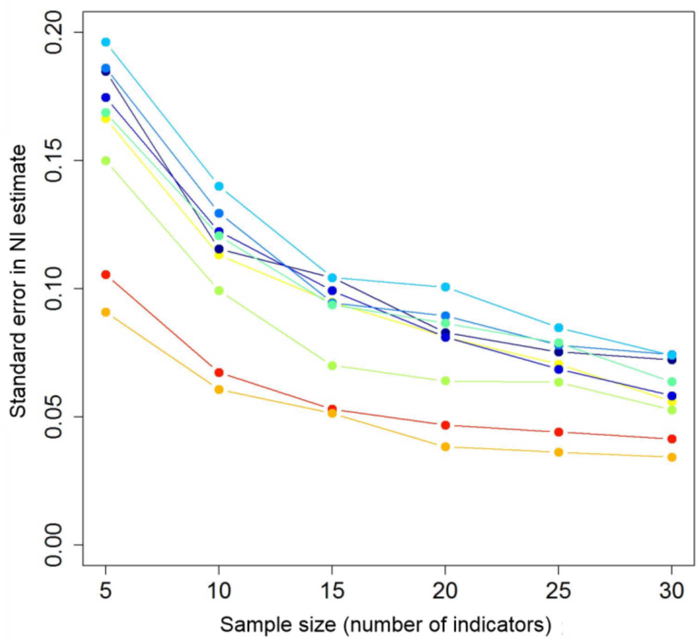

Figure 7.7. *Standard errors when calculating the Nature Index for Norway without weighting indicators. The analyses are based on the assumption that the indicators are randomly sampled (cf. discussion in text). Standard errors are calculated for 9 major ecosystem based on data consisting of from 5 to 30 indicators: freshwater (red), wetlands (orange), open lowland (yellow), forest (green), mountain (light green). The four blue lines that grade in colour from dark to light blue represent ocean bottom, ocean pelagic, coast bottom and coast pelagic respectively. Standard errors are estimated as the standard deviation from the Nature Index distribution simulated by repeated resampling with replacement of indicators from the Nature Index's data. The estimates are based on 700 simulations for each combination of sample size and major ecosystem.*

8 Database and web portal

Bård Pedersen and Pål Kvaløy
Norwegian Institute for Nature Research

8.1 IT infrastructure

An Internet-based information system has been developed for input, storage and presentation of the data that are used as a basis for calculating the Nature Index (Figure 8.1). The system consists of a database for storing indicator observations and other data for the calculation and presentation of the Nature Index, along with results from statistical calculations. There is also a website for inputting data to the base (naturindeks.nina.no), where individual experts can update information for the indicators for which they are responsible, and a set of routines for calculating the Nature Index and analysing raw data and results. A system for presenting the results and background data on the Internet has also been developed (www.naturindeks.no).

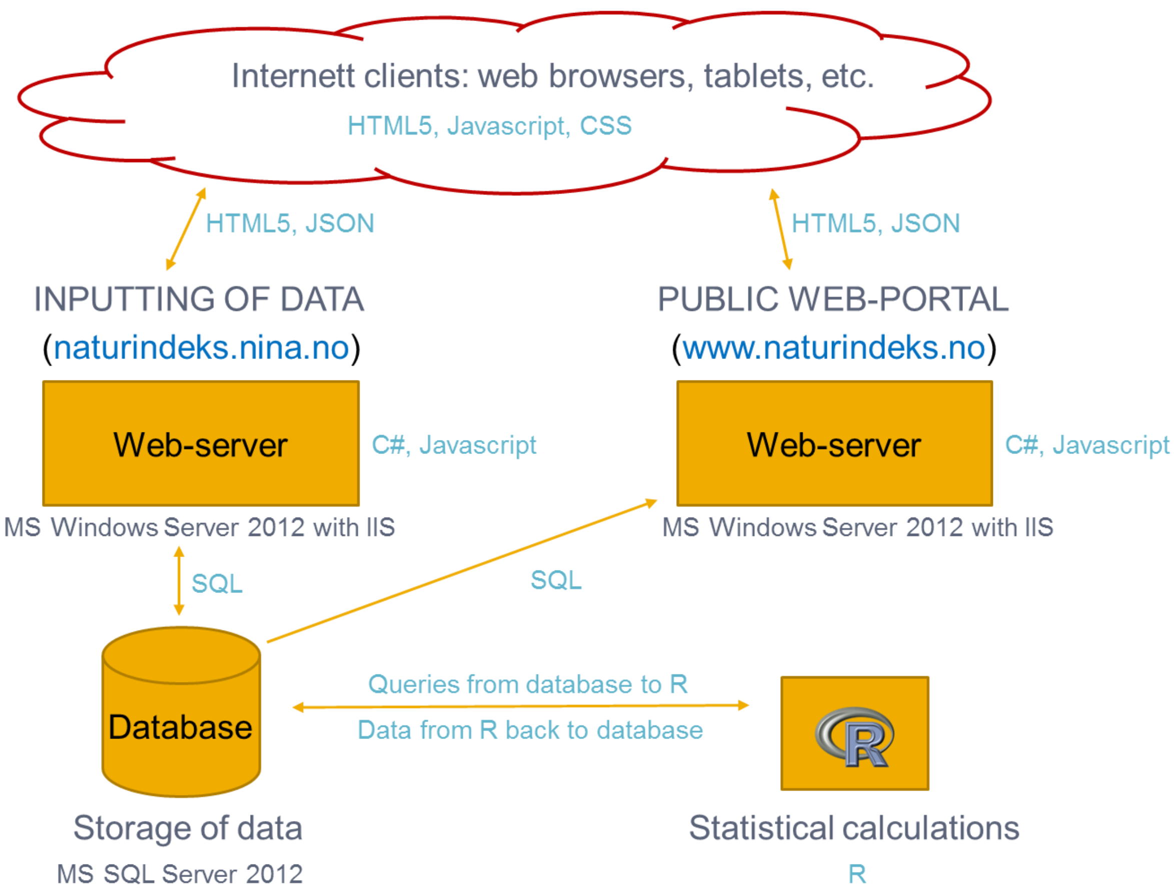

Figure 8.1 *Schematic representation of the information systems developed for input (web server, naturindeks.nina.no) and storage (database) of basic data for the Nature Index, the calculation of Nature Index (R, statistical calculations) and for the presentation of data and results (web server, www.naturindeks.no). The orange boxes represent the system's software components; orange arrows show the flow of data; grey-coloured text describes the functions of the various components and their hardware platforms; light-blue text describes the programming languages and data transport that have been used; while the blue text indicates the addresses (URL) to the web-based components.*

8.2 Website for inputting of data

The website is designed as an interface where an individual expert can enter, edit and update observations and other information about the indicators for which the expert is responsible. It also includes features for uploading images, documents and links to documents to the database. These in turn are presented and made available to the public via the web portal (Chapter 8.4). The web address for the input interface is http://naturindeks.nina.no/. To access the website and the Nature Index database, the expert must be registered in advance with a username and password. Upon registration, each expert is only given read/write access to those indicators for which they are responsible. Login to the interface is permitted for a limited period each year when new data can be entered and when the data stored in the database are available for editing. The interface is in English.

The site consists of six "pages" to which the user has access. Initially, users must use the login page to access the other five pages. The main page contains information about new versions and updates of the interface and provides access to a user's manual for the website (English version: Pedersen & Kvaløy 2015). The indicator page is used to select an indicator and input different information about it. The area page is used to define and edit the geographic areas that are applicable to the indicator observations, while observations and reference values can be recorded on the values page. There is also access to a separate page where the user can edit their login and contact information. The website also contains a separate page for administrative tasks, to which only users with special status have access. This page allows administrators to assign indicators to individual experts, for example, and indicators can be set in passive mode as they are no longer updated and are removed from the basis for calculating the Nature Index.

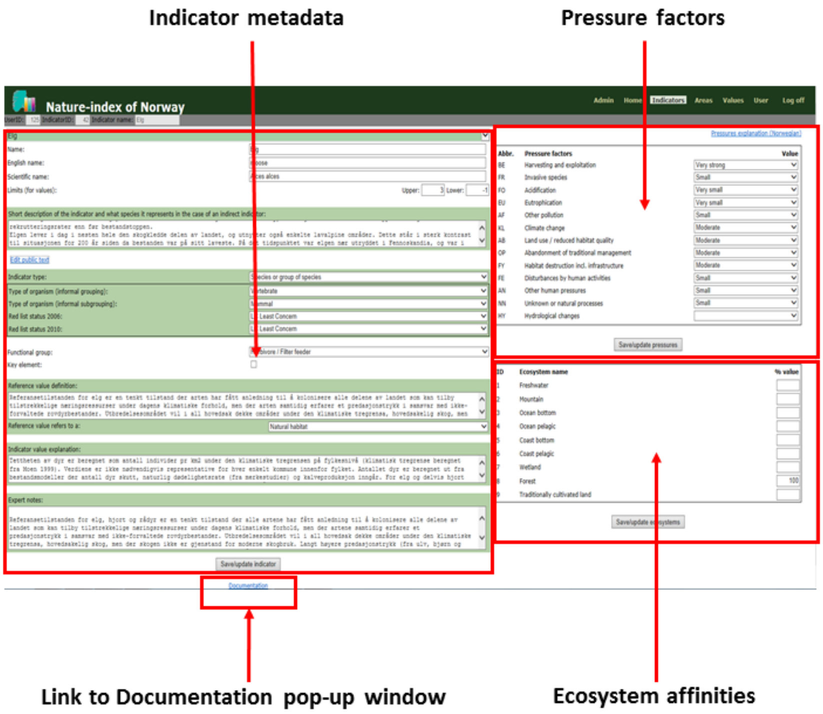

Figure 8.2 *Webpage for input of indicator information into the Nature Index database.*

The indicator page (Figure 8.2) contains fields for the input of indicator metadata, the indicator's sensitivity to the various pressure factors (Chapter 4) and its links to the nine major ecosystems (Chapter 3, 5.3). The metadata include the indicator name, Red List status, type of organism, functional group (Chapter 2.3, 5.3), scaling model (Chapter 5.2), whether the indicator is a key indicator or not (Chapter 2.3, 5.3). Here the user also procides information as to whether the indicator represents a species, group of species or an indirect indicator (Chapter 2.2), and whether the indicator's reference value refers to a natural or semi-natural habitat (Chapter 2.5), as well as descriptions of the indicator, its source data and methodology for the determination of reference values. The indicator page also contains a link to a popup window for uploading photos, reports and other documentation that form the basis for indicator values and other information that are entered into the database (Figure 8.3).

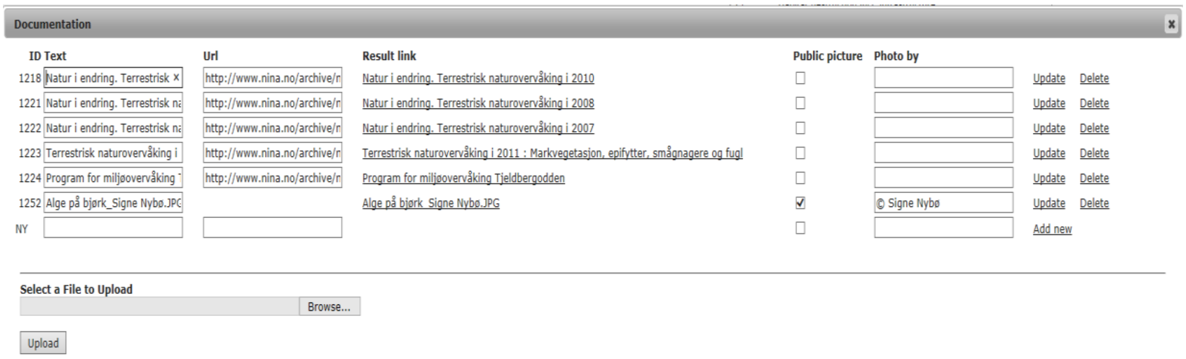

Figure 8.3 *Popup window for downloading indicator documentation to the Nature Index database.*

The area page is designed to delineate geographical units, the areas for which the various indicator observations are applicable. The Nature Index's mathematical framework allows for the indicator values to be specified with different geographical resolutions, in accordance with the source data for each indicator. One limitation is that the geographical units must consist of one or more municipalities and/or ocean areas, however. Two types of geographical units are defined for each indicator on the area page: the "definition area" and areas with data. The definition area is the total geographical area where the indicator is relevant. Usually this corresponds to the indicator's distribution area. One or more areas with data may be delimited within the definition area. The definition area is used to document where information is lacking.

The content of the page is context-dependent, but normally the page contains a list of indicator areas that have already been delimited, a list of possible operations that can be done on the page, such as create, name, delete, or edit an area's delimitation, and a municipality list that changes depending on the operation to be performed (Figure 8.4). The central part of the area page contains a map with content that is also dependent on the context, i.e. the operation undertaken and areas that have already been delimited. The page is constructed so that operations can be carried out either by clicking on the municipalities shown on the map or by selecting from the municipal list. To facilitate the first option, a number of help features have been added to the map. The map resolution and output sections can be adapted as needed, and municipalities that have either been selected or not selected are shown with different colours, and the municipality's name and code appears whenever the user moves the mouse cursor over the municipality on the map.

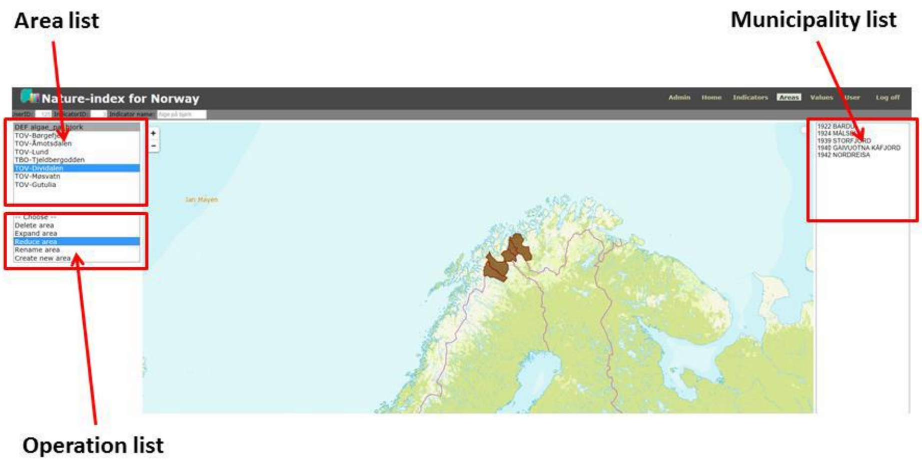

Figure 8.4 *Webpage for the delineation of geographical units.*

Observations and reference values for a selected indicator are recorded in the database on the values page, either directly to a table on the page or via an Excel import. The page also includes a list of indicator areas and a tool for visualizing and proofreading data that have been recorded on the map (Figure 8.5).

For direct data entry on the page, the user first selects one of the indicator areas from the area list. Previously entered values are then presented in the data table and are available for correction if necessary, while fields where data have not previously been recorded are empty. The table consists of five columns: dates, expected value, lower and upper quartile (Chapter 5.5) and data type (monitoring data, model-based data or data from expert assessment). The table has a row for the area's reference value and a row for each of the years the Nature Index was calculated. Excel files can be imported by using the import tool that is available on the values page, which generates an Excel file with information as in the table described above, but that includes all of the indicator areas. New data can be recorded in the file or previously entered values can be corrected before the data are imported to the database via the import tool.

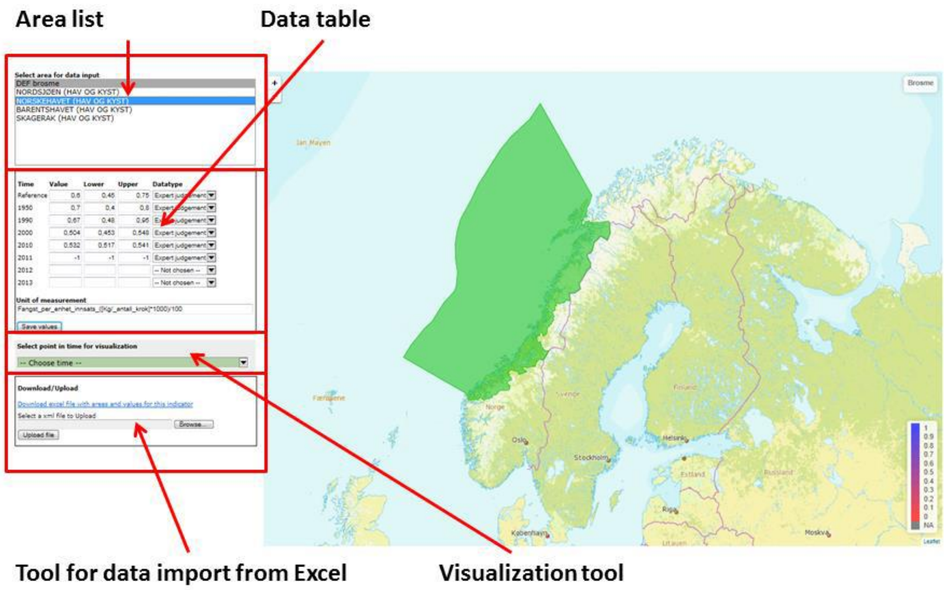

Figure 8.5 *Webpage for the input of indicator observations and reference values.*

8.3 Database

The Nature Index database is a SQL relational database. It consists of a set of main tables containing data on the most important object types for which information is stored in the database, and a number of lookup tables that contain mostly information and names of the features that characterize the objects in the main tables, such as tables about sampling time, major ecosystem, trophic group, Red List categories, type of probability distribution (see Chapter 5.5), data type and scaling model. All objects in the main and lookup tables are assigned unique ID codes. The database also consists of connection tables that link information in the other tables via the objects' ID codes, and that also include information that characterizes the connection. For example, the link table "Indikator_Okosystem", which connects the main table "Indicator" and the lookup table "T_Okosystem" contains data on the indicator's connections to the various major ecosystems (see Chapter 5.3, Figure 8.2). The database consists of a large number of tables. The most important tables are presented here.

The database is structured around the following object types, each with its own main table: indicators, indicator values or values, areas, municipalities, and experts (Figure 8.6). The indicator table contains metadata about the indicators (Chapter 8.2), while the connection tables "Indikator_Okosystem" and "Paavirkning_Indikator" contain data on the indicator's connection to major ecosystems and the indicators' sensitivity to pressure factors, respectively. Information that governs experts' access to indicator data via the input interface is in the connection table "Indikator_Ekspert."

The main table "Kommune" includes the geographical polygons for Norwegian municipalities and ocean areas. The municipality table contains the smallest geographic units used in the Nature Index for Norway. The percentage distribution of major ecosystems within each municipality or the individual body of water is stored in the connection table "Kommune_Okosystem" (cf. Chapter 5.4). The area table contains the areas' names and IDs for the indicators they have been defined for, while the connection table "Omraade_Kommune" includes the municipalities included in each area for each indicator.

The values table consists of one object for each indicator observation and reference value. In addition to the observations' expected values and lower and upper quartiles, the table also includes the indicator's ID, time/reference value, the area ID, data type (expert assessment, model-based or monitoring data) and unit of measure. Information about the probability distribution that is attached to each individual observation, such as the type of distribution and the distribution's parameter values (Chapter 5.5) are also stored in this table.

Metadata about documents that are uploaded via the input interface are stored in the "Dokumentasjon" table. The physical documents and pictures are stored in a dedicated file area on the web server.

Results from calculations of the Nature Index and thematic indices from R are also stored in the database. They are distributed in two tables. Table "NI_results" contains the calculated index values as point estimates and confidence intervals (ref. Chapter 5.6), and information about the year, the major ecosystem and area the values apply to, as well as a run_ID. The second table, "NI_runs", contains background information and technical details describing the scope and conditions for the various calculations.

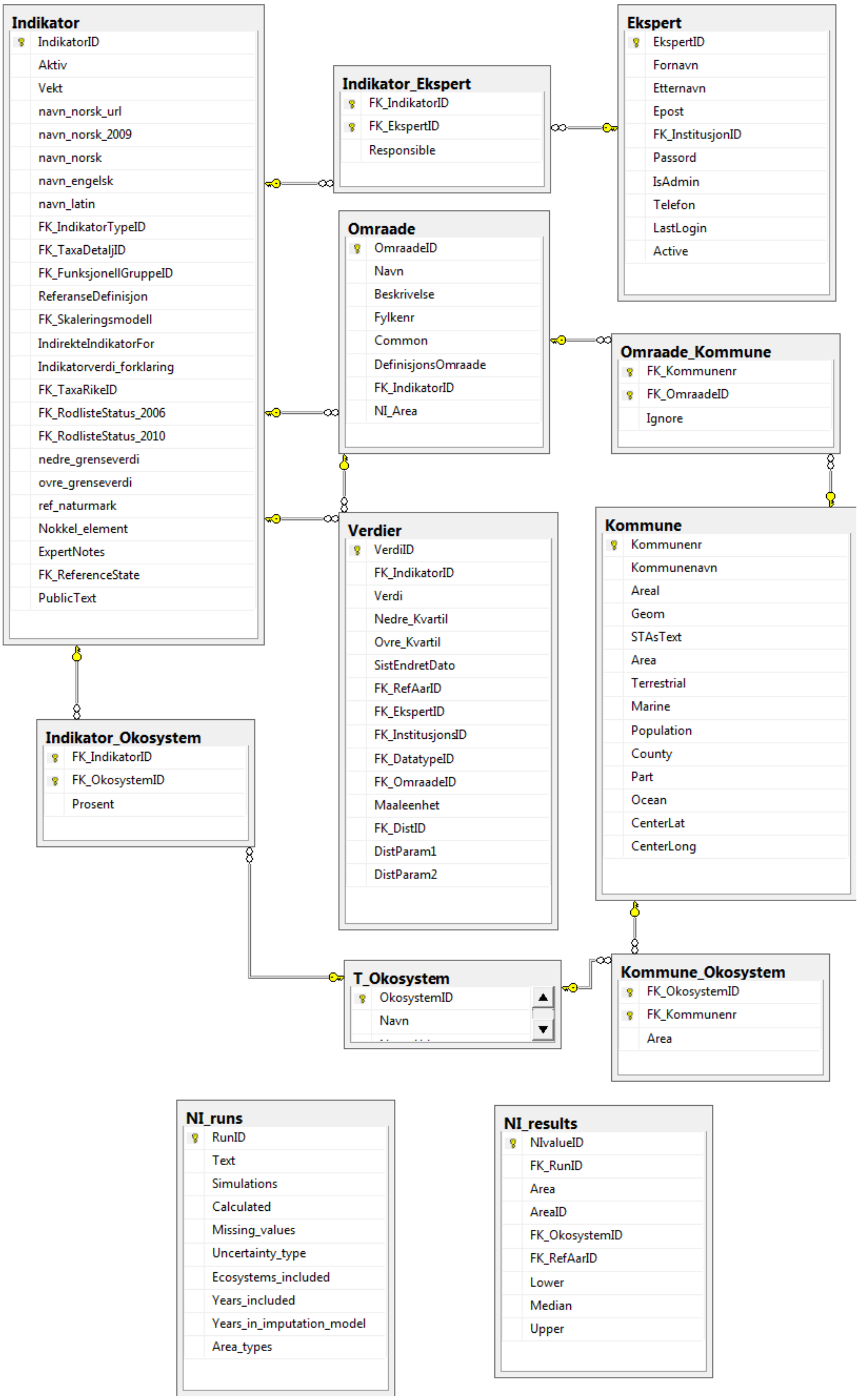

Figure 8.6. *The table structure for the Nature Index database. The figure shows the main tables containing data that underlie the calculation of the Nature Index, and the relationships between them.*

8.4 Calculations

Calculations of the Nature Index (Chapter 5), themed indices, various statistics that describe the data, adaptation of probability distributions to indicator observations (elicitation, Chapter 5.5), analysis of the Nature Index's statistical properties (e.g. Pedersen & Skarpaas 2012, Skarpaas & Pedersen 2012) and the like are done by scripts developed in R version 3.1.0 (R Core Team 2014). The scripts are developed as needed. Elicitation and the calculation of the Nature Index are routine tasks that are repeated many times, however.

The procedure for elicitating indicator observations first involves opening an ODBC connection to the Nature Index base and then reading the observations to be elicitated from the "Verdier" table and information about the model distributions in the lookup table "T_Distributions." Next, a probability distribution is fitted for each indicator observation as described in Chapter 5.5. The type of distribution that is fitted and its parameter values are written back in the "Verdier" table in the Nature Index base. Routines from the R library RODBC (Ripley & Lapsley 2013) are used to help open the ODBC connection and read and write to the Nature Index base. Fitting the model distribution is done by using routines from gamlss.dist (Stasinopoulos & Rigby 2014), MSM (Jackson 2011) and truncnorm (Trautmann et al. 2014) libraries.

The calculation of the Nature Index similarly involves importing data from the "Verdier" table, and a number of other tables in the Nature Index base and restructuring of these data. Next, a large number of data sets to calculate the Nature Index from are generated by sampling at random from each model distribution fitted for the indicator observations. Each sampled value is scaled by the reference value and the scaling model chosen for the indicator in question. Weights are calculated based the observations, indicators and major ecosystems that are involved (Chapter 5.3, 5.4). The index is calculated for each data set as a weighted mean of the scaled values (Equation 5.1). A point estimate for the Nature Index with confidence intervals is estimated at the end (Chapter 5.6) before the results may be entered in the "NI_results" - and "NI_runs" tables in the Nature Index base. The script uses routines from the MASS library (Venables & Ripley, 2002) in addition to those mentioned above.

8.5 Web portal

An online information source for the Nature Index for Norway has been constructed (www.naturindeks.no). The goal of the website is to provide users and the public at large insight into what the Nature Index is, the purpose it is meant to serve, how it is calculated and what kind of data it is based on. The website provides information about – and hopefully creates interest in – the state of biodiversity in Norway, how this state has developed in the recent past and what is known and not known about these questions.

The web portal is included as part of the Norwegian Environment Agency's online website directed at the public. The site layout therefore follows the same template as the Agency's other web sites (Figure 8.7). The website largely replaces previous public outreach efforts about the Nature Index and its underlying data in the form of reports (Nybø 2010a, 2010b Nybø). The web portal is being developed, however, by the Norwegian Institute for Nature Research and is hosted on one of the institute's servers. It is was completed in the autumn of 2015 and hosted at the address www.naturindeks.no.

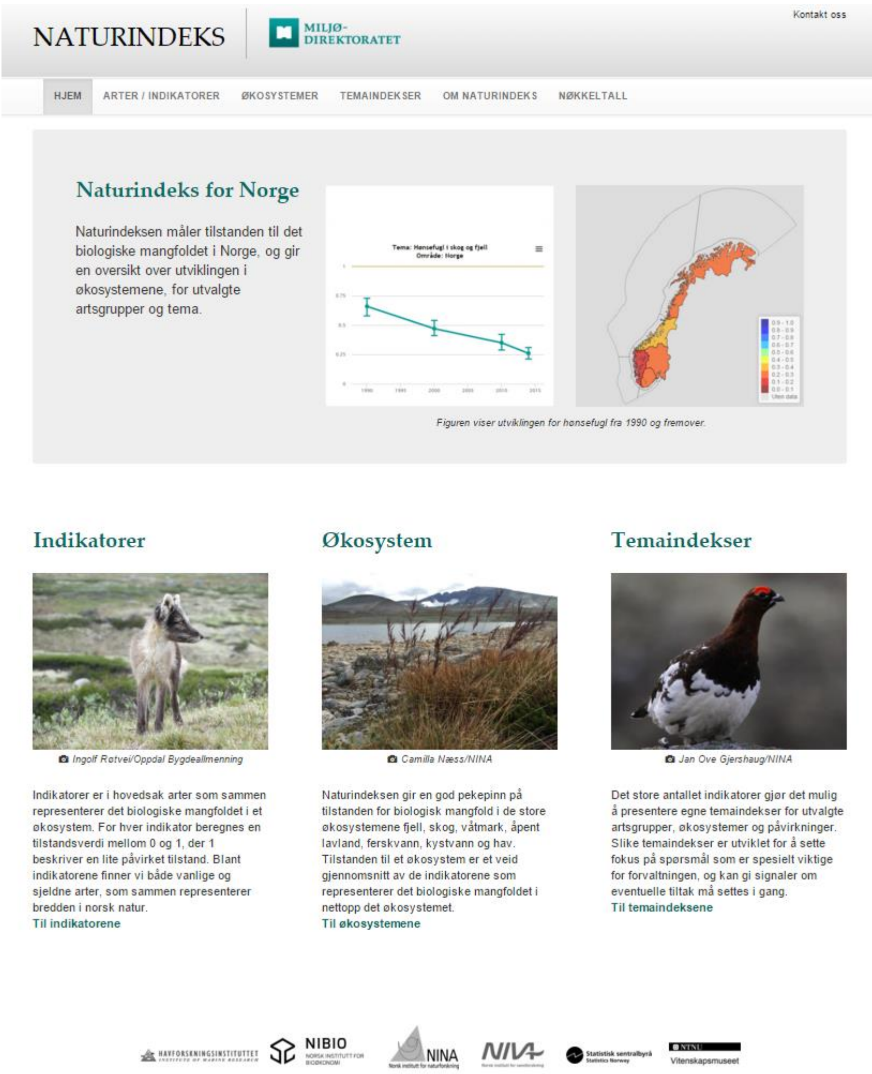

***Figure 8.7** Home page of the public webportal for the Nature Index, www.naturindeks.no.*

The web portal consists of six "pages". The page *ARTER / INDIKATORER* (species / indicators) (Figure 8.8) contains general descriptions of each indicator, their underlying data and the determination of reference values. The page also shows a map of each indicator that depicts the scaled values for the years for which there are data and a graph showing the trend of the indicator's state at a national level (with confidence intervals). The page also contains an overview of the major ecosystem to which the indicators belong, a list of anthropogenic factors that put negative pressure on the indicators, links to background documents and contact details for the experts that are responsible for the indicators.

The *ØKOSYSTEMER* (ecosystems) page (Figure 8.9) presents the index values for each major ecosystem in maps and graphs (with confidence intervals) in the period from 1990 until the present day. The maps portray index values for each region and ocean area. The home page *HJEM* (home) (Figure 8.7) contains a general introduction to the Nature Index, a page with *NØKKELTALL* (key numbers) for the Nature Index containing number of indicators in each major ecosystem, number of experts involved and so on, a page *OM NATURINDEKS* (about the Nature Index) that provides an introduction to the Nature Index framework and how it is calculated, as well as a page that presents *TEMAINDEKSER* (thematic indices) where 11 thematic indices are presented in graphs and maps for the whole country as well as each region.

The web portal is developed with a so-called responsive design so that it can be viewed on all types of devices such as mobile phones, tablets, PCs and Macs. The solution is designed to support multiple languages, but a translation is not currently included.

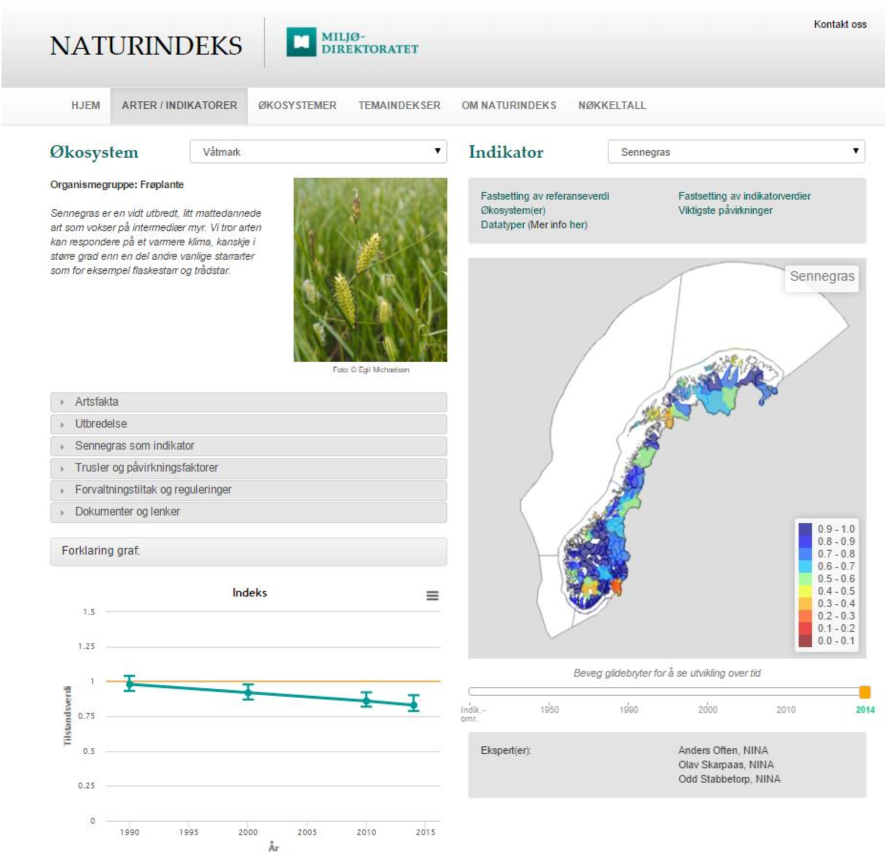

Figure 8.8 *Example of how an indicator (Bladder sedge,* Carex vesicaria*) is presented on the web portal. The page contains descriptions of the biology and distribution of the indicator as well as threats, pressure factors and other information relevant for its management. The indicator status is presented on a map and with a graph. The page includes links to background documentation and descriptions of indicator sensitivity to pressure factors and methods for determining reference values, among other information.*

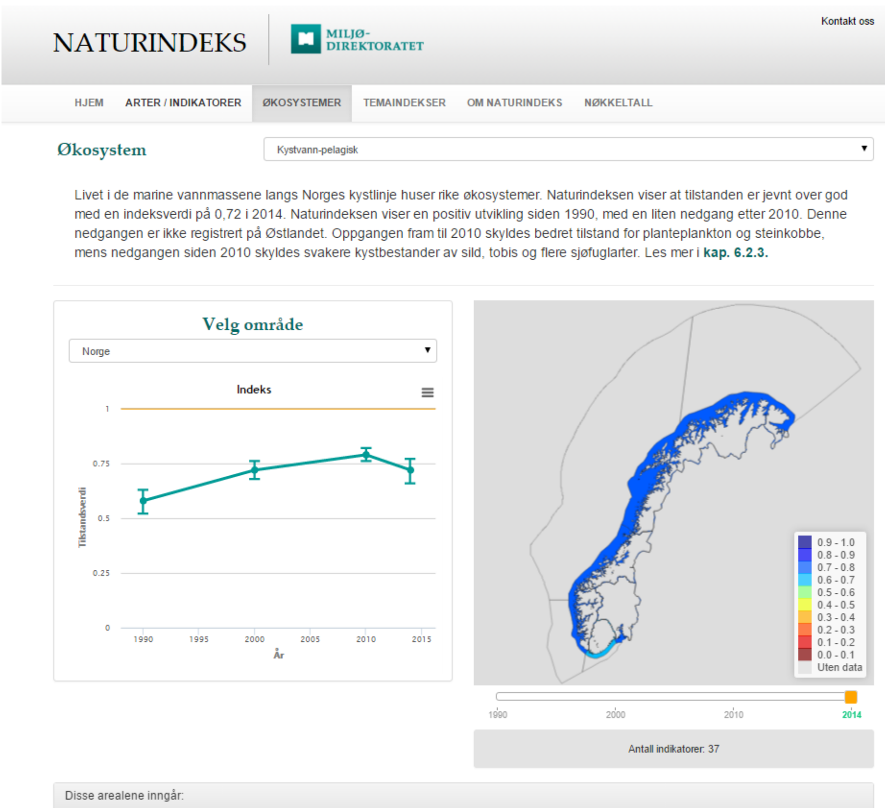

Figure 8.9 *The web portal page that presents major ecosystems, here exemplified by* coast pelagic. *The state of the ecosystem is presented in a map and with a graph showing the overall trend over time. As for individual indicators, the map is dynamic and the user can move a slider to view the state at different times.*

8.6 Software

The servers for the Nature Index run on a Microsoft Windows platform. The database server is a Microsoft SQL Server 2012 installed on a Microsoft Windows Server 2008 platform. The web server is a Microsoft Internet Information Server 8 running on a Windows Server 2012 platform. The programming language used for the server-side components is C #. The web server and the database communicate using SQL. The clients (browsers) access the functionality on the web services as an Ajax call to services that is implemented as Web API services.

The web pages that constitute the users' experience of the Nature Index are built from a combination of CSS, JavaScript and HTML5. The map engine used on the client side is Leaflet JS, and the client side MVVM (Model View View Model) is implemented using the JavaScript framework Knockout JS. The website has been tested on newer versions of Google Chrome and Microsoft Internet Explorer as well as various Android devices. Other modern HTML5 browsers (like Opera and Firefox) will probably work well. JavaScript is assumed to be turned ON in the web browser’s security settings.

The systems are implemented at the Norwegian Institute for Nature Research’s server park. The server park is virtualized, meaning that no servers have their own dedicated hardware. Memory, processing power and disk size are allocated dynamically as needed to each virtual server.

9 International work

Signe Nybø
Norwegian Institute for Nature Research

The Nature Index for Norway has attracted international interest. The Nature Index data base ensures the systematizing and storage of time series and other knowledge, and assembles these data into an assessment of the state and trends in the state of ecosystems.

The Nature Index has been presented at numerous international conferences, and has been presented as "side event" at the October 2011 meeting in Montreal of the Scientific Committee (SBSTTA) under the Convention for Biodiversity. Prior to the SBSTTA meeting, Norway was invited to present the method to a committee that worked to identify indicators for the Convention on Biological Diversity (Ad hoc technical committee). The Nature Index has also been presented at the Eurostat conference on sustainable indicators in Luxembourg in 2012.

Nine scientific articles have also been published in refereed international journals. An overview of these articles is available at the website of NINA. The first article was published in PLoS ONE by Certain et al. in 2011, and described the approach and methodology. Both the ecological and the mathematical framework have been further refined since then, partly in order to make it easier to communicate results (see this report).

In 2014, two pilot projects were initiated outside Norway. One of the projects was to facilitate testing the Nature Index framework and database in northern areas, to create an Arctic Nature Index. The work was a collaboration with the CAFF Secretariat (Conservation of Arctic Flora and Fauna) under the Arctic Council. The work was funded by the Ministry of Climate and Environment (KLD) and executed by the Norwegian Environment Agency. An application was submitted by NINA in 2015 with the idea of continuing the project. The CAFF Secretariat has already received project funding from the Nordic Council of Ministers. There has also been an effort to facilitate the use of the Nature Index in Svalbard waters. The project was funded by the Norwegian Environment Agency. The results of these two pilot projects have been summarised by Certain et al. (2015)

The Nature Index framework and database have also been tested in Costa Rica with InBio as the host institution (Barton et al. 2014). In Costa Rica, the researchers decided not to use administrative units (municipalities) as the smallest geographical unit but hexagons instead. The Nature Index was tested in forest ecosystems. The project was successful, and several ideas related to the use of the results were discussed. One of the ideas is that the results can be developed to be used to ensure reporting of biodiversity in the REDD + process. There is also a desire to use the tool for capacity building in biodiversity work both within Costa Rica, but also in Central America in general as relevant for IPBES work (Barton et al. 2014). There will be an application for funding to continue the project. The Norwegian Ministry of Foreign Affairs financed the project in 2014 through funds provided for IPBES work. The Norwegian Environment Agency recommended that the project be prioritized.

Through the EEA Agreement, Norway has a comprehensive agreement to support projects in Eastern Europe. A portion of these projects should address biodiversity and ecosystem services. Parts of the Nature Index have been included in predefined projects in Bulgaria, and a simplified version of the Nature Index has been developed for Lithuania. The projects have been designed at the request of these countries.

Statistics Norway has been involved in designing an experimental handbook for ecosystem calculations (European Commission et al. 2013). The handbook has been developed by the EU, OECD, UN Statistical Office and the World Bank. The Convention on Biological Diversity has been involved in the work. The Nature Index was mentioned as a possible approach to ecosystem accounting in this handbook. Moreover, the Ministry of Climate and Environment has provided funding for participation in follow-up meetings for NINA and SSB, which among other things has resulted in a memorandum which specifies how the Nature Index's framework can contribute to ecosystem accounting (Certain et al. 2013). No efforts have been initiated to test the Nature Index in this context. The Ministry of Climate and Environment has provided support for NINA's work.

Figure 9.1 shows some of the publications from the Nature Index work in Norway and internationally.

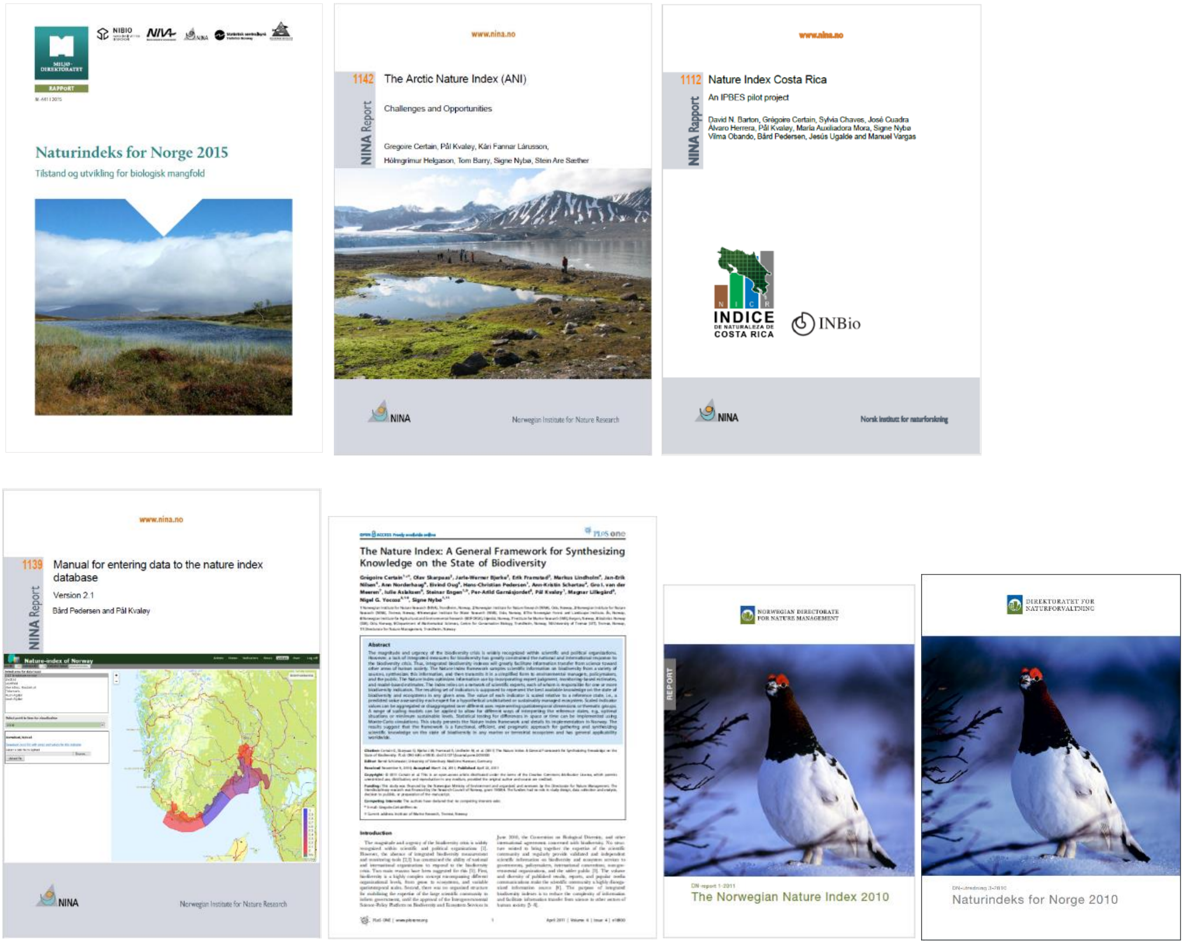

Figure 9.1. *Some key publications from the Norwegian Nature Index and pilot projects in other countries, with links to pdf files.*

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11 Appendix 1: Indicator list

This appendix lists all indicators for each major ecosystem together with their scaling models (Model), whether they have status as key indicators, and their fidelity to the major ecosystem in question (cf. chapter 5.3). Also listed are average area size (measured as number of municipalities per area), coverage (fraction of municipalities with the major ecosystem where the indicator is documented with data) and fractions of observations that are expert judgements (E), model based estimates (M) or observatons from monitoring programs (O) (cf. chapter 6.3). Some are indicators for more than one major ecosystem.

Freshwater

Name	Scientific name		Model	Key indicator	Specificty	Area size	Coverage	E/M/O	Contact(s)	Institution
Acidification index bottomfauna			Low	x	1.00	5.00	0.03	58 / 0 / 42	Hanne Edvardsen Tor Erik Eriksen	NIVA
Aquatic flora lakes		Seed plant	Low	x	1.00	1.30	0.10	41 / 51 / 8	Hanne Edvardsen Marit Mjelde	NIVA
ASPT index bottomfauna			Low	x	1.00	1.08	0.03	42 / 0 / 58	Hanne Edvardsen Tor Erik Eriksen	NIVA
Atlantic salmon coast and rivers	*Salmo salar*	Bony fish	Low		0.60	11.13	0.41	16 / 84 / 0	Peder Fiske	NINA
Black-throated loon	*Gavia arctica*	Bird	Low		1.00	215.00	1.00	50 / 0 / 50	Hans Christian Pedersen	NINA
Brook-side Feather-moss	*Hygroamlystegium fluviatile*	Moss	Low		1.00	19.00	0.44	100 / 0 / 0	Kristian Hassel	NTNU
Brown trout	*Salmo trutta*	Bony fish	Low		1.00	25.00	0.87	20 / 0 / 80	Trygve Hesthagen	NINA
Common goldeneye	*Bucephala clangula*	Bird	Low		1.00	379.00	0.88	0 / 0 / 100	Hans Christian Pedersen	NINA
Common gull freshwater	*Larus canus*	Bird	Low		1.00	215.00	1.00	33 / 0 / 67	Hans Christian Pedersen	NINA
Common sandpiper	*Actitis hypoleuca*	Bird	Low		1.00	215.00	1.00	33 / 0 / 67	Hans Christian Pedersen	NINA
Common scoter	*Melanitta nigra*	Bird	Low		1.00	201.50	0.94	100 / 0 / 0	Hans Christian Pedersen	NINA
Dipper	*Cinclus cinclus*	Bird	Low		0.75	214.50	1.00	100 / 0 / 0	Hans Christian Pedersen	NINA
Eurasian teal	*Anas crecca*	Bird	Low		1.00	215.00	1.00	0 / 0 / 100	Hans Christian Pedersen	NINA
European Eel	*Anguilla anguilla*	Bony fish	Low		0.25	4.50	0.06	0 / 0 / 100	Caroline Durif Tore Johannesen	IMR
Freshwater pearl mussel	*Margaritifera margaritifera*	Mollusc	Low		1.00	16.16	0.71	100 / 0 / 0	Bjørn Mejdell Larsen	NINA
Greater scoup	*Aythya marila*	Bird	Low		1.00	59.00	0.27	100 / 0 / 0	Hans Christian Pedersen	NINA
Holt's Mouse-tail Moss	*Isothecium holtii*	Moss	Low		1.00	25.00	0.23	100 / 0 / 0	Kristian Hassel	NTNU

Freshwater (cont.)										
Name	Scientific name		Model	Key indicator	Specificty	Area size	Coverage	E/M/O	Contact(s)	Institution
Lake phytoplankton		Algae	Low	x	1.00	1.00	0.63	3 / 0 / 97	Hanne Edvardsen Birger Skjelbred	NIVA
Macrofauna, rivers		Insect	Low	x	1.00	22.63	1.00	59 / 0 / 41	Terje Bongard Zlatko Petrin	NINA
Mallard	*Anas platyrhynchos*	Bird	Low		1.00	215.00	1.00	50 / 0 / 50	Hans Christian Pedersen	NINA
Noble Crayfish	*Astacus astacus*	Crustacean	Low		1.00	8.10	0.19	100 / 0 / 0	Stein Ivar Johnsen	NINA
Osprey	*Pandion haliaetus*	Bird	Low		1.00	73.67	0.51	100 / 0 / 0	Hans Christian Pedersen	NINA
Otter coastal areas	*Lutra lutra*	Mammal	Low		0.35	1.00	0.65	0 / 100 / 0	Jiska Van Dijk	NINA
Otter inland area	*Lutra lutra*	Mammal	Low		1.00	1.00	0.35	0 / 100 / 0	Jiska Van Dijk	NINA
Red-breasted merganser	*Mergus serrator*	Bird	Low		1.00	215.00	1.00	50 / 0 / 50	Hans Christian Pedersen	NINA
Red-throated loon	*Gavia stellata*	Bird	Low		1.00	205.50	0.96	50 / 0 / 50	Hans Christian Pedersen	NINA
River substrate acidification index algae		Algae	Low	x	1.00	1.00	0.02	0 / 0 / 100	Hanne Edvardsen Susi Schneider	NIVA
River substrate eutrofication index algae		Algae	Low	x	1.00	1.00	0.03	21 / 0 / 79	Hanne Edvardsen Susi Schneider	NIVA
Straw prongwort	*Herbertus stramineus*	Liverwort	Low		1.00	28.33	0.20	87 / 0 / 13	Kristian Hassel	NTNU
Tufted duck	*Aythya fuligula*	Bird	Low		1.00	215.00	1.00	50 / 0 / 50	Hans Christian Pedersen	NINA
Velvet scoter	*Melanitta fusca*	Bird	Low		1.00	97.50	0.45	100 / 0 / 0	Hans Christian Pedersen	NINA
Viking prongwort	*Herbertus norenus*	Liverwort	Low		1.00	26.00	0.06	100 / 0 / 0	Kristian Hassel	NTNU
Zooplankton composition		Crustaceans	Low	x	1.00	11.94	1.00	100 / 0 / 0	Bjørn Walseng	NINA

Mountain										
Name	Scientific name		Model	Key indicator	Specificty	Area size	Coverage	E/M/O	Contact(s)	Institution
Alpine azalea	*Loiseleuria procumbens*	Seed plant	Low		1.00	1.00	0.93	0 / 100 / 0	Anders Often Olav Skarpaas Odd Stabbetorp	NINA
Alpine willows		Seed plants	Low	x	1.00	8.80	0.45	83 / 0 / 17	Jarle W. Bjerke	NINA
Arctic Fox	*Vulpes lagopus*	Mammal	Low		1.00	1.00	0.57	33 / 0 / 67	Nina Elisabeth Eide	NINA

Mountain (cont.)										
Name	Scientific name		Model	Key indicator	Specificty	Area size	Coverage	E/M/O	Contact(s)	Institution
Arctic poppy	*Papaver radicatum radicatum*	Seed plant	Low		1.00	1.00	0.12	0 / 100 / 0	Anders Often Olav Skarpaas Odd Stabbetorp	NINA
Atractylocarpus alpinus	*Atractylocarpus alpinus*	Moss	Low		1.00	11.00	0.11	100 / 0 / 0	Kristian Hassel	NTNU
Bluethroat	*Luscinia svecica*	Bird	Low		1.00	196.00	1.00	0 / 0 / 100	Hans Christian Pedersen	NINA
Brown bear	*Ursus arctos*	Mammal	Low		0.25	196.00	1.00	0 / 38 / 63	Henrik Brøseth	NINA
Cloud Earwort	*Scapania nimbosa*	Liverwort	Low		1.00	18.00	0.09	80 / 0 / 20	Kristian Hassel	NTNU
Donn's Notchwort	*Anastrophyllum donnianum*	Liverwort	Low		1.00	16.00	0.33	90 / 0 / 10	Kristian Hassel	NTNU
Eurasian dotterel	*Charadrius morinel-lus*	Bird	Low		1.00	74.00	0.76	100 / 0 / 0	Hans Christian Pedersen	NINA
Eurasian golden plover	*Pluvialis apricaria*	Bird	Low		1.00	98.00	1.00	50 / 0 / 50	Hans Christian Pedersen	NINA
Glacier crowfoot	*Ranunculus glacialis*	Seed plant	Low		1.00	1.00	0.54	0 / 100 / 0	Anders Often Olav Skarpaas Odd Stabbetorp	NINA
Golden eagle	*Aquila chrysaetos*	Bird	Low		1.00	97.50	0.99	100 / 0 / 0	Hans Christian Pedersen	NINA
Gyrfalcon	*Falco rusticolus*	Bird	Low		1.00	90.00	0.92	100 / 0 / 0	Hans Christian Pedersen	NINA
Joergensen's notchwort	*Anastrophyllum joergensenii*	Liverwort	Low		1.00	24.00	0.12	80 / 0 / 20	Kristian Hassel	NTNU
Lapland longspur	*Calcarius lapponicus*	Bird	Low		1.00	70.00	0.71	50 / 0 / 50	Hans Christian Pedersen	NINA
Lichen heath	*Cladonia & Cetraria s.l. spp.*	Lichens	Low		0.85	2.21	0.44	77 / 2 / 21	Jarle W. Bjerke	NINA
Long-tailed duck	*Clangula hyemalis*	Bird	Low		1.00	49.00	0.50	100 / 0 / 0	Hans Christian Pedersen	NINA
Meadow pipit	*Anthus pratensis*	Bird	Low		1.00	65.33	1.00	33 / 0 / 67	Hans Christian Pedersen	NINA
Northern wheatear	*Oenanthe oenanthe*	Bird	Low		1.00	98.00	1.00	50 / 0 / 50	Hans Christian Pedersen	NINA
Raven	*Corvus corax*	Bird	Low		1.00	98.00	1.00	0 / 0 / 100	Hans Christian Pedersen	NINA
Ring ouzal	*Turdus torquatus*	Bird	Low		1.00	98.00	1.00	25 / 0 / 75	Hans Christian Pedersen	NINA
Rock ptarmigan	*Lagopus muta*	Bird	Low		1.00	11.80	0.90	100 / 0 / 0	Erlend Nilsen Hans Christian Pedersen	NINA
Rough-legged buzzard	*Buteo lagopus*	Bird	Low		0.80	96.00	0.98	50 / 0 / 50	Hans Christian Pedersen	NINA
Shore lark	*Eremophila alpestris*	Bird	Low		1.00	27.00	0.28	100 / 0 / 0	Hans Christian Pedersen	NINA

Mountain (cont.)										
Name	Scientific name		Model	Key indicator	Specificty	Area size	Coverage	E/M/O	Contact(s)	Institution
Small rodents mountain		Mammals	Low	x	1.00	11.27	0.63	100 / 0 / 0	Erik Framstad	NINA
Snow bunting	*Plectrophenax nivalis*	Bird	Low		1.00	92.00	0.94	50 / 0 / 50	Hans Christian Pedersen	NINA
Swollen thread-moss	*Aulacomnium turgidum*	Moss	Low		1.00	16.80	0.86	100 / 0 / 0	Kristian Hassel	NTNU
Wild reindeer	*Rangifer tarandus*	Mammal	Low	x	1.00	2.39	0.22	0 / 100 / 0	Olav Strand	NINA
Willow ptarmigan	*Lagopus lagopus*	Bird	Low		0.70	12.47	0.95	100 / 0 / 0	Erlend Nilsen Hans Christian Pedersen	NINA
Wolverine	*Gulo gulo*	Mammal	Low		0.75	28.00	1.00	0 / 0 / 100	Henrik Brøseth	NINA
Ocean bottom										
Name	Scientific name		Model	Key indicator	Specificty	Area size	Coverage	E/M/O	Contact(s)	Institution
Atlantic cod	*Gadus morhua*	Bony fish	Low	x	0.60	1.50	0.75	0 / 100 / 0	Asgeir Aglen	IMR
Atlantic halibut	*Hippoglossus hippoglossus*	Bony fish	Low		0.15	1.33	1.00	70 / 0 / 30	Erik Berg	IMR
Blue ling	*Molva dypterygia*	Bony fish	Low		1.00	1.00	0.75	100 / 0 / 0	Kristin Helle	IMR
Caryophyllia smithii	*Caryophyllia smithii*	Cnidarian	Low		1.00	1.00	0.25	100 / 0 / 0	Gro van der Meeren	IMR
Cerianthus lloydii	*Cerianthus lloydii*	Cnidarian	Low		1.00	1.00	0.25	100 / 0 / 0	Gro van der Meeren	IMR
Deep sea redfish	*Sebastes mentella*	Bony fish	Low		0.25	2.00	0.50	0 / 100 / 0	Benjamin Planque	IMR
European Hake	*Merluccius merluccius*	Bony fish	Low		0.15	1.00	0.25	100 / 0 / 0	Otte Bjelland	IMR
Filograna implexa	*Filograna implexa*	Annelid	Low	x	1.00	1.00	0.25	100 / 0 / 0	Gro van der Meeren	IMR
Geodia spp	*Geodia spp*	Sponges	Low	x	1.00	1.00	0.25	25 / 0 / 75	Gro van der Meeren	IMR
Golden redfish	*Sebastes marinus*	Bony fish	Low		0.25	2.00	0.50	14 / 86 / 0	Benjamin Planque	IMR
Gorgonocephalus arcticus	*Gorgonocephalus arcticus*	Echinoderm	Low		1.00	1.00	0.25	100 / 0 / 0	Gro van der Meeren	IMR
Gorgonocephalus eucnemis	*Gorgonocephalus eucnemis*	Echinoderm	Low		1.00	1.00	0.25	100 / 0 / 0	Gro van der Meeren	IMR
Gorgonocephalus lamarcki	*Gorgonocephalus lamarcki*	Echinoderm	Low		1.00	1.00	0.25	100 / 0 / 0	Gro van der Meeren	IMR
Greenland halibut	*Reinhardtius hippoglossoides*	Bony fish	Low		0.60	1.00	0.50	53 / 47 / 0	Elvar H. Alfredsson	IMR

Ocean bottom (cont.)										
Name	Scientific name		Model	Key indicator	Specificty	Area size	Coverage	E/M/O	Contact(s)	Institution
Haddock	*Melanogrammus aeglefinus*	Bony fish	Low		1.00	1.00	1.00	50 / 50 / 0	Jennifer Devine	IMR
Heliometra glacialis	*Heliometra glacialis*	Echinoderm	Low		1.00	1.00	0.25	100 / 0 / 0	Gro van der Meeren	IMR
Hooded seal	*Cystophora cristata*	Mammal	Low		0.20	1.00	0.25	0 / 100 / 0	Tor Arne Øigård	IMR
Ling	*Molva molva*	Bony fish	Low		0.80	1.00	1.00	0 / 0 / 100	Kristin Helle	IMR
Lophelia sp.	*Lophelia sp*	Cnidarians	Low	x	1.00	2.00	0.50	100 / 0 / 0	Gro van der Meeren	IMR
Northern deep sea shrimp	*Pandalus borealis*	Crustacean	Low		0.70	1.00	0.75	0 / 86 / 14	Guldborg Søvik	IMR
Norway pout	*Trispoterus esmarkii*	Bony fish	Low		0.80	1.00	0.75	67 / 33 / 0	Espen Johnsen	IMR
Phakellia ventilabrum	*Phakellia ventilabrum*	Sponge	Low	x	1.00	1.00	0.25	100 / 0 / 0	Gro van der Meeren	IMR
Plaice	*Pleuronectes platessa*	Bony fish	Low		0.70	1.00	0.50	50 / 50 / 0	Tore Jakobsen	IMR
Polar cod	*Boreogadus saida*	Bony fish	Low		0.40	1.00	0.25	0 / 100 / 0	Sigurd Tjelmeland	IMR
Poliometra prolixa	*Poliometra prolixa*	Echinoderm	Low		1.00	1.00	0.25	100 / 0 / 0	Gro van der Meeren	IMR
Rays, skates	*Rajiformes*	Cartilaginous fish	Low		1.00	2.00	1.00	100 / 0 / 0	Tove Vollen	IMR
Roundnose grenadier	*Coryphaenoides rupestris*	Bony fish	Low		1.00	1.00	0.25	100 / 0 / 0	Hege Øverbø Hansen	IMR
Sand eel	*Ammodytes sp.*	Bony fish	Low	x	0.40	1.00	0.75	22 / 78 / 0	Espen Johnsen	IMR
Soft bottom fauna diversity ocean			Low	x	1.00	1.00	1.00	17 / 0 / 83	Eivind Oug	NIVA
Tentorium semisuberites	*Tentorium semisuberites*	Sponge	Low		1.00	1.00	0.25	100 / 0 / 0	Gro van der Meeren	IMR
Tusk	*Brosme brosme*	Bony fish	Low		0.80	1.00	1.00	14 / 0 / 86	Kristin Helle	IMR
Umbellula encrinus	*Umbellula encrinus*	Echinoderm	Low		1.00	1.00	0.25	100 / 0 / 0	Gro van der Meeren	IMR
Whiting	*Merlangius merlangus*	Bony fish	Low		0.60	2.00	0.50	0 / 100 / 0	Jennifer Devine	IMR

Ocean pelagic										
Name	Scientific name		Model	Key indicator	Specificty	Area size	Coverage	E/M/O	Contact(s)	Institution
Atlantic cod	*Gadus morhua*	Bony fish	Low	x	0.40	1.50	0.75	0 / 100 / 0	Asgeir Aglen	IMR
Atlantic halibut	*Hippoglossus hippoglossus*	Bony fish	Low		0.50	1.33	1.00	70 / 0 / 30	Erik Berg	IMR
Atlantic puffin	*Fratercula arctica*	Bird	Low		0.67	1.00	0.75	0 / 0 / 100	Svein Håkon Lorentsen	NINA
Atlantic salmon ocean	*Salmo salar*	Bony fish	Low		1.00	1.00	0.25	14 / 86 / 0	Vidar Wennevik	IMR
Basking shark	*Cetorhinus maximus*	Cartilaginous fish	Low		1.00	3.00	0.75	100 / 0 / 0	Tove Vollen	IMR
Blue whiting	*Micromesistius poutassou*	Bony fish	Low		1.00	2.00	0.50	0 / 100 / 0	Åge Høines	IMR
Calanus spp.	*Calanus spp.*	Crustaceans	Low	x	0.95	1.33	1.00	0 / 0 / 100	Cecilie Broms Tone Falkenhaug Tor Knutsen	IMR
Capelin	*Mallotus villosus*	Bony fish	Low	x	1.00	1.00	0.25	0 / 100 / 0	Sigurd Tjelmeland	IMR
Common guillemot	*Uria aalge*	Bird	Low		0.67	1.00	0.25	0 / 0 / 100	Svein Håkon Lorentsen	NINA
Deep sea redfish	*Sebastes mentella*	Bony fish	Low		0.75	2.00	0.50	0 / 100 / 0	Benjamin Planque	IMR
European Hake	*Merluccius merluccius*	Bony fish	Low		0.70	1.00	0.25	100 / 0 / 0	Otte Bjelland	IMR
Fin whale	*Balaenoptera physalus*	Mammal	Low		1.00	2.00	0.50	0 / 100 / 0	Nils Øien	IMR
Golden redfish	*Sebastes marinus*	Bony fish	Low		0.75	2.00	0.50	14 / 86 / 0	Benjamin Planque	IMR
Great skua	*Stercorarius skua*	Bird	Low		0.50	1.00	0.50	0 / 0 / 100	Svein Håkon Lorentsen	NINA
Greenland halibut	*Reinhardtius hippoglossoides*	Bony fish	Low		0.40	1.00	0.50	53 / 47 / 0	Elvar H. Alfredsson	IMR
Harp seal	*Phoca groenlandica*	Mammal	Low		1.00	1.00	0.25	25 / 75 / 0	Tor Arne Øigård	IMR
Herring – ocean populations	*Clupea harengus*	Bony fish	Low	x	0.80	1.50	0.75	0 / 100 / 0	Cecilie Kvamme Erling Kåre Stenvik	IMR
Herring (1-2 years)	*Clupea harengus*	Bony fish	Low	x	1.00	1.00	0.25	0 / 100 / 0	Erling Kåre Stenvik	IMR
Hooded seal	*Cystophora cristata*	Mammal	Low		0.80	1.00	0.25	0 / 100 / 0	Tor Arne Øigård	IMR
Humpback whale	*Megaptera novaeangliae*	Mammal	Low		1.00	1.00	1.00	91 / 0 / 9	Nils Øien	IMR
Jellyfish	*Scyphozoa sp*	Cnidarians	Low		0.90	1.00	0.25	0 / 0 / 100	Tone Falkenhaug	IMR
Lions mane jellyfish	*Cyana capilata*	Cnidarian	Low		0.90	1.00	0.25	0 / 0 / 100	Tone Falkenhaug	IMR

Ocean pelagic (cont.)										
Name	Scientific name		Model	Key indicator	Specificty	Area size	Coverage	E/M/O	Contact(s)	Institution
Mackerel	*Scomber scombrus*	Bony fish	Low	x	0.80	1.50	0.75	0 / 100 / 0	Leif Nøttestad	IMR
Minke whale	*Balaenoptera acutorostrata*	Mammal	Low		1.00	1.50	0.75	40 / 60 / 0	Nils Øien	IMR
Moon jelly	*Aurelia aurita*	Cnidarian	Low		0.90	1.00	0.25	0 / 0 / 100	Tone Falkenhaug Gro van der Meeren	IMR
Northern deep sea shrimp	*Pandalus borealis*	Crustacean	Low		0.30	1.00	0.75	0 / 86 / 14	Guldborg Søvik	IMR
Northern fulmar	*Fulmarus glacialis*	Bird	Low		0.67	1.00	0.50	8 / 0 / 92	Svein Håkon Lorentsen	NINA
Northern gannet	*Morus bassanus*	Bird	Low		0.67	1.00	0.75	6 / 0 / 94	Svein Håkon Lorentsen	NINA
Norway pout	*Trispoterus esmarkii*	Bony fish	Low		0.20	1.00	0.75	67 / 33 / 0	Espen Johnsen	IMR
Polar cod	*Boreogadus saida*	Bony fish	Low		0.60	1.00	0.25	0 / 100 / 0	Sigurd Tjelmeland	IMR
Razorbill	*Alca torda*	Bird	Low		0.67	1.00	0.50	17 / 0 / 83	Svein Håkon Lorentsen	NINA
Saithe	*Pollachius virens*	Bony fish	Low		0.10	1.00	0.50	0 / 58 / 42	Jennifer Devine	IMR
Sand eel	*Ammodytes sp.*	Bony fish	Low	x	0.20	1.00	0.75	22 / 78 / 0	Espen Johnsen	IMR
Silver smelt	*Argentina silus*	Bony fish	Low		1.00	1.00	0.50	100 / 0 / 0	Elvar H. Alfredsson	IMR
Coast bottom										
Name	Scientific name		Model	Key indicator	Specificty	Area size	Coverage	E/M/O	Contact(s)	Institution
Angler fish	*Lophus piscatorius*	Bony fish	Low		1.00	95.00	0.66	100 / 0 / 0	Otte Bjelland	IMR
Atlantic cod coastal populations	*Gadus morhua*	Bony fish	Low	x	0.80	21.36	0.82	19 / 24 / 57	Asgeir Aglen	IMR
Atlantic ditch shrimp	*Palaemonetes varians*	Crustacean	Low		1.00	7.00	0.15	71 / 0 / 29	Eivind Oug	NIVA
Atlantic halibut	*Hippoglossus hippoglossus*	Bony fish	Low		0.25	109.00	0.76	54 / 0 / 46	Erik Berg	IMR
Ballan wrasse	*Labrus surmuletus*	Bony fish	Low		1.00	4.57	0.11	0 / 0 / 100	Anne-Berit Skiftesvik	IMR
Benthic fauna sensitivity			Low	x	1.00	1.00	0.45	7 / 0 / 93	Hege Gundersen	NIVA
Benthic fauna species coast			Low	x	1.00	1.00	0.45	7 / 0 / 93	Hege Gundersen	NIVA
Black guillemot	*Cepphus grylle*	Bird	Low		1.00	2.00	0.01	17 / 0 / 83	Svein Håkon Lorentsen	NINA
Blue mussel	*Mytilus edulis*	Mollusc	Low		1.00	8.71	0.73	0 / 0 / 100	Eivind Oug	NIVA

Coast bottom (cont.)										
Name	Scientific name		Model	Key indicator	Specificty	Area size	Coverage	E/M/O	Contact(s)	Institution
Common eider	*Somateria mollissima*	Bird	Low		1.00	6.58	0.28	4 / 0 / 96	Svein Håkon Lorentsen	NINA
Corkwing wrasse	*Symphodus melops*	Bony fish	Low		1.00	4.67	0.10	0 / 0 / 100	Tore Johannesen	IMR
Cuvie	*Laminaria hyperborea*	Alga	Low	x	1.00	5.63	0.53	57 / 43 / 0	Hege Gundersen	NIVA
Dwarf Spike-rush	*Eleocharis parvula*	Seed plant	Low		1.00	54.00	0.57	33 / 0 / 67	Hanne Edvardsen Marit Mjelde	NIVA
Edible crab	*Cancer pagurus*	Crustacean	Low		1.00	23.33	0.49	13 / 0 / 87	Guldborg Søvik	IMR
European Eel	*Anguilla anguilla*	Bony fish	Low		0.75	4.50	0.09	0 / 0 / 100	Caroline Durif Tore Johannesen	IMR
European Hake	*Merluccius merluccius*	Bony fish	Low		0.05	22.00	0.08	100 / 0 / 0	Otte Bjelland	IMR
European lobster	*Homarus gammarus*	Crustacean	Low		1.00	12.22	0.38	0 / 0 / 100	Ann-Lisbeth Agnalt Alf Ring Kleiven	IMR
European oysters	*Ostrea edulis*	Mollusc	Low		1.00	3.00	0.02	93 / 0 / 7	Torjan Bodvin Øivind Strand	IMR
Gobies	*Gobidae*	Bony fish	Low		1.00	4.75	0.07	0 / 0 / 100	Tore Johannesen	IMR
Grey seal	*Halichoerus grypus*	Mammal	Low		0.30	11.80	0.21	38 / 63 / 0	Kjell Tormod Nilssen	IMR
Harbour seal	*Phoca vitulina*	Mammal	Low		0.30	9.57	0.47	32 / 17 / 52	Kjell Tormod Nilssen	IMR
King scallop	*Pecten maximus*	Mollusc	Low		1.00	7.00	0.02	100 / 0 / 0	Øivind Strand	IMR
Ling	*Molva molva*	Bony fish	Low		0.20	71.50	1.00	0 / 0 / 100	Kristin Helle	IMR
Lumpfish	*Cyclopterus lumpus*	Bony fish	Low		0.65	12.17	0.26	50 / 0 / 50	Knut Sunnanå	IMR
Macroalgae intertidal index		Algae	Low	x	1.00	4.06	0.23	100 / 0 / 0	Tone Kroglund Eivind Oug	NIVA
Macroalgae lower limit of growth		Algae	Low	x	1.00	1.00	0.12	0 / 0 / 100	Janne Kim Gitmark	NIVA
Otter coastal areas	*Lutra lutra*	Mammal	Low		0.65	1.01	0.97	0 / 100 / 0	Jiska Van Dijk	NINA
Plaice	*Pleuronectes platessa*	Bony fish	Low		0.30	80.00	0.56	100 / 0 / 0	Tore Jakobsen	IMR
Pollack	*Pollachius pollachius*	Bony fish	Low		0.75	4.33	0.09	0 / 0 / 100	Tore Johannesen	IMR
Saithe	*Pollachius virens*	Bony fish	Low		0.40	95.00	0.66	0 / 58 / 42	Jennifer Devine	IMR
Sand eel	*Ammodytes sp.*	Bony fish	Low	x	0.25	17.57	0.43	36 / 64 / 0	Espen Johnsen	IMR

Coast bottom (cont.)										
Name	Scientific name		Model	Key indicator	Specificty	Area size	Coverage	E/M/O	Contact(s)	Institution
Sand gaper	*Mya arenaria*	Mollusc	Low		1.00	36.71	0.90	100 / 0 / 0	Eivind Oug	NIVA
Spiny dogfish	*Squalus acanthias*	Cartilaginous fish	Low		0.70	247.00	0.86	100 / 0 / 0	Ole Albert Thomas	IMR
Sugar kelp	*Saccharina latissima*	Alga	Low	x	1.00	14.25	0.40	0 / 0 / 100	Hege Gundersen	NIVA
Tusk	*Brosme brosme*	Bony fish	Low		0.20	71.50	1.00	14 / 0 / 86	Kristin Helle	IMR
Whiting	*Merlangius merlangus*	Bony fish	Low		0.40	91.00	0.32	100 / 0 / 0	Jennifer Devine	IMR
Wolffish	*Anarhichas lupus*	Bony fish	Low		1.00	56.00	0.59	100 / 0 / 0	Kjell Nedreaas	IMR

Coast pelagic										
Name	Scientific name		Model	Key indicator	Specificty	Area size	Coverage	E/M/O	Contact(s)	Institution
Arctic tern	*Sterna paradisaea*	Bird	Low		1.00	7.33	0.08	20 / 0 / 80	Svein Håkon Lorentsen	NINA
Atlantic cod coastal populations	*Gadus morhua*	Bony fish	Low	x	0.20	21.36	0.82	19 / 24 / 57	Asgeir Aglen	IMR
Atlantic halibut	*Hippoglossus hippoglossus*	Bony fish	Low		0.10	109.00	0.76	54 / 0 / 46	Erik Berg	IMR
Atlantic puffin	*Fratercula arctica*	Bird	Low		0.33	2.80	0.05	9 / 0 / 91	Svein Håkon Lorentsen	NINA
Atlantic salmon coast and rivers	*Salmo salar*	Bony fish	Low		0.40	9.25	0.52	16 / 84 / 0	Peder Fiske	NINA
Black-legged kittiwake	*Rissa tridactyla*	Bird	Low		1.00	3.00	0.05	0 / 0 / 100	Svein Håkon Lorentsen	NINA
Brünnich guillemot	*Uria lomvia*	Bird	Low		0.33	3.00	0.01	0 / 0 / 100	Svein Håkon Lorentsen	NINA
Calanus spp.	*Calanus spp.*	Crustaceans	Low	x	0.05	10.33	0.11	0 / 0 / 100	Cecilie Broms Tone Falkenhaug Tor Knutsen	IMR
Common guillemot	*Uria aalge*	Bird	Low		0.33	3.00	0.05	3 / 0 / 97	Svein Håkon Lorentsen	NINA
Common gull coast	*Larus canus*	Bird	Low		0.50	7.33	0.08	0 / 0 / 100	Svein Håkon Lorentsen	NINA
Common tern	*Sterna hirundo*	Bird	Low		1.00	5.50	0.04	0 / 0 / 100	Svein Håkon Lorentsen	NINA
European Hake	*Merluccius merluccius*	Bony fish	Low		0.10	22.00	0.08	100 / 0 / 0	Otte Bjelland	IMR
European shag	*Phalacrocorax aristotelis*	Bird	Low		1.00	3.00	0.04	0 / 0 / 100	Svein Håkon Lorentsen	NINA
Great black-backed gull	*Larus marinus*	Bird	Low		0.50	8.00	0.08	0 / 0 / 100	Svein Håkon Lorentsen	NINA

Coast pelagic (cont.)

Name	Scientific name		Model	Key indicator	Specificty	Area size	Coverage	E/M/O	Contact(s)	Institution
Great cormorant ssp. carbo	*Phalacrocorax carbo carbo*	Bird	Low		1.00	4.29	0.10	0 / 0 / 100	Svein Håkon Lorentsen	NINA
Great cormorant ssp. sinensis	*Phalacrocorax carbo sinensis*	Bird	Low		1.00	6.00	0.02	0 / 0 / 100	Svein Håkon Lorentsen	NINA
Great skua	*Stercorarius skua*	Bird	Low		0.50	2.50	0.02	0 / 0 / 100	Svein Håkon Lorentsen	NINA
Grey seal	*Halichoerus grypus*	Mammal	Low		0.70	11.80	0.21	38 / 63 / 0	Kjell Tormod Nilssen	IMR
Harbour seal	*Phoca vitulina*	Mammal	Low		0.70	9.57	0.47	32 / 17 / 52	Kjell Tormod Nilssen	IMR
Herring – coastal populations	*Clupea harengus*	Bony fish	Low	x	1.00	94.00	0.66	100 / 0 / 0	Cecilie Kvamme	IMR
Herrring gull	*Larus argentatus*	Bird	Low		0.50	7.67	0.08	0 / 0 / 100	Svein Håkon Lorentsen	NINA
Lesser black-backed gull ssp. fuscus	*Larus fuscus fuscus*	Bird	Low		1.00	8.50	0.06	0 / 0 / 100	Svein Håkon Lorentsen	NINA
Lesser black-backed gull ssp. intermedius	*Larus fuscus intermedius*	Bird	Low		1.00	5.50	0.04	0 / 0 / 100	Svein Håkon Lorentsen	NINA
Lions mane jellyfish	*Cyana capilata*	Cnidarian	Low		0.10	1.00	0.00	0 / 0 / 100	Tone Falkenhaug	IMR
Lumpfish	*Cyclopterus lumpus*	Bony fish	Low		0.35	12.17	0.26	50 / 0 / 50	Knut Sunnanå	IMR
Mackerel	*Scomber scombrus*	Bony fish	Low	x	0.20	79.50	0.56	0 / 100 / 0	Leif Nøttestad	IMR
Moon jelly	*Aurelia aurita*	Cnidarian	Low		0.10	1.00	0.00	0 / 0 / 100	Tone Falkenhaug Gro van der Meeren	IMR
Northern fulmar	*Fulmarus glacialis*	Bird	Low		0.33	4.33	0.05	15 / 0 / 85	Svein Håkon Lorentsen	NINA
Northern gannet	*Morus bassanus*	Bird	Low		0.33	5.00	0.07	0 / 0 / 100	Svein Håkon Lorentsen	NINA
Phytoplankton			Max	x	1.00	1.08	0.55	0 / 0 / 100	Wenche Eikrem Lars-Johan Naustvold Eivind Oug	IMR NIVA
Pollack	*Pollachius pollachius*	Bony fish	Low		0.25	4.33	0.09	0 / 0 / 100	Tore Johannesen	IMR
Razorbill	*Alca torda*	Bird	Low		0.33	2.67	0.03	0 / 0 / 100	Svein Håkon Lorentsen	NINA
Saithe	*Pollachius virens*	Bony fish	Low		0.50	95.00	0.66	0 / 58 / 42	Jennifer Devine	IMR
Sand eel	*Ammodytes sp.*	Bony fish	Low	x	0.15	17.57	0.43	36 / 64 / 0	Espen Johnsen	IMR
Spiny dogfish	*Squalus acanthias*	Cartilaginous fish	Low		0.30	247.00	0.86	100 / 0 / 0	Ole Albert Thomas	IMR
Sprat	*Sprattus sprattus*	Bony fish	Low		1.00	53.33	0.56	100 / 0 / 0	Cecilie Kvamme	IMR
White-tailed eagle	*Haliaeetus albicilla*	Bird	Low		0.70	20.40	0.71	100 / 0 / 0	Torgeir Nygård	NINA

Forest										
Name	Scientific name		Model	Key indicator	Specificty	Area size	Coverage	E/M/O	Contact(s)	Institution
Albatrellus cristatus	*Albatrellus cristatus*	Basidiomycete	Low		1.00	9.00	0.02	100 / 0 / 0	Tor Erik Brandrud	NINA
Algae on Birch		Algae	Low		1.00	1.00	1.00	0 / 100 / 0	Inga Bruteig Marianne Evju	NINA
Amylocystis lapponica	*Amylocystis lappon-ica*	Basidiomycete	Low		1.00	25.00	0.06	100 / 0 / 0	Tor Erik Brandrud	NINA
Antrodia albobrunnea	*Antrodia albobrunnea*	Basidiomycete	Low		1.00	352.00	0.82	100 / 0 / 0	Tor Erik Brandrud	NINA
Artomyces pyxidatus	*Artomyces pyxidatus*	Basidiomycete	Low		1.00	341.00	0.80	100 / 0 / 0	Tor Erik Brandrud	NINA
Bay Willow swamp woodland			Low		1.00	17.00	0.12	100 / 0 / 0	Jarle W. Bjerke	NINA
Bilberry	*Vaccinium myrtillus*	Seed plant	Low	x	1.00	18.57	1.00	0 / 60 / 40	Ken Olaf Storaunet	NIBIO
Black grouse	*Tetrao tetrix*	Bird	Low		1.00	21.68	0.96	100 / 0 / 0	Erlend Nilsen Hans Christian Pedersen	NINA
Black woodpecker	*Dryocopus martius*	Bird	Low		1.00	207.00	0.48	0 / 0 / 100	Hans Christian Pedersen	NINA
Blackcap	*Sylvia atricapilla*	Bird	Low		1.00	194.50	0.91	33 / 0 / 67	Hans Christian Pedersen	NINA
Brambling	*Fringilla montifrin-gilla*	Bird	Low		1.00	213.50	1.00	0 / 0 / 100	Hans Christian Pedersen	NINA
Brown bear	*Ursus arctos*	Mammal	Low		0.75	427.00	1.00	0 / 38 / 63	Henrik Brøseth	NINA
Bullfinch	*Pyrrhula pyrrhula*	Bird	Low		1.00	213.50	1.00	0 / 0 / 100	Hans Christian Pedersen	NINA
Bumblebees in forest		Insects	Low		1.00	40.33	0.28	0 / 0 / 100	Sandra Åström	NINA
Butterflies in forest		Insects	Low		1.00	40.33	0.28	0 / 0 / 100	Sandra Åström	NINA
Cantharellus melanoxeros	*Cantharellus melanoxeros*	Basidiomycete	Low		1.00	50.00	0.12	100 / 0 / 0	Tor Erik Brandrud	NINA
Capercaillie	*Tetrao urogallus*	Bird	Low		1.00	20.74	0.92	100 / 0 / 0	Erlend Nilsen Hans Christian Pedersen	NINA
Coal tit	*Parus ater*	Bird	Low		1.00	200.50	0.94	0 / 0 / 100	Hans Christian Pedersen	NINA
Common blackbird	*Turdus merula*	Bird	Low		1.00	201.00	0.94	0 / 0 / 100	John-Atle Kålås Hans Chris-tian Pedersen	NINA
Common chaffinch	*Fringilla coelebs*	Bird	Low		1.00	213.50	1.00	0 / 0 / 100	Hans Christian Pedersen	NINA
Common Chiffchaff	*Phylloscopus collybita*	Bird	Low		1.00	212.50	1.00	33 / 0 / 67	Hans Christian Pedersen	NINA
Common redstart	*Phoenicurus phoenicurus*	Bird	Low		1.00	213.50	1.00	0 / 0 / 100	Hans Christian Pedersen	NINA

Forest (cont.)

Name	Scientific name		Model	Key indicator	Specificty	Area size	Coverage	E/M/O	Contact(s)	Institution
Common wood pigeon	*Columba palumbus*	Bird	Low		1.00	205.50	0.96	0 / 0 / 100	Hans Christian Pedersen	NINA
Cortinarius cupreorufus	*Cortinarius cupreorufus*	Basidiomycete	Low		1.00	36.00	0.08	100 / 0 / 0	Tor Erik Brandrud	NINA
Cortinarius nanceiensis	*Cortinarius nanceiensis*	Basidiomycete	Low		1.00	1.00	0.02	100 / 0 / 0	Tor Erik Brandrud	NINA
Crested tit	*Parus cristatus*	Bird	Low		1.00	341.00	0.80	33 / 0 / 67	Hans Christian Pedersen	NINA
Cujucus cinnaberinus	*Cujucus cinnaberinus*	Insect	Low		1.00	2.00	0.01	100 / 0 / 0	Frode Ødegaard	NINA
Diacanthous undulatus	*Diacanthous undulatus*	Insect	Low		1.00	42.00	0.59	100 / 0 / 0	Frode Ødegaard	NINA
Dunnock	*Prunella modularis*	Bird	Low		1.00	213.50	1.00	0 / 0 / 100	Hans Christian Pedersen	NINA
Eearwort species	*Scapania apiculata*	Moss	Low		1.00	25.10	0.59	100 / 0 / 0	Kristian Hassel	NTNU
Eurasian jay	*Garrulus glandarius*	Bird	Low		1.00	383.00	0.90	0 / 0 / 100	Hans Christian Pedersen	NINA
Eurasian treecreeper	*Certhia familiaris*	Bird	Low		1.00	396.00	0.93	25 / 0 / 75	John-Atle Kålås Hans Chris-tian Pedersen	NINA
European robin	*Erithacus rubecula*	Bird	Low		1.00	205.00	0.96	0 / 0 / 100	Hans Christian Pedersen	NINA
European Roe Deer	*Capreolus capreolus*	Mammal	Low		1.00	23.67	1.00	5 / 95 / 0	Erling Solberg	NINA
Fallen dead wood (volume)			Low	x	1.00	18.57	1.00	0 / 86 / 14	Ken Olaf Storaunet	NIBIO
Fallen dead wood (area)			Low		1.00	18.57	1.00	0 / 33 / 67	Ken Olaf Storaunet	NIBIO
Frullania bolanderi	*Frullania bolanderi*	Liverwort	Low		1.00	18.83	0.26	100 / 0 / 0	Kristian Hassel	NTNU
Garden warbler	*Sylvia borin*	Bird	Low		1.00	427.00	1.00	0 / 0 / 100	Hans Christian Pedersen	NINA
Geastrum spp.	*Geastrum spp.*	Basidiomycete	Low		1.00	427.00	1.00	100 / 0 / 0	Tor Erik Brandrud	NINA
Goldcrest	*Regulus regulus*	Bird	Low		1.00	204.00	0.96	0 / 0 / 100	Hans Christian Pedersen	NINA
Gomphus clavatus	*Gomphus clavatus*	Basidiomycete	Low		1.00	28.00	0.07	100 / 0 / 0	Tor Erik Brandrud	NINA
Goshawk	*Accipiter gentilis*	Bird	Low		1.00	21.50	0.91	96 / 0 / 4	Torgeir Nygård	NINA
Gray lungwort	*Lobaria hallii*	Lichen	Low		1.00	7.89	0.17	100 / 0 / 0	Jarle W. Bjerke	NINA
Great spotted woodpecker	*Dendrocopos major*	Bird	Low		1.00	204.00	0.96	0 / 0 / 100	Hans Christian Pedersen	NINA
Green woodpecker	*Picus viridis*	Bird	Low		1.00	328.00	0.77	0 / 0 / 100	Hans Christian Pedersen	NINA
Hypogymnia physodes alpine birch forest	*Hypogymnia phy-sodes*	Lichen	Max		1.00	4.17	0.06	14 / 59 / 27	Inga Bruteig Marianne Evju	NINA

Forest (cont.)										
Name	Scientific name		Model	Key indicator	Specificty	Area size	Coverage	E/M/O	Contact(s)	Institution
Icterine warbler	*Hippolais icterina*	Bird	Low		1.00	129.00	0.91	33 / 0 / 67	Hans Christian Pedersen	NINA
Kusymre	*Primula vulgaris*	Seed plant	Low		1.00	1.00	0.22	0 / 100 / 0	Anders Often Olav Skarpaas Odd Stabbetorp	NINA
Lichen heath	*Cladonia & Cetraria s.l. spp.*	Lichens	Low		0.10	2.17	0.21	76 / 2 / 21	Jarle W. Bjerke	NINA
Lynx	*Lynx lynx*	Mammal	Low		1.00	53.38	1.00	0 / 0 / 100	Henrik Brøseth	NINA
Melanelia olivacea alpine birch forest	*Melanelia olivacea*	Lichen	Low		1.00	4.17	0.06	12 / 63 / 26	Inga Bruteig Marianne Evju	NINA
Mistle thrush	*Turdus viscivorus*	Bird	Low		1.00	232.00	0.54	50 / 0 / 50	Hans Christian Pedersen	NINA
Moose	*Alces alces*	Mammal	Low		1.00	23.67	1.00	5 / 95 / 0	Erling Solberg	NINA
Neckera pennata	*Neckera pennata*	Moss	Low		1.00	17.14	0.28	100 / 0 / 0	Kristian Hassel	NTNU
Nothorhina punctata	*Nothorhina punctata*	Insect	Low		1.00	16.83	0.24	100 / 0 / 0	Frode Ødegaard	NINA
Oak fern in alpine birch forest	*Gymnocarpium dryopteris*	Fern	Low		1.00	6.83	0.10	25 / 50 / 25	Per Arild Aarrestad	NINA
Oak fern in spruce forest	*Gymnocarpium dryopteris*	Fern	Low		1.00	4.70	0.11	0 / 85 / 15	Tonje Økland	NIBIO
Old deciduous forest			Low	x	1.00	19.43	0.96	0 / 33 / 67	Ken Olaf Storaunet	NIBIO
Old trees			Low	x	1.00	18.57	1.00	0 / 33 / 67	Ken Olaf Storaunet	NIBIO
One-flowered wintergreen	*Moneses uniflora*	Seed plant	Low		1.00	1.00	0.64	0 / 100 / 0	Anders Often Olav Skarpaas Odd Stabbetorp	NINA
Orthotrichum rogeri	*Orthotrichum rogeri*	Moss	Low		1.00	24.00	0.39	100 / 0 / 0	Kristian Hassel	NTNU
Phellinus nigrolimitatus	*Phellinus nigrolimitatus*	Basidiomycete	Low		1.00	387.00	0.91	100 / 0 / 0	Tor Erik Brandrud	NINA
Pied Flycatcher	*Ficedula hypoleuca*	Bird	Low		1.00	213.50	1.00	33 / 0 / 67	Hans Christian Pedersen	NINA
Plagiosterna aenea	*Plagiosterna aenea*	Insect	Low		1.00	76.40	0.89	100 / 0 / 0	Frode Ødegaard	NINA
Red deer	*Cervus elaphus*	Mammal	Low		1.00	23.88	0.89	5 / 95 / 0	Erling Solberg	NINA
Redwing	*Turdus iliacus*	Bird	Low		1.00	213.50	1.00	0 / 0 / 100	Hans Christian Pedersen	NINA
Rough-legged buzzard	*Buteo lagopus*	Bird	Low		0.20	185.00	0.87	50 / 0 / 50	Hans Christian Pedersen	NINA
Sarcodon spp.	*Sarcodon spp.*	Basidiomycete	Low		1.00	383.00	0.90	100 / 0 / 0	Tor Erik Brandrud	NINA

Forest (cont.)										
Name	Scientific name		Model	Key indicator	Specificty	Area size	Coverage	E/M/O	Contact(s)	Institution
Scots elm	*Ulmus glabra*	Seed plant	Low		1.00	1.00	0.76	0 / 100 / 0	Anders Often Olav Skarpaas Odd Stabbetorp	NINA
Small rodents forest		Mammals	Low	x	1.00	19.27	0.50	100 / 0 / 0	Erik Framstad	NINA
Song thrush	*Turdus philomelos*	Bird	Low		1.00	209.00	0.98	33 / 0 / 67	Hans Christian Pedersen	NINA
Sphagnum wulfianum	*Sphagnum wulfianum*	Moss	Low		1.00	22.71	0.37	100 / 0 / 0	Kristian Hassel	NTNU
Spotted flycatcher	*Muscicapa striata*	Bird	Low		1.00	213.50	1.00	0 / 0 / 100	Hans Christian Pedersen	NINA
Stair-step Moss	*Hylocomium splendens*	Moss	Max		1.00	5.73	0.15	0 / 85 / 15	Tonje Økland	NIBIO
Standing dead wood (area)			Low		1.00	18.57	1.00	0 / 33 / 67	Ken Olaf Storaunet	NIBIO
Standing dead wood (volume)			Low	x	1.00	18.57	1.00	0 / 86 / 14	Ken Olaf Storaunet	NIBIO
Tayloria splachnoides	*Tayloria splachnoides*	Moss	Low		1.00	26.17	0.37	100 / 0 / 0	Kristian Hassel	NTNU
Tree pipit	*Anthus trivialis*	Bird	Low		1.00	106.75	1.00	0 / 0 / 100	Hans Christian Pedersen	NINA
Trees with pendant lichens			Low		1.00	18.24	0.90	0 / 31 / 69	Ken Olaf Storaunet	NIBIO
Wayvy hairgrass in subalpine birch forest	*Avenella flexuosa*	Seed plant	Max		1.00	7.00	0.10	35 / 52 / 13	Per Arild Aarrestad	NINA
Wayvy Hairgrass in spruce forest	*Avenella flexuosa*	Seed plant	Max		1.00	5.73	0.15	0 / 85 / 15	Tonje Økland	NIBIO
Willow ptarmigan	*Lagopus lagopus*	Bird	Low		0.30	17.68	0.79	100 / 0 / 0	Erlend Nilsen Hans Christian Pedersen	NINA
Willow tit	*Parus montanus*	Bird	Low		1.00	211.50	0.99	33 / 0 / 67	Hans Christian Pedersen	NINA
Willow Warbler	*Phylloscopus trochilus*	Bird	Low		1.00	106.75	1.00	33 / 0 / 67	Hans Christian Pedersen	NINA
Wolf	*Canis lupus*	Mammal	Low		1.00	22.47	1.00	0 / 0 / 100	Henrik Brøseth	NINA
Wolverine	*Gulo gulo*	Mammal	Low		0.25	53.38	1.00	0 / 0 / 100	Henrik Brøseth	NINA
Wren	*Troglodytes troglodytes*	Bird	Low		1.00	188.50	0.88	0 / 0 / 100	Hans Christian Pedersen	NINA

Wetland										
Name	Scientific name		Model	Key indicator	Specificty	Area size	Coverage	E/M/O	Contact(s)	Institution
Atlantic raised bog			Low	x	1.00	19.18	0.49	100 / 0 / 0	Jarle W. Bjerke	NINA
Austin's bog moss	*Sphagnum austinii*	Moss	Low		1.00	30.00	0.07	50 / 0 / 50	Kristian Hassel	NTNU
Bladder sedge	*Carex vesicaria*	Seed plant	Low		1.00	1.00	0.66	0 / 100 / 0	Anders Often Olav Skarpaas Odd Stabbetorp	NINA
Brown beak-sedge	*Rhynchospora fusca*	Seed plant	Low		1.00	1.00	0.36	0 / 100 / 0	Anders Often Olav Skarpaas Odd Stabbetorp	NINA
Cinclidium arcticum	*Cinclidium arcticum*	Moss	Low		1.00	23.75	0.22	100 / 0 / 0	Kristian Hassel	NTNU
Common crane	*Grus grus*	Bird	Low		1.00	88.33	0.62	67 / 0 / 33	Hans Christian Pedersen	NINA
Common Frog	*Rana temporaria*	Amphibian	Low		1.00	24.06	0.95	100 / 0 / 0	Børre Dervo	NINA
Common redshank	*Tringa totanus*	Bird	Low		1.00	214.50	1.00	33 / 0 / 67	Hans Christian Pedersen	NINA
Common snipe	*Gallinago gallinago*	Bird	Low		1.00	214.50	1.00	33 / 0 / 67	Hans Christian Pedersen	NINA
Dipper	*Cinclus cinclus*	Bird	Low		0.25	214.00	1.00	100 / 0 / 0	Hans Christian Pedersen	NINA
Dune tiger beetle	*Cicindela maritima*	Insect	Low	x	1.00	1.00	0.04	100 / 0 / 0	Frode Ødegaard	NINA
Dunlin	*Calidris alpina*	Bird	Low		1.00	166.50	0.78	100 / 0 / 0	Hans Christian Pedersen	NINA
Early marsh-orchid	*Dactylorhiza incarnata incarnata*	Seed plant	Low		1.00	1.00	0.47	0 / 100 / 0	Anders Often Olav Skarpaas Odd Stabbetorp	NINA
Elaphrus uliginosus	*Elaphrus uliginosus*	Insect	Low		1.00	29.80	0.69	100 / 0 / 0	Frode Ødegaard	NINA
Few-flowered sedge	*Carex pauciflora*	Seed plant	Low		1.00	1.00	0.90	0 / 100 / 0	Anders Often Olav Skarpaas Odd Stabbetorp	NINA
Great Crested Newt	*Triturus cristatus*	Amphibian	Low		1.00	15.71	0.26	25 / 0 / 75	Børre Dervo	NINA
Great snipe	*Gallinago media*	Bird	Low		1.00	27.33	0.19	100 / 0 / 0	Hans Christian Pedersen	NINA
Great sundew	*Drosera anglica*	Seed plant	Low		1.00	1.00	0.87	0 / 100 / 0	Anders Often Olav Skarpaas Odd Stabbetorp	NINA
Greenshank	*Tringa nebularia*	Bird	Low		1.00	113.50	0.53	50 / 0 / 50	Hans Christian Pedersen	NINA
Lichen heath	*Cladonia & Cetraria s.l. spp.*	Lichens	Low		0.05	2.17	0.21	76 / 2 / 21	Jarle W. Bjerke	NINA

Wetland (cont.)										
Name	Scientific name		Model	Key indicator	Specificty	Area size	Coverage	E/M/O	Contact(s)	Institution
Marsh fern	*Thelypteris palustris*	Fern	Low		1.00	1.00	0.09	0 / 100 / 0	Anders Often Olav Skarpaas Odd Stabbetorp	NINA
Meesia longiseta	*Meesia longiseta*	Moss	Low		1.00	22.78	0.48	100 / 0 / 0	Kristian Hassel	NTNU
Oblong-leaved sundew	*Drosera intermedia*	Seed plant	Low		1.00	1.00	0.39	0 / 100 / 0	Anders Often Olav Skarpaas Odd Stabbetorp	NINA
Palsa mire			Low	x	1.00	3.63	0.07	91 / 0 / 9	Jarle W. Bjerke	NINA
Red-necked phalarope	*Phalaropus lobatus*	Bird	Low		1.00	79.00	0.37	100 / 0 / 0	Hans Christian Pedersen	NINA
Reed bunting	*Emberiza schoeniclus*	Bird	Low		1.00	214.50	1.00	33 / 0 / 67	Hans Christian Pedersen	NINA
Sedge warbler	*Acrocephalus schoenobaenus*	Bird	Low		1.00	168.50	0.79	100 / 0 / 0	Hans Christian Pedersen	NINA
Smooth Newt	*Lissotriton vulgaris*	Amphibian	Low		1.00	16.00	0.41	16 / 0 / 84	Børre Dervo	NINA
Varnished hook-moss	*Hamatocaulis vernicosus*	Moss	Low		1.00	21.00	0.39	100 / 0 / 0	Kristian Hassel	NTNU
Whimbrel	*Numenius phaeopus*	Bird	Low		1.00	164.00	0.76	50 / 0 / 50	Hans Christian Pedersen	NINA
White beak-sedge	*Rhynchospora alba*	Seed plant	Low		1.00	1.00	0.64	0 / 100 / 0	Anders Often Olav Skarpaas Odd Stabbetorp	NINA
Wood sandpiper	*Tringa glareola*	Bird	Low		1.00	149.50	0.70	50 / 0 / 50	Hans Christian Pedersen	NINA
Yellow wagtail	*Motacilla flava*	Bird	Low		1.00	175.50	0.82	50 / 0 / 50	Hans Christian Pedersen	NINA
Open lowland										
Name	Scientific name		Model	Key indicator	Specificty	Area size	Coverage	E/M/O	Contact(s)	Institution
Arnica	*Arnica montana*	Seed plant	Low		1.00	1.00	0.47	0 / 100 / 0	Anders Often Olav Skarpaas Odd Stabbetorp	NINA
Bell heather	*Erica cinerea*	Seed plant	Low		1.00	1.00	0.10	0 / 100 / 0	Anders Often Olav Skarpaas Odd Stabbetorp	NINA
Broad scalewort	*Porella obtusata*	Liverwort	Low		1.00	28.33	0.20	100 / 0 / 0	Kristian Hassel	NTNU
Bumblebees in open lowland		Insects	Low		1.00	40.67	0.28	0 / 0 / 100	Sandra Åström	NINA

Open lowland (cont.)

Name	Scientific name		Model	Key indicator	Specificty	Area size	Coverage	E/M/O	Contact(s)	Institution
Butterflies in open lowland		Insects	Low		1.00	40.67	0.28	0 / 0 / 100	Sandra Åström	NINA
Clavaria spp.	*Clavaria spp.*	Basidiomycete	Low		1.00	27.31	0.83	100 / 0 / 0	Tor Erik Brandrud John-Bjarne Jordal	NINA Biolog J.B. Jordal AS
Clouded Apollo	*Parnassius mnemosyne*	Insect	Low		1.00	6.00	0.01	100 / 0 / 0	Frode Ødegaard	NINA
Coastal heathland state		Seed plants	Low	x	1.00	1.00	0.25	100 / 0 / 0	Knut Anders Hovstad Line Johansen	NIBIO
Common Extinguisher-moss	*Encalypta vulgaris*	Moss	Low		1.00	19.50	0.45	100 / 0 / 0	Kristian Hassel	NTNU
Common gull coast	*Larus canus*	Bird	Low		0.50	7.33	0.05	0 / 0 / 100	Svein Håkon Lorentsen	NINA
Dor Beetle	*Geotrupes stercorarius*	Insect	Low		1.00	51.38	0.96	100 / 0 / 0	Frode Ødegaard	NINA
Entoloma bloxamii	*Entoloma bloxamii*	Basidiomycete	Low		1.00	25.33	0.71	100 / 0 / 0	Tor Erik Brandrud John-Bjarne Jordal	NINA Biolog J.B. Jordal AS
Eurasian eagle owl	*Bubo bubo*	Bird	Low		1.00	209.00	0.97	100 / 0 / 0	Hans Christian Pedersen	NINA
Eurasian oystercatcher	*Haematopus ostralegus*	Bird	Low		1.00	318.00	0.74	0 / 0 / 100	Hans Christian Pedersen	NINA
Eurasian rock pipit	*Anthus petrosus*	Bird	Low		1.00	83.67	0.58	100 / 0 / 0	Hans Christian Pedersen	NINA
Geoglossum, Microglossum, Trichoglossum spp.	*Geoglossum, Microglossum, Trichoglossum spp.*	Ascomycete	Low		1.00	23.21	0.76	100 / 0 / 0	Tor Erik Brandrud John-Bjarne Jordal	NINA Biolog J.B. Jordal AS
Great black-backed gull	*Larus marinus*	Bird	Low		0.50	8.00	0.06	0 / 0 / 100	Svein Håkon Lorentsen	NINA
Heath plait-moss	*Hypnum jutlandicum*	Moss	Low		1.00	27.11	0.57	100 / 0 / 0	Kristian Hassel	NTNU
Herrring gull	*Larus argentatus*	Bird	Low		0.50	7.67	0.05	0 / 0 / 100	Svein Håkon Lorentsen	NINA
Hygrocybe spp.	*Hygrocybe spp.*	Basidiomycete	Low		1.00	22.69	0.84	100 / 0 / 0	Tor Erik Brandrud John-Bjarne Jordal	NINA Biolog J.B. Jordal AS
Meligethes norvegicus	*Meligethes norvegicus*	Insect	Low		1.00	1.33	0.01	100 / 0 / 0	Frode Ødegaard	NINA

Open lowland (cont.)										
Name	Scientific name		Model	Key indicator	Specificty	Area size	Coverage	E/M/O	Contact(s)	Institution
Oxeye daisy	*Leucanthemum vulgare*	Seed plant	Low		1.00	1.00	0.90	0 / 100 / 0	Anders Often Olav Skarpaas Odd Stabbetorp	NINA
Pale bog-moss	*Sphagnum strictum*	Moss	Low		1.00	25.08	0.70	100 / 0 / 0	Kristian Hassel	NTNU
Peregrine falcon	*Falco peregrinus*	Bird	Low		1.00	106.33	0.74	100 / 0 / 0	Hans Christian Pedersen	NINA
Purple moore grass	*Molinia caerulea*	Seed plant	Max		1.00	12.33	0.17	100 / 0 / 0	Per Arild Aarrestad	NINA
Red-throated pipit	*Anthus cervinus*	Bird	Low		1.00	37.00	0.09	100 / 0 / 0	Hans Christian Pedersen	NINA
Semi-natural grasslands state		Seed plants	Low	x	1.00	1.00	1.00	100 / 0 / 0	Knut Anders Hovstad Line Johansen	NIBIO
Violet Oil-beetle	*Meloe violaceus*	Insect	Low	x	1.00	28.67	1.00	100 / 0 / 0	Frode Ødegaard	NINA
White-tailed eagle	*Haliaeetus albicilla*	Bird	Low		0.30	20.60	0.48	100 / 0 / 0	Torgeir Nygård	NINA

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NINA Report

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Norwegian Institute for Nature Research
NINA head office
Postal address: P.O. Box 5685 Sluppen, NO-7485 Trondheim, NORWAY
Visiting address: Høgskoleringen 9, 7034 Trondheim
Phone: +47 73 80 14 00
E-mail: firmapost@nina.no
Organization Number: 9500 37 687
http://www.nina.no

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