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NINA Report

The Arctic Nature Index (ANI)

Challenges and Opportunities

Gregoire Certain, Pål Kvaløy, Kári Fannar Lárusson,

Hólmgrímur Helgason, Tom Barry, Signe Nybø, Stein Are Sæther

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Norwegian Institute for Nature Research

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The Arctic Nature Index (ANI)

Challenges and Opportunities

Gregoire Certain[1]

Pål Kvaløy[1]

Kári Fannar Lárusson[2]

Hólmgrímur Helgason[2]

Tom Barry[2]

Signe Nybø[1]

Stein Are Sæther[1]

1 - Norwegian Institute for Nature Research, Trondheim, Norway.

2 - CAFF secretariat, Akureyri, Iceland.

Conservation of Arctic Flora and Fauna

Norwegian Institute for Nature Research

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KONTAKTOPPLYSNINGER

NINA hovedkontor
Postboks 5685 Sluppen
7485 Trondheim
Telefon: 73 80 14 00

NINA Oslo
Gaustadalléen 21
0349 Oslo
Telefon: 73 80 14 00

NINA Tromsø
Framsenteret
9296 Tromsø
Telefon: 77 75 04 00

NINA Lillehammer
Fakkelgården
2624 Lillehammer
Telefon: 73 80 14 00

www.nina.no

Abstract

Certain, G., Kvaløy, P., Lárusson, K. F., Helgason, H., Barry, T., Nybø, S., Sæther, S. A. 2015. The Arctic Nature Index (NI). Challenges and opportunities - NINA Report 1142, 37 pp.

This report summarizes the results of two joint pilot projects conducted by the Conservation of Arctic Flora and Fauna (CAFF), the biodiversity working group of the Arctic Council and the Norwegian Environment Agency (NEA), concerning the implementation of the Nature Index (NI) framework in Svalbard and the circumpolar Arctic. The aims of these two pilot projects were to (1) investigate the possibility of establishing the NI in the Arctic; (2) transfer competence to the CAFF secretariat to manage such implementation; and (3) establish a pilot website to test the NI-framework. This report discuss choices regarding area divisions, major ecosystems and indicators for the implementation of the Nature Index framework in the Arctic. It presents a pilot website designed to test indicators for Arctic areas. Basic spatial units have been selected and implemented in the pilot web-site for the Barents Sea, Iceland and Svalbard. For all areas, both marine and terrestrial, basic spatial units must be agreed upon before implementation in the website. Testing the website and methodology is only possible when basic spatial units are defined.

Successful implementation of a useful Arctic Nature Index (ANI) and in Svalbard will depend upon the quality and extent of included indicator data series; broader inclusion of taxonomic and ecological functions will strengthen its value. We recommend that the already established expert groups within CAFF and Environmental monitoring of Svalbard and Jan Mayen (MOSJ) should define the indicators and the necessary ecological information. Scientists participating in the project should be in charge of selecting what nature indices are presented, that is, indices presenting the state of biodiversity within a major ecosystem and/or area, or thematic indices on e.g., groups of species. The participating scientists should also be involved in writing reports/ papers based on these results as is the practice in Norway. The purpose of this pilot project is therefore to propose a platform to collect, standardize and present ecological information on these indicators – not to replace an already existing process

Corresponding author: Signe Nybø, Norwegian Institute for Nature Research (NINA), Postboks 5685 Sluppen, NO-7485 Trondheim . signe.nybo@nina.no

Sammendrag

Certain, G., Kvaløy' P., Lárusson, K. F., Helgason, H., Barry, T., Nybø, S. Sæther, S. A. 2015. The Arctic Nature Index (ANI). Challenges and opportunities - NINA Report 1142, 37 pp.

Denne rapporten oppsummerer resultatet av to utviklingsprosjekt satt i gang av Arktisk Råds arbeidsgruppe Conservation of Arctic Flora and Fauna (CAFF) og Miljødirektoratet. Målet med pilotprosjektene var (1) å vurdere om Naturindeksens rammeverk og database kan benyttes i Arktis inkludert Svalbard (2) å overføre kompetanse til CAFF-sekretariatet til å administrere en slik gjennomføring (3) etablere en webbasert database som kan benyttes i et eventuelt pilotprosjekt i Arktis. Denne rapporten diskuterer områdeinndeling, inndeling i store økosystemer og potensielle indikatorer som må på plass for å teste ut implementering. Minste arealenheter har blssitt definert for Barentshavet, Island og Svalbard. For ale områder, både marine og terrestriske, må minste arealenheter bli diskutert og avgjort i relevante fôra og deretter implementert i nettstedet før rammeverket kan testes ut. Praktisk testing av den web-baserte databasen er bare mulig når minste arealenheter er definert.

En vellykket utvikling av en Arktis Naturindeks og for Svalbard vil avhenge av kvaliteten og omfanget av de indikator-dataserier som indeksen bygger på. Et bredere utvalg av taksonomiske grupper og økologiske funksjoner vil styrke verdien av en slik indeks. Vi anbefaler videre at allerede eksisterende ekspertgrupper i CAFF og MOSJ skal definere indikatorer og nødvendig økologisk informasjon. Videre anbefaler vi at forskere som deltar i prosjektet skal være ansvarlig for å velge hvilke temaindekser og naturindekser for økosystemer og områder som bør presenteres. Deltagende forskere bør også være involvert i å skrive rapporter / artikler basert på disse resultatene, slik det gjøres i Norge

Formålet med pilotprosjektet er dermed å legge til rette en plattform for å samle inn, standardisere og presentere økologisk informasjon på en oversiktlig og lettfattelig måte. Formålet med prosjektet er ikke å erstatte eksisterende prosesser.

Kontakt: Signe Nybø, Norsk institutt for naturforskning (NINA), Postboks 5685 Sluppen, NO-7485 Trondheim. signe.nybo@nina.no

Contents

Foreword

The Norwegian Environmental Agency and the Conservation of Arctic Flora and Fauna (CAFF) Arctic Council Working Group are exploring if the Nature Index framework, and its website for entering information on biodiversity indicators, can be used for Svalbard and the Arctic. It is important for the Environmental Agency that any implementation of the framework at Svalbard should be in accordance with how it is implemented in Norway, both in marine and terrestrial ecosystems.

The project has been the subject of several meetings with the Environmental Agency and CAFF, presented at a seminar on the vulnerability of polar areas at the Norwegian Polar Institute in November 2014, and presented at the Arctic Biodiversity Congress in Trondheim, December 2014. We would like to thank many persons for their contributions and fruitful discussions. For any follow-up projects, please contact Signe Nybø at NINA (signe.nybo@nina.no).

March 27th 2015, Gregoire Certain

1 The need for an integrated tool to manage Arctic biodiversity information

1.1 Biodiversity monitoring and assessment in the Arctic: The international scale

1.1.1 International developments concerning Ecosystem Accounting, Biodiversity and Ecosystem Services

The need to monitor biodiversity and ecosystem services in an integrated and quantified way, with clear connections between natural systems and socio-economical systems, has been recognized and called for by major international institutions. The objectives of the International Panel of experts for Biodiversity and Ecosystem Services (IPBES) work program clearly points towards assessment of biodiversity and ecosystem services, at both regional and global scales, and on the interface between ecological and socio-economical systems to enhance the societal response to the environmental threat. In parallel, the System of Environmental-Economic Accounting (SEEA) led by the United Nation's statistical office initiated the development of the Experimental Ecosystem Accounting framework (SEEA-EEA). The purpose of SEEA-EEA is to synthesize information on ecosystems in the form of "assets" in a way that respects fundamental properties of environmental systems but should ultimately allow the conversion of ecosystem services into monetary terms. Such initiatives are currently triggering numerous localized studies around the world. At the national scale, the SEEA-EEA framework is now being tested in Vietnam, Mauritius, Mexico, Chile, Bhutan, Indonesia and South Africa, and further test applications are planned in several other countries. CAFF, in partnership with TEEB, UNEP, WWF Arctic and GRID-Arendal are also conducting the TEEB Arctic Scoping Study as a first step towards mainstreaming Arctic biodiversity and ecosystem services into policy and decision-making processes.

At a more global scale, a recent UN report attempted a worldwide evaluation of marine and terrestrial ecosystem assets (Dickson *et al.* 2014). These developments show that at both global and local scales, environmental managers are calling upon scientists to provide integrated assessment of the state of biodiversity and ecosystem services. These assessments should be produced in a transparent way, easily accessible by the main management institutions and the public. Such assessments should be formulated quantitatively and preferably in a currency that can be easily translated into socio-economical terms.

A common feature of SEEA and IPBES is that they stress the need to establish reference values, or baselines, on the state of biodiversity and ecosystem services. These baselines would be used to define management targets and trade-offs. Baselines do not necessarily need to be management targets; however, it is convenient if both reference values and management goals can be expressed at similar spatial or temporal scales, and in the same currencies.

1.1.2 CAFF: the Arctic Biodiversity Assessment and the Circumpolar Biodiversity Monitoring Programme

CAFF has released the Arctic Biodiversity Assessment (ABA, CAFF 2013), a comprehensive summary of the state of biodiversity for the Arctic including terrestrial, freshwater and marine areas (http://www.Arcticbiodiversity.is/the-report). This work is the result of a large-scale consultation of ~250 scientists working across the Arctic. In addition to ecological information, the report includes chapters focusing on provisioning and cultural ecosystem services, and various socio-economic issues. The report provides a much needed description of the current status and trends of the Arctic's ecosystems and biodiversity and creates a baseline for use in global and regional assessments of Arctic biodiversity and is informing and guiding future Arctic Council work. The ABA provides up-to-date knowledge, identifies gaps in the data record, describes key mechanisms driving change and presents suggestions for measures to secure Arctic biodiversity.

CAFF's cornerstone program, the Circumpolar Biodiversity Monitoring Programme (CBMP is an international network of scientists, governments, Indigenous organizations and conservation groups working to harmonize and integrate efforts to monitor the Arctic's living resources. The CBMP's goal is to facilitate more rapid detection, communication, and response to the significant biodiversity-related trends and pressures affecting the circumpolar world.

The CBMP organizes its efforts around the major ecosystems of the Arctic. It coordinates marine, freshwater, terrestrial and coastal monitoring activities while establishing international linkages to global biodiversity initiatives. The CBMP emphasizes data management (through the Arctic Biodiversity Data Service), capacity building, reporting, coordination and integration of Arctic monitoring, and communications, education and outreach.

The CBMP has been endorsed by the Arctic Council and the UN Convention on Biological Diversity and the official Arctic Biodiversity Observation Network of the Group on Earth Observations Biodiversity Observation Network (GEOBON).

CBMP experts are developing four coordinated and integrated Arctic Biodiversity Monitoring Plans to help guide circumpolar monitoring efforts. Results will be channelled into effective conservation, mitigation and adaptation policies. These plans represent the Arctic's major ecosystems: marine, freshwater, terrestrial, and coastal. Out of the four monitoring plans the marine, freshwater and terrestrial monitoring plans have been completed and are in implementation, while the coastal monitoring plan is in development.

These monitoring plans present a nested classification of possible ecosystem indicators of ecosystem status and trends. The first level of organization consists of "focal ecosystem components" (FEC), corresponding to large communities of organisms sharing a number of ecological traits and functions and identified as key compartments in Arctic Ecosystems. For example, "large herbivores" are considered a focal ecosystem component in terrestrial systems. Each FEC is comprised of several “attributes”, corresponding to various elements that provide information on the status of the FEC. These attributes can be ecological (abundance, demography, spatial distribution), physiological (individual health status), molecular (genetic diversity), or any other aspect that provide information on the state of the FEC. Finally, attributes are themselves split into “parameters” which point towards the measurable elements for each attribute. For example, the attribute “abundance” has “numbers” and “density” as parameters. A similar 3 level nested structure has been established for the marine monitoring plan, with some slight changes in terms of wording (for example, “indicators” is used instead of “attributes”). In these monitoring plans, the clear identification of FEC, together with conceptual models that highlight their role and importance for the Arctic ecosystems, are strong elements for structuring data collection, analysis and communication resulting from biodiversity monitoring.

1.2 Biodiversity Monitoring and Assessment in the Arctic: The Norwegian scale

1.2.1 Environmental monitoring of Svalbard and Jan Mayen (MOSJ)

Environmental monitoring of Svalbard and Jan Mayen (MOSJ) is part of the Norwegian contribution to the monitoring of Arctic ecosystems. MOSJ focuses on both terrestrial and marine ecosystems, and involves a network of ~ 50 Norwegian scientists, most of whom are also involved in CAFF initiatives, notably the Arctic Biodiversity Assessment (ABA) and the Circumpolar Biodiversity Monitoring Programme (CBMP). Therefore, a number of commonalities can be found between MOSJ and CAFF activities. The marine and terrestrial parts of MOSJ were evaluated in two recent reports (Fauchald et al. 2014; Ims et al. 2014).

For the marine, MOSJ indicators can be classified in fourgroups, corresponding to four types of pressures (climate change, harvest, pollutants, and interactions). These indicators are mostly single populations, but some are communities and others oceanographical variables. Each indicator was evaluated by Fauchald et al. (2014) according to its ability to contribute to three management goals: (i) limiting the effect of human activity; (ii) restoring or maintaining marine ecosystems, and (iii) improving the status of threatened species. In the report, marine MOSJ indicators are presented and interpreted separately, without being clearly linked to a conceptual model of the marine ecosystem. Some additional indicators not currently monitored were suggested, and the absence of some important ecosystem components was highlighted.

The terrestrial part of MOSJ was evaluated by Ims et al. (2014). In addition to presenting each indicator, Ims et al. (2014) interpreted the MOSJ indicators in terms of “pressure-impact models of the terrestrial Svalbard food webs”, i.e. conceptual food web models including the major trophic components of the Arctic food web, their interactions and the effect of the main drivers on these food web compartments. Each of these food web models targets one “key attribute”, *i.e.* one trophic compartment considered of major importance for ecosystem functioning. These key attributes are Arctic fox, ungulate, ptarmigan and goose. For each of these food web models, a number of state variables are identified. These state variables are either “pressure indicators”, such as precipitation or air temperature, or “ecological state indicators”, such as Svalbard reindeer or vegetation. Some of these are currently covered by MOSJ, others are not. Thus, the report identifies what information is lacking from the perspective of analysing ecosystem dynamics, and suggests improvements. The terrestrial “key attributes” identified by Ims et al. (2014) are comparable to the Focal Ecosystem Components (FECs) used within CAFF’s CBMP, even though the range of FECs considered by CAFF are much wider, encompassing also parasites, pollinators and decomposers while current MOSJ indicators are mainly restricted to higher trophic vertebrates and are missing some fundamental components of the terrestrial ecosystem.

1.2.2 Nature Index for Norway

The Nature Index (NI) is a synthesis and communication tool that gathers the available knowledge on the various constituents of ecosystems to provide a standardized measure of the state of biodiversity and ecosystems (Certain *et al.* 2011). A selected group of scientists (~ 20) from various institutions have been heavily involved in developing the method as presented in chapter 2. The methodology has evolved over time (Pedersen and Nybø (2015). Today there is an emphasis on selecting species, surrogates of species or biodiversity indices as indicators. Participating scientist's quality check results and decide if produced indices give ecological meaningful results. Scientists from institutions that enter data into the database are responsible for writing reports based on calculations based on the Nature Index framework supported by additional information as needed. These reports are then communicated to target audiences, including policy and decision makers, and will be available by late 2015. In addition to the report, there will be an online presentation of indicators, datasets and results.

In Norway, the NI primarily involves of a set of ~100 scientists that are entering standardized ecological information for more than 300 indicators (see appendices in Certain et al. 2011 for a complete list). Each scientist is responsible for (i) defining the biodiversity indicators, (ii) delineating the areas over which the indicator is relevant, and the sub-area(s) over which it can be documented, (iii) providing a reference state for the indicators and (iv) entering the corresponding ecological information in an online database that is coupled to a presentation website available to the public. Instead of documenting values, experts can also document lack of knowledge, allowing to pinpoint areas or ecosystems where monitoring is crucially needed.

For standardization, indicator values are scaled by their reference value to be expressed between 0 and 1. Several indicators can then be averaged, when relevant, to produce thematic indices. Thematic indices bring together a selected set of indicators relevant for a given theme, for example a conservation priority or an environmental pressure. Within the NI, aggregation is a possibility, but not a requirement. The more indicators are averaged, the more difficult it is to interpret changes in NI values. Therefore, indicators belonging to different ecosystems are usually kept separated.

A weighting system (Certain *et al.* 2011) has been established to give emphasis to well-known and monitored indicators of key aspects of biodiversity and ecosystem functioning, and to reduce the effect of bias in the research effort. By default, the weighting system gives equal weight to all trophic levels when aggregated together. The individual contribution of many indicators belonging to the same trophic level will therefore be down-weighted compared to the contribution of indicators that are the sole representative of their trophic level.

The NI is currently implemented for Norway, but not in Svalbard. It is spatially resolved at the municipality level as the basic spatial unit, but most indicators are documented only at larger scales such as counties and regions.

1.3 A pilot study for developing the Arctic Nature Index (ANI)

CAFF's Circumpolar Biodiversity Monitoring Program (CBMP) is working with scientists from around the Arctic to harmonize and enhance long-term Arctic biodiversity monitoring efforts. A key component of the CBMP is to create a publicly accessible, efficient, and transparent platform for collecting and disseminating information on the status and trends of Arctic biodiversity. The Arctic Biodiversity Data Service (ABDS – www.abds.is) is the data-management framework for information generated via the CAFF and the CBMP. It is an online, interoperable data management system serving as a focal point and common platform for all CAFF programs and projects as well as a dynamic source for up-to-date circumpolar Arctic biodiversity information and emerging trends. It will allow for discovery, archiving and access to data at various spatial, temporal, and taxonomic scales (e.g., populations, regions, nations, circumpolar, biomes, habitats) allowing users to explore relationships and factors driving change. Such a framework is essential to ensure effective, consistent, and long-term management of the data resulting from CAFF and partners activities. This objective will be instrumental in achieving the CBMP's mandate to report on trends in a timely and compelling manner so as to enable effective policy responses. The NI methodology is specifically designed to contribute towards achieving these goals (Certain *et al.* 2011)

The goal of the pilot study is to transfer knowledge and tools from the Norwegian Institute for Nature Research (NINA) to the CAFF secretariat to facilitate the work of collecting circumpolar biodiversity data and present various biodiversity indices that can be used in Arctic assessments. In practice, this required the establishment of a prototype version of an NI framework for CAFF. The present report describes this prototype framework, and the process through which it has been designed.

1.3.1 The Norwegian Environment Agency mandate

In parallel to the CAFF initiatives, the Norwegian Environment Agency funded a pilot study to investigate whether it was possible to create a biodiversity index of Svalbard under the same framework as the Nature Index of Norway. The pilot project had to identify the relevant data and knowledge required to apply the NI methodology for the Svalbard area. In particular, possible indicators should be identified, and possible delineation for spatial areas and major ecosystems should be proposed. In practice, this meant to build upon the recent development in the Environmental monitoring of Svalbard and Jan Mayen (MOSJ) to evaluate whether the NI methodology could be used to organize the synthesis and communication of results concerning the various MOSJ terrestrial and marine indicators. As most MOSJ experts are strongly involved within the various expert groups led by CAFF and to avoid duplication of efforts and resources, it was crucial that both the Arctic Council and the Norwegian Environment Agency mandates be addressed jointly.

1.3.2 A brief summary of the present report

The present report describes the choices and issues that were made in order to realize a pilot NI framework that would serve the purposes of both CAFF and the Norwegian Environment Agency. These choices are the outputs of a series of meetings conducted with CAFF and the marine expert monitoring group part of CAFF's Circumpolar Biodiversity Monitoring Program (CBMP).

First, we explain the NI framework as it is currently implemented in Norway. Then we summarize discussions envisioned for the delineation of spatial areas for the pilot ANI. Thirdly, we describe the delineation of major ecosystems chosen. Fourthly, we review a list of potential indicators, and explain how they can be aggregated while respecting the existing hierarchy established within CAFF and MOSJ. Finally, we report on discussions with experts on the potential challenges in developing an ANI. The work presented in this report is a collaboration between the Norwegian Institute for Nature Research (NINA) and CAFF.

Comment [PB1]: See comment related to ABDS above.

The purposes that ANI would serve is not clear to me after reading the introduction. I think it is important to state these purposes and relate them to the other ongoing projects and initiatives.

The challenge that NI relates to is well formulated in the last two paragraphs on page 7. What remains is to explain or suggest how ANI would possibly fit into CAFFs (and MOSJs) strategy with respect to meet these challenges.

As stated in the text – "The Nature Index (NI) is a synthesis and communication tool". So, who is the audience for a ANI? How does ANI fit with CAFFs strategy for communicating with the public, policy makers etc.?

I guess it is not possible to clarify these topics within the present report. However, it should be done in the new project and be part of the basis for evaluating the results from that project.

2 Ecological framework of the NI in short

2.1 Overview

The Nature Index (NI) is a composite index that includes many individual indicators. These are scaled, combined and weighted to produce an index that aims to assess the state and trends in the state of ecosystems (Box 1). Its main purpose is to synthesize knowledge for communication with policy makers and various target audiences (Box 1).

The methodology builds on methods developed for international indexes, e.g. the Natural Capital Index (RIVM 2002) and the Biodiversity Intactness Index (Scholes & Biggs 2005). Furthermore GLOBIO is based on the Natural Capital Index and is used by the Convention on Biodiversity (CBD) to model global biodiversity (Alkemade et al. 2009).

The Nature Index focuses on species, species indices or surrogates of species and their abundance in major ecosystems. Figure 1 illustrates the principles of how the index is built. The mathematical framework for aggregation is described in several papers (Certain et al. 2011, Pedersen & Nybø 2015).

***Box 1**. The Nature Index measures the state and trends of biological diversity in major ecosystems.*

The state of biodiversity is measured as a weighted average of indicators in relation to a baseline (reference state). Key elements/species are given greater importance (weight) than other indicators. These indicators are considered to be of vital importance for the health of the ecosystem.

The Nature Index is designed to reflect the total effect of human activities on the ecosystem; e.g. resulting from changes in land use, harvesting, pollution, alien species and climate change.

A thematic index may be produced from a subset of indicators reflecting a special thematic issue; e.g. commercial marine fish or seabirds.

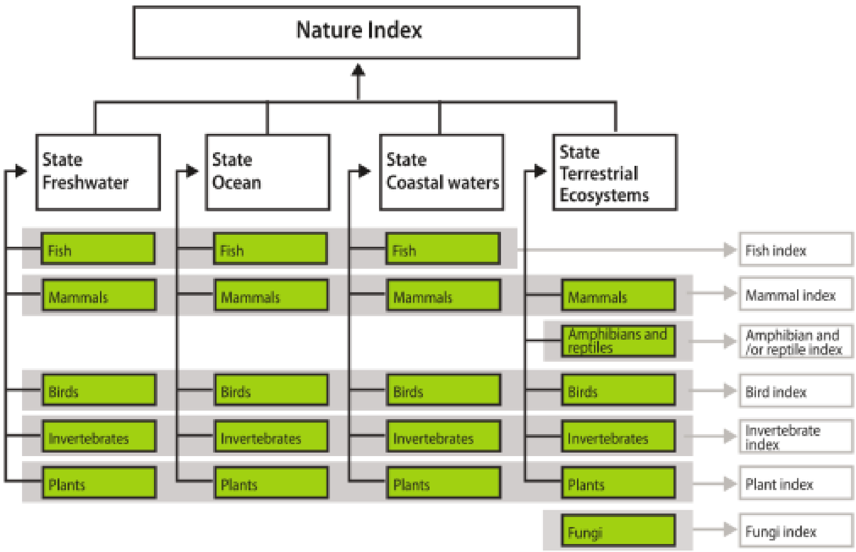

Figure 1. *Schematic illustration on how the Nature Index is built up by indicators to calculate the state of biodiversity in major ecosystems. The white boxes to the right illustrate how a combination of some indicators can be used to form a thematic index (from* Aslaksen et al. (2015) *.*

2.2 Selecting indicators

The selection of indicators should be based on (i) properties of individual indicators (quality and relevance) and (ii) properties of combined sets of indicators (balance and representativeness). Listed below are the two sets of criteria used in the Nature Index for Norway (Pedersen & Nybø 2015).

Properties of individual indicators:

- Quantifiable (in nature).
- Measurements linked to defined spatial areas.
- Possible to estimate a reference condition/state.
- Linked to one (or several) major ecosystem categories.
- The indicator should be sustainable at its reference value in each major ecosystem category, when the ecosystem is in the reference state.
- Data must be of sufficient quality to indicate trends over time.
- The indicator should preferably be a population property.
- Respond to environmental changes.

Properties of combined set of indicators:

- Taxonomically balanced/representative; both invertebrates, plants and vertebrates should be included.
- Functionally representative; different trophic levels and functional groups included.
- Both rare and abundant species should be included.
- Include key-species whose abundance influence the populations of a large number of other species.
- In sum the indicators should respond to a wide range of influences, so that the index not only reflects one or a few environmental factors (e.g. harvest, climate, pollution) but the total impact.
- Represent different biotopes and natural succession stages within each major ecosystem.
- Should not include non-native species.

2.3 Reference states and scaling/weighting

In order to calculate an averaged index based on indicators measured in different ways, it is necessary to transform each indicator to the same scale. This scaling is done by expressing each indicator as a proportional deviation from its reference state. In the following text “reference state” is used as a synonymous term to “baseline”.

The definition of a reference state is given in Box 2. The use of low impacted ecosystems as the baseline is a common feature of several indices e.g. the Natural Capital Index (RIVM 2002), the Biological Intactness Index (Scholes & Biggs 2005), the GLOBIO model based on “Mean Species Abundance” (Alkemade et al. 2009), the Water Frame Directive in Europe and in the Norwegian Nature Index (Pedersen & Nybø 2015).

Box 2. *Definition of the reference state*

- For natural ecosystems the reference state is defined as an ecosystem which has low impact of human activity.
- Semi-natural ecosystems are formed by human activities over a long time span such as livestock grazing, traditional hay collecting or burning. Furthermore these semi-natural ecosystems have not been plowed and there has been no use of fertilizers. These ecosystems often have low density of trees or shrubs. The reference condition is set as the composition of species given this old traditional farming. Other impacts from human activities are low.
- For natural and semi-natural ecosystems, ecological functions, species composition and the species abundance are similar to an intact ecosystem (i.e. low impact of human activity) during 1961-1990.
- For human created ecosystems such as cropland, infrastructures and cities the reference state/ baseline is not yet developed.
- At the reference state, the climate is similar to the climate during 1961-1990. Thus the reference state is related to the state of current ecosystems, not as they were 500 or 1,000 years ago.

More specifically, in the reference state there is an absence of anthropogenic inputs of pollutants, acid rain and eutrophic substances. Natural background levels of some of these compounds may be present in intact ecosystems. The fragmentation of ecosystems by infrastructure such as roads and power lines are minimal. Habitat disturbance by human activities such as trawling, forestry, overgrazing by domestic animals, landfills and waste disposal is low. Hydrological state changes to human installations, e.g. hydroelectric power plants and river channeling, are absent. The impact on species abundance by harvesting is low. Furthermore, the abundance of alien species is low and not affecting natural populations.

Alien species may be included in the NI, but then as an inverse-indicator surrogate (see below on scaling) where high values indicate low abundance of natural species. Data on alien species may also be stored at the NI-website without being included in the calculations of the index.

Based on knowledge of the reference state a numerical reference value for is set 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 theoretically be possible to achieve this state that the reference values together describe for a main ecosystem. Consideration should be given to natural variation when the indicator reference value is determined. The reference values are used to scale all indicators to a value between 0 and 1, where a value of 1 is the indicator value in the reference state. In this way one can combine data for different indicators and thus estimate the impact of human activity on the state of biodiversity.

The deviation of the NI value from the reference value (1), can be seen as a measure of the total load of all the human activity that has a negative impact on biodiversity. The lower Nature Index value, the higher the total impact on biodiversity. Management measures that improve the state of biodiversity in ecosystems could then increase the Nature Index value. The advantage of this approach is that, on rough scale, one can quantify how large impact the sum of human activities has on biodiversity, and how this changes over time. The NI approach avoids confusing what humans needs of goods and ecosystem services with the state of biodiversity (Aslaksen et al. 2015). It does not specify what the management goals should be, but makes it possible to explicitly state such goals.

In addition to serving as scaling factors, the reference values also set limits for how much an increase in one indicator may compensate a decrease in another when combined in the composite index – scaled indicator values above the reference state is set to 1. It is also possible to include indicators that have an inverse effect on the index (the case for 7 out of 303 indicators in the Norwegian Nature Index as of late 2014). In this case indicator values lower than the reference state is set to 1 and larger than twice the reference value is set to 0.

Both reference value and indicator values generally have some degree of uncertainty. The responsible expert estimates these uncertainties for each value, expressed as the inter-quartile range. Based on these estimates, probability distributions are fitted for each value. These distributions are then used to calculate the NI as a stochastic variable using parametric bootstrapping, where the median of the simulated distribution represents the NI estimate and confidence limits are obtained from the simulated distribution.

The available indicator data is often biased, for example towards vertebrates. In order to secure a representative index for the whole ecosystem, without disregarding data, a weighting scheme is being employed. The weighting is currently made so that trophic groups contribute equally per spatial unit to the Nature Index value, and contribute in total to fifty percent of the index (Figure 2). The remaining fifty percent is assigned to key-indicators. These extra-representative indicators are those that influence a large number of other species (at least 100), occur over a large area, and are represented by high quality data (for example Capelin in the Barents Sea).

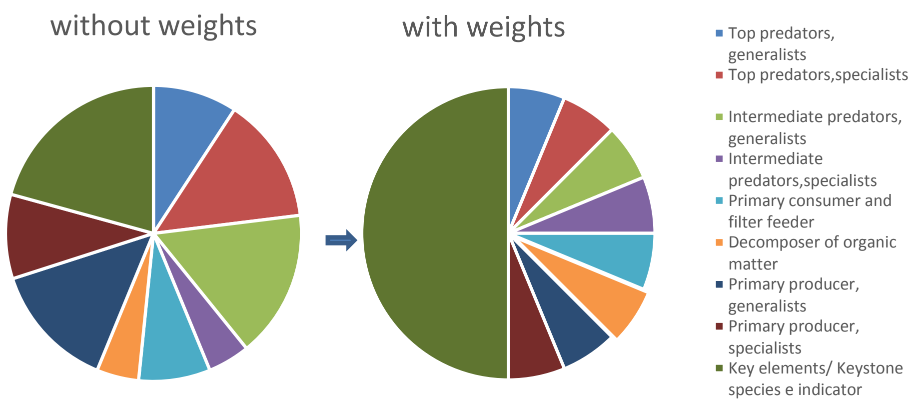

***Figure 2**. Schematic overview of the weighting of different functional groups*

The Nature Index is designed to measure the state of an ecosystem type in a certain area. For terrestrial systems, the spatial extent of an ecosystem can change over time. The Nature Index can thus be combined with land cover type changes from remote sensing data (see chapter 3.2) to illustrate ecosystem changes in two dimensions, both spatial extent and state changes within each ecosystem (Figure 3).

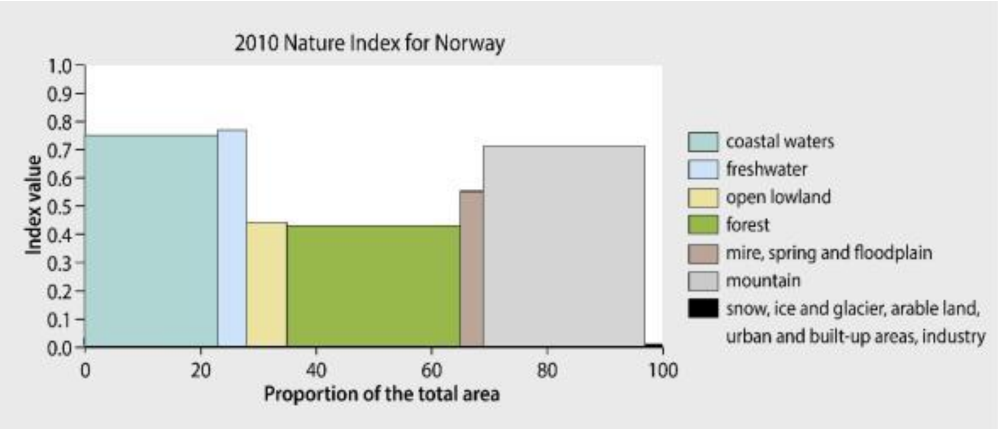

***Figure 3.** The state and extent of major ecosystems in Norway 2010 (from Nybø et al. 2011)*

3 Building a pilot website for the Arctic Nature Index

3.1 Spatial areas

3.1.1 Definitions

The definition of spatial zone for the entire Arctic area has been the most challenging task in establishing the pilot ANI data entry website. The NI methodology is spatially explicit, meaning that the documentation of an indicator is tailored to a particular area. Different types of areas have to be documented (Fig. 4). The first defines a *definition area* that corresponds to the area over which the indicator should be present as an indicator. Within the definition area there are *basic spatial units* which correspond to the minimum area within which ecological information can be entered. Some of these basic spatial units may be aggregated to greater units called *documentation areas.* They correspond to areas where a dataset or expert judgements can be documented for that indicator. Basic spatial units within the definition area but without data or expert judgements, are used to document lack of knowledge After defining all documentation units for an indicator, data or lack of data is entered. All these areas can have various scales. For example, a definition area can be very wide, because the indicator is widely spread in an entire region, but the documentation area can be very small, because information on this indicator is only collected through monitoring at a few locations. The purpose of such distinction between areas is to be able to document, at the same time and on similar temporal scale, both information and lack of knowledge.

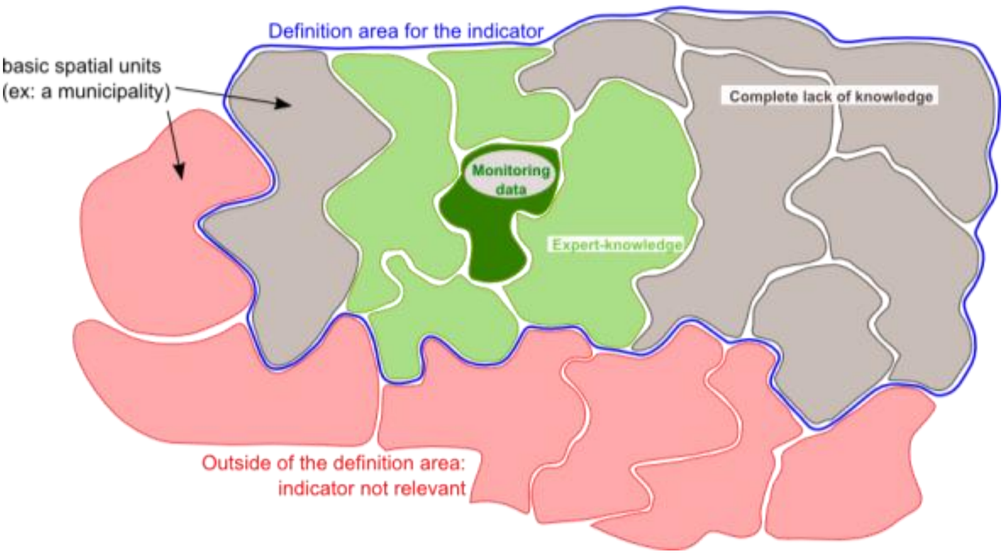

Figure 4. *Area definitions within the Nature Index framework*

Many types of areas have already been defined for the Arctic, based on either ecological or management boundaries. However, for the sake of harmonization, only one set of basic spatial units can be defined for use within the NI. They must be designed in such a way that, depending on how they are aggregated, the output can correspond to already defined areas in the various research and management initiatives currently existing in the Arctic. Another important feature of these basic spatial sub-units is that they are static and are not likely to change in a near future. This constraint ensures the comparability of NI outputs for different time periods.

3.1.2 Spatial areas for the marine environment

For the marine environment, the first important areas considered were the Arctic Marine Areas (AMAs) defined for use within the CBMP Marine monitoring group (Fig. 5).

Figure 5. *Arctic Marine Areas*

However, these regional divisions correspond to very large scale regions, while in many cases information concerning ecological indicators is available on much smaller scales. Some indicators for example are sampled over very localized sites, and extrapolation to other sites may not be straightforward. Some indicators focusing e.g. on reindeer or polar bears are evaluated over large scales, but present clear discrepancies between spatial regions, which requires divisions smaller than the AMAs in order to be properly documented.

It was decided to sub-divide the AMAs into smaller spatial units. Such sub-division could be achieved in accordance to already existing management or ecological boundaries or through a regular design such as a grid. For the pilot, we focused on the AMA-1 that corresponds to Svalbard, the Barents Sea and the Norwegian Sea, where experts from the Norwegian Institute had already defined a set of ecological regions for Marine Research (IMR). These are currently being used to build a model including both physical and biological variables of the Barents and Norwegian Sea (Hansen 2014). One important feature of these sub-regions is that they have been defined according to both ecological and oceanographic features, and correspond to ecologically and environmentally homogeneous areas. As they are being used for the development of a new model (named Atlantis) (see Hansen 2014) a wide range of ecological and oceanographical data is already available at their scale. Furthermore, a numerical biodiversity baseline has recently been established for the Barents Sea area at the scale of these polygons(Certain and Planque (2015), offering a solid theoretical basis for reporting on the state of biodiversity. The resulting set of polygons for marine areas in the North-Atlantic can be seen on Fig. 6. Basic spatial units for the rest of marine areas must be decided and implemented if the nature index shall be tested in these areas. There has been some discussions on using a regular grid in these areas, but further consideration is needed.

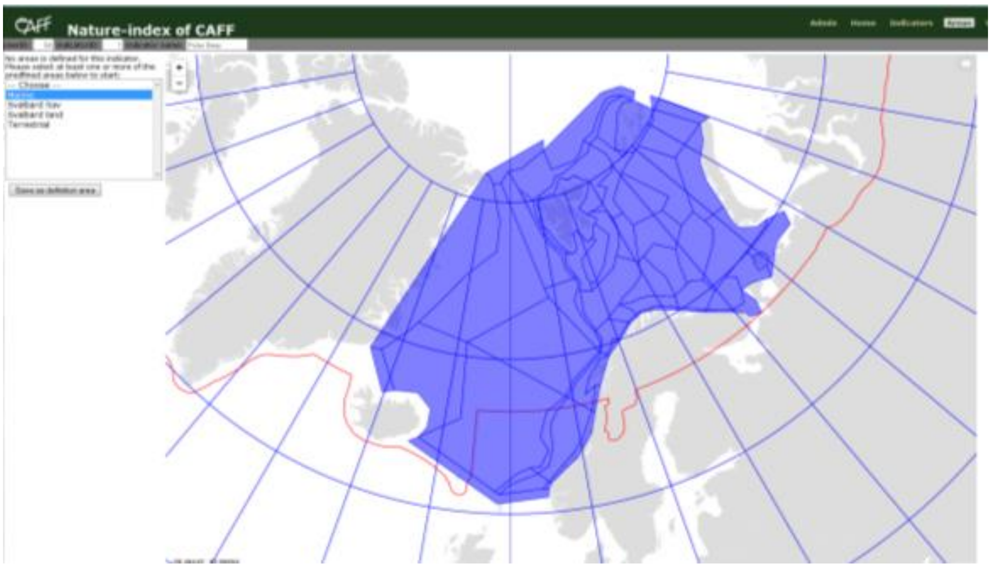

Figure 6. *Set of marine polygon areas as defined in the Atlantis model (Norwegian and Barents Sea****)***

3.1.3 Spatial areas for the coastal environment

Spatial areas for the coastal environment have arbitrarily been defined as extending 20 km from the coastline, as exemplified for Iceland (Fig. 7). In Norway the coastal environment in accordance with Norwegian legislation has been set to 1 nautical mile beyond the base-line/ coastline. The baseline used is the outermost line of the terrestrial territory of a nation. Within these areas Norwegian municipalities have jurisdiction.

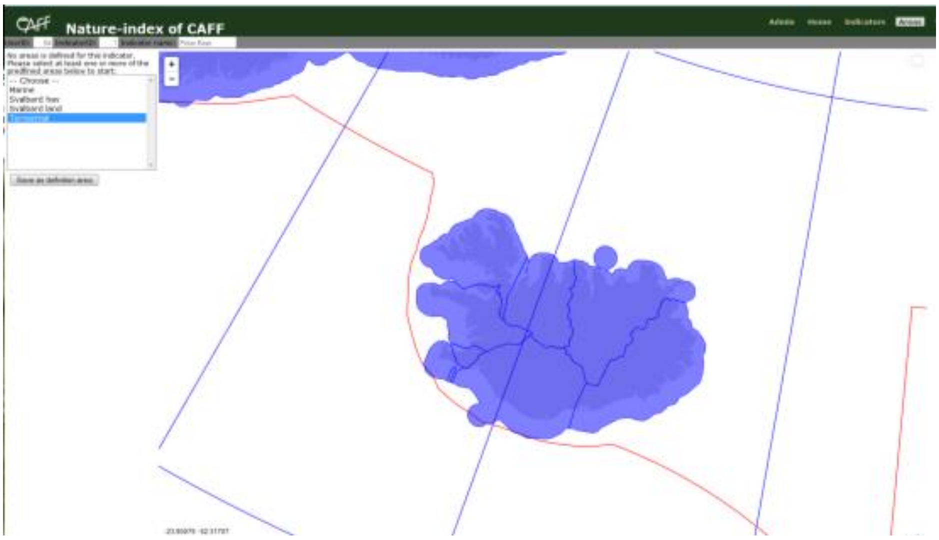

Figure 7. *Extent of coastal buffer for Iceland*

3.1.4 Spatial areas for the terrestrial environment.

Discussions on the definition of basic spatial units for the terrestrial environment oscillated between two possibilities, either using ecological boundaries such as the Circumpolar Arctic Vegetation Map (CAVM) (Fig. 8) and the Arctic bioclimatic subzones (Fig. 9), or using administrative boundaries such as municipalities, regions or management areas.

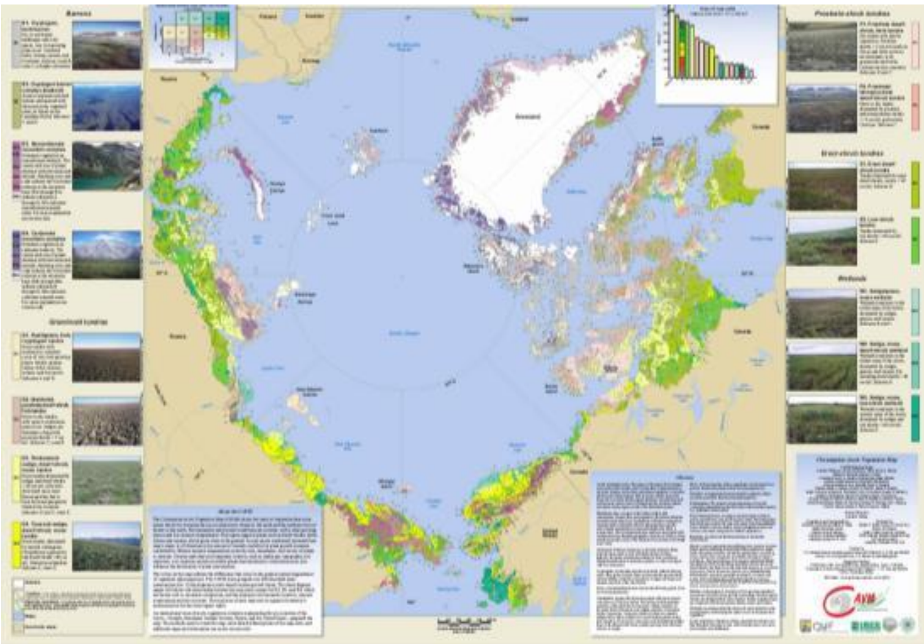

Figure 8. *Circumpolar Arctic Vegetation Map (high resolution version available at: http://www.geobotany.uaf.edu/cavm/)*

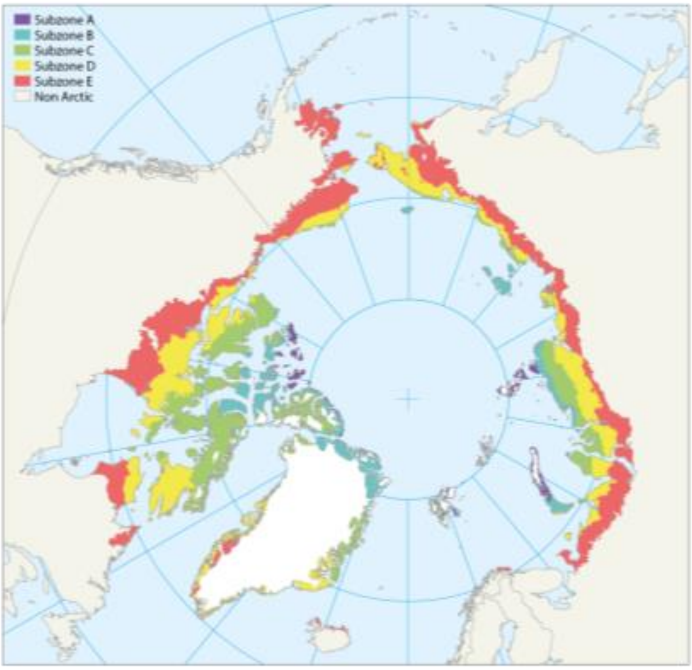

Figure 9. *Arctic bioclimatic subzones*

Ecologically, the Arctic vegetation map is most applicable (Fig. 8), as each vegetation category corresponds to a particular landscape. However, the shape of the vegetation subunits is complex, and as climate change will likely have a strong impact the vegetation map may be very different in 10 or 20 years.

Compared to the CAVM, the Arctic bioclimatic subzones (Fig. 9) are ecological areas with a simpler shape that are less likely to fluctuate, even though their boundaries are still dependent on climate. These were another candidate for defining areas, but have not been retained because of their size. Indeed, bioclimatic subzones can encompass several countries, which in the case of the ANI would have presented a practical problem. Most Arctic biodiversity monitoring is organized at the country scale: for example, Norwegian scientists mostly gather ecological information in Svalbard, Troms and Finnmark, and experts would undoubtedly prefer to enter ecological information in a localized manner, which is not possible by solely using the Arctic bioclimatic subzones.

For the pilot website, while no area definition for the entire Arctic has been decided. The pilot website currently displays the largest administrative level for all countries (Fig 10). Further division into smaller basic units is necessary for the website to be useful for scientist to enter data.

Administrative boundaries have several advantages: they are more stable through time than ecological entities and they are by definition country based and can offer good possibilities in terms of the spatial localization of ecological information. Lastly, as ANI outputs are intended to serve management purposes, having these outputs at the scale of administrative boundaries will ease information transfer between ecologists, managers and policymakers. However, these administrative units are often sub-divided into several layers, from small municipalities to broad regions. In addition, the hierarchical organization of spatial units varies between countries. Therefore further discussion is needed prior to agreement as to which administrative level should be used within each country.

Smaller scale administrative levels would offer the advantages of better possibilities for spatially localizing ecological information but they would also increase the complexity of the information entry process. Custom designed areas could be envisioned e.g. one approach might be to intersect administrative units with ecological boundaries such as the Arctic bioclimatic subzones, in order to include both administrative and ecological features in the design of basic spatial units. However such an approach would require significant GIS work. It is therefore recommended that basic spatial units are defined within each of the countries within the Arctic. The area of basic spatial units should not deviate too much between countries.

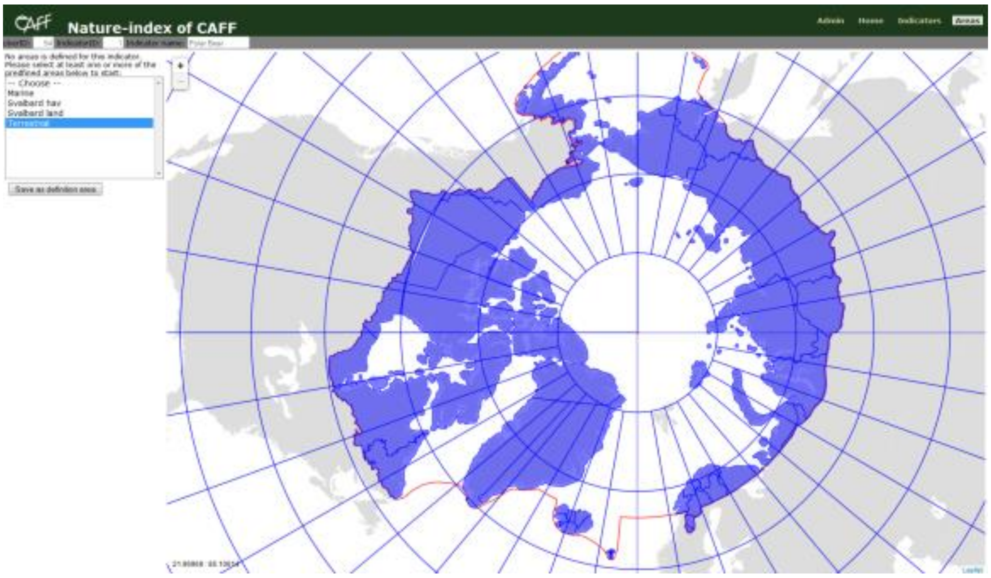

Figure 10. *Terrestrial sub-areas for ANI*

In the particular case of Svalbard, more information on area definition was available in the form of management areas provided by the Norwegian Polar Institute and these were therefore used. (Fig. 11).

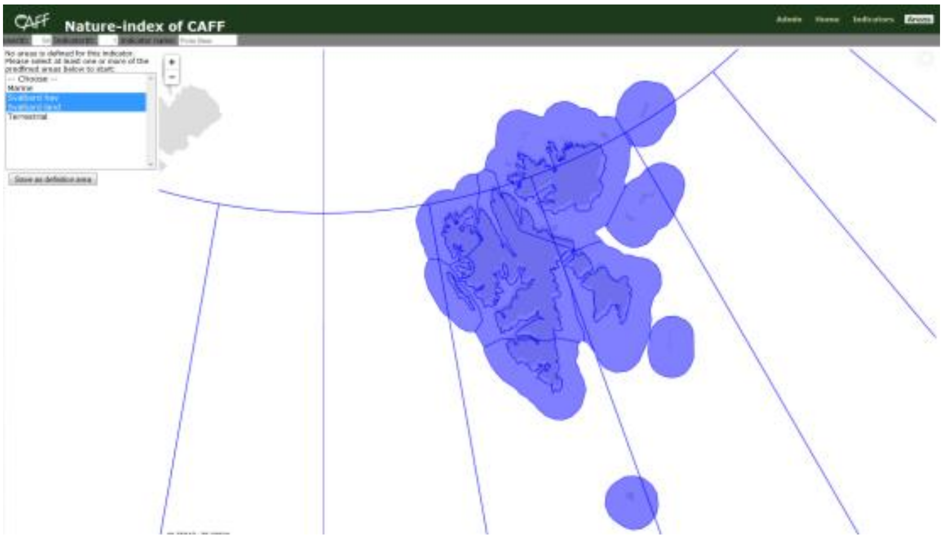

Figure 11. *Basic spatial Units for Svalbard*

3.2 Major Arctic Ecosystems

The NI methodology is designed to be applied in any terrestrial, freshwater or marine ecosystems. In order to properly classify indicators, major ecosystem types should be identified, so that it is possible to formally attribute one or several ecosystem types to each indicator. This information is then used for calculations, for example when defining weights, and for deciding on indicator aggregation. In the first release of the Nature Index for Norway, maps for each ecosystem types were made (Certain *et al.* 2011). In Norway, nine ecosystem types were identified, namely forest, mountain, freshwater, open lowland, mires and wetland, coast pelagic, coast bottom, ocean pelagic and ocean bottom. Some of these categories would need to be refined, if they were to be adapted for use across the Arctic.

For the purposes of the pilot project the classification applied was provided by the Pan-Arctic Satellite Remote Sensing Product (Shuchman *et al.* in press), which was used to measure land-cover change in the Arctic between 2001 and 2012. This classification distinguishes eight terrestrial ecosystem types: (1) barren or sparsely vegetated land; (2) cropland; (3) shrubland; (4) terrestrial snow and ice; (5) freshwater; (6) grassland/savanna; (7) wetland; (8) forest. In addition, coastal and marine ecosystem types had to be identified and these followed the same classification used in the Norwegian NI, i.e., a simple distinction between pelagic and bottom areas. However, we added a third ecosystem type, sea-ice, as it is a typical habitat for many Arctic marine species. The NI pilot website for the Arctic therefore contains 14 ecosystem types, 8 for terrestrial and freshwater; three for the coastal environment (coastal pelagic, coastal bottom and coastal sea ice), and three for the oceanic environment (ocean pelagic, ocean bottom, and oceanic sea ice).

3.3 Potential indicators for the Arctic Nature Index

A major element for building an ANI is a proposal for an indicator list, available in the following tables.

Table 1 presents the Focal Ecosystem Components (FEC) identified by the CAFF expert monitoring groups for the whole Arctic area. Each FEC should not be understood as one indicator, but as a category for which one or several indicators could be defined, covering different populations, species or community, or dedicated to various ecological aspects such as diversity, abundance, spatial distribution, demography, phenology, health, and the degree to which various ecosystem functions (pollination, decomposition) are performed, as advocated in the expert monitoring group reports. The precise formulation of indicators for each FEC is an ongoing process, and it would be premature to present here more than these FECs. For vertebrates, a number of monitored potential indicators are listed in the Arctic Species Trend Index (McRae et al. 2010).

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Table 2 exemplifies some possible indicators for Svalbard and briefly describes the nature of the data. It simply synthesizes indicators suggested by MOSJ (Fauchald et al. 2014, Ims et al. 2014).

Table 1. *List of biotic Focal Ecosystem Components for the Arctic, as identified by CAFF marine, terrestrial and freshwater expert monitoring groups.*

Marine[1]	**Terrestrial**[2]	**Freshwater**[3]
Phytoplankton	Blood feeding arthropods	Fish
Protists	Pollinators	Benthic invertebrates
Microbes	Arthropod prey for vertebrates	Zooplankton
Zooplankton	Arthropod decomposers	Benthic algae
Diatoms	Arthropod herbivores	Phytoplankton
Dinoflagellates	Trees	Macrophytes
Flagellates	Deciduous shrub	Riparian vegetation
Sea-ice invertebrates	Evergreen shrub	Aquatic birds
Benthic macro- and mega-fauna	Forbs	Salmon
Benthic macroalgae	Graminoids	Arctic char
Benthic meiofauna and microbes	Moss	
Pelagic fish	Lichen	
Pelagic shrimps	Herbivore birds	
Capelin	Insectivore birds	
Benthic and demersal fish	Carnivore birds	
Arctic cod	Omnivore birds	
Polar cod	Piscivore birds	
Atlantic cod	Large herbivore mammals	
Walleye pollock	Medium herbivore mammals	
Greenland halibut	Small herbivore mammals	
Bering flounder	Large predator mammals	
Shorthorn sculpin	Medium predator mammals	
Walrus	Small predator mammals	
Ringed seal		
Beluga		
Bowhead whale		
Polar bear		
Black-legged kittiwake		
Common guillemot		
Brunnich's guillemot		
Common eider		

[1]Gill et al. (2011). [2]Christensen et al. (2013). [3]Culp et al. (2012)

Not all indicators suggested in MOSJ or in CAFF's CBMP Arctic Biodiversity Monitoring Plans are included in the present report, only those indicators related to biological or ecological species, populations and processes have been selected as potential contributors to the ANI, while indicators related to physical-chemical or meteorological processes, such as temperature or ice thickness, have not been considered. In other words, only biological response variables and not drivers should be included in the ANI. Furthermore, some

MOSJ indicators have been excluded as they do not fulfil the indicator criteria listed in chapter 2.2 (e.g., anecdotal sightings of whales).

Several major ecosystem components are not currently included in MOSJ. In marine systems most notably: phytoplankton; benthic fauna; littoral zone fauna and flora (Fauchald et al. 2014). Some of these would require the establishment of new monitoring programmes while some could be obtained by modifying existing programmes. One example of the latter is to identify benthos in trawl catch on national scientific fishery research vessels, a practice already established in the Barents Sea (CBMP-Marine Benthos Expert Network, 2013).

It is important to understand that the already established expert groups within CAFF and MOSJ should define the indicators and the necessary ecological information. As shown in the previous tables, and the corresponding reports, a process is already ongoing within the CBMP to identify FECs and to implement the Arctic biodiversity monitoring plans. The purpose of this pilot project is therefore to propose a platform to collect, standardize and present ecological information on these indicators not to replace an already existing process.

However, the ANI framework identifies some properties of the set of indicators that should be fulfilled (see 2.2), most notably that all important ecological functions should be included. This is consistent with the biodiversity monitoring plans published by CAFF, and the evaluation reports on MOSJ.

Table 2. *List of MOSJ indicators that could be used for the ANI.*

Organism	Indicator data series	Period
Marine indicators[1]		
Zooplankton	Biomass, species composition (proportion Atlantic/Arctic *Calanus* species)	1988-
Atlantic cod	Stock of North-East Arctic cod in the Barents Sea (biomass of the spawning stock and the total stock, and number of 3-year-old)	1946-
Capelin	Capelin stock (biomass) in the Barents Sea	1972-
Herring	Biomass of 1-3 year-old herring in the Barents Sea	1999
Brunnich's guillemot	Population density, survival, reproduction, diet	1988-
Polar bear	Population density (dens observed), reproduction (cubs per female, % of females with cubs, litter size), condition (body condition of males)	1979
Walrus	Population size	1980
Harp seals	Population size, pup production	1945-
Hooded seals	Population size, pup production	1945-
Greenland halibut	Biomass of the total stock, the biomass of the spawning stock and the number of recruits	
Beaked redfish	Biomass of mature part of the stock, biomass of total stock and number of recruits	1992
Golden redfish	Biomass of mature part of the stock, biomass of total stock and number of recruits	1986-
Common guillemot	Population size (selected colonies)	1988

Black-legged kittiwake	Population size (selected colonies)	1988
Common eider	Population size (breeding females)	1981-
Glaucous gull	Population size (number of nests), reproduction (chicks per nest)	1987-
Terrestrial indicators[2]		
Arctic fox	Reproduction (% of known dens with cubs)	1993-
Svalbard rock ptarmigan	Population density (territorial males)	2000-
Svalbard reindeer	Population density	1978-
Barnacle goose	Under development	
pink-footed goose	Under development	
light-bellied brent goose	Under development	
Thermophilic plant community	Under development	2009-
Forage plant community	Under development	2009-
All vegetation	Under development	2009-
Salix polaris	Under development	2009-
Drya octopetala	Under development	2009-

[1]*Fauchald et al. (2014).* [2]Ims et al. (2014)

3.4 Using the pilot website

Following the recommendations given in the previous sections, a pilot website for the ANI has been made available at the following address:

http://nicaff.azurewebsites.net

The pilot website is fully functional for the Norwegian Sea, the Barents Sea and Svalbard. It is incomplete concerning other Arctic areas, where area definitions still need to be agreed upon. Now that the website has been established, it needs to be properly tested by the experts. The easiest way to do so is to select some well-known indicators, and try to enter information within the website. This should be easier with indicators concerning AMA-1 or Svalbard, as basic spatial units are well defined within these regions (Figs. 3 and 8). Therefore, the website already offers the possibility of a precise and integrated representation of all the MOSJ indicators, provided that MOSJ experts document their information in it. Such a process should be viewed as a test of the feasibility of the framework, as well as an opportunity to consider its usefulness.

To do so, experts willing to test the framework should request a password by emailing CAFF's data manager (hoddi@caff.is), log-in and follow the instructions in the NI manual available on the pilot website. In Norway and Svalbard Pål Kvaøy (pal.kvaloy@nina.no) will manage users.

The first task would be to create an indicator, select a definition area for their indicator by selecting appropriate basic spatial units, and then report ecological information or lack of knowledge for the corresponding areas. Once ecological information concerning several indicators has been entered and if there is a wish within MOSJ and/or CAFF to communicate about these, an output website should be established and integrated within CAFFs Arctic Biodiversity Data Service (ABDS – www.abds.is), on the same model used for the

Norwegian NI, to allow experts, managers and other audiences to quickly look at information entered about the state of a selected set of indicators.

3.5 Synthesis of the discussions with potential experts

During the course of the pilot project, numerous discussions have been carried out with experts about the possible implementation of the ANI. The following sections attempt to synthesize these discussions and to answer to the most common questions/concerns of ecological scientists involved within MOSJ and CAFF.

3.5.1 How do you enter information on pressures?

Experts and managers repeatedly ask "how does one explicitly include pressures within the NI framework?" Indeed, the original NI framework is restricted to ecological information on the state of indicators, and does not include other types of information such as pressures. The question of pressure however is crucial for the management in the Arctic, and the ANI website can be modified to allow information on pressures to be entered. Our suggestion is to do so through "pressure indicators", i.e. specific indicators dedicated to pressure for which no reference state is needed e.g. intensity of fishing, level of fragmentation. This way, it is possible to enter information on pressure intensity at the very same spatial scale as the ecological information on various indicators, allowing to explore statistically the link between pressure intensity and indicator state. This requires only a small modification of the website and database, i.e., creating two categories of indicators, either "ecological indicators" or "pressure indicators", the former being associated to a reference state while the latter is not. We stress that pressure indicators are not to be included in any thematic indices or the Nature Index itself. Indicators included in ANI are solely going to express state of biodiversity or various groups of indicators, e.g. marine fish or seabirds. However, pressure indicators may be displayed on the output website as information on threats facing Arctic biodiversity.

3.5.2 How will information entered within the ANI website be used?

During discussions with the CBMP's marine expert group, a number of key points were raised. There were concerns as to how data entered into the ANI would be stored, who would use them, for what purpose, and there was a special concern regarding the possibility of aggregating indicators into indices. It has been decided that the CAFF-Secretariat will host the database, and that aggregation should only be done in agreement with the various expert groups involved, clearly identifying which indicator should be integrated over which area. The ANI will store and display information on an indicator basis. Researchers who have contributed with these data will be in charge of updating and correcting information related to his/ her indicator. We further recommend that scientists participating in the project should be in charge of selecting what nature indices should be presented, i.e.

indices presenting the state of biodiversity within a major ecosystem or thematic indices reflecting selected information on e.g. a species group. Participating scientists should also be responsible for writing reports/ papers based on these results as is the case in Norway.

3.5.3 How to define reference states for the Arctic?

Another common concern was related to the definition of the reference state. Here, discrepancies in knowledge across various ecosystem components will probably prevent the use of a general definition for the reference state across all indicators. The Arctic Biodiversity Assessment is designated as a baseline. Indeed, it is an impressive summary of the state of knowledge on Arctic ecosystems. But for some indicators, further developments may be required to provide a numerical value that can serve as a reference. If sustainable population size can be fairly easily expressed for long-term monitored indicators such as fish or marine mammals, other less known trophic groups such as phytoplankton may have severe difficulties in expressing these reference states. Statistical analyses have shown that the value of the NI is robust with respect to both random errors and systematic bias in the determination of reference values (Pedersen & Skarpaas 2012; 2015).

The range from 0 to 1 of possible NI-values should ideally correspond to states of nature that can be obtained. Consequently, it should be possible to achieve the reference state for all indicators at the same time (see also chapter 8 in (Pedersen et al. 2013); (Pedersen & Kvaløy 2014, Pedersen & Nybø 2015, Pedersen et al. 2013). This calls for harmonizing reference values over indicators from the same ecosystem based on a common reference state for that ecosystem. It is, however important, at least for the first implementation of the Arctic NI, that experts choose reference states for their indicators in a flexible way, according to what they judge is in accordance with a numerical value that is achievable in intact nature for their indicators. Then, once a first set of reference values is chosen for an indicator set in a given ecosystem, examination of this set of values can be carried out with experts to search for potential discrepancies between them and eventually harmonize reference states across entire ecosystems.

3.5.4 How to deal with uncertainty and lack of knowledge?

The NI framework recommends entering information about uncertainties in several ways. First, when recording information, the source of the information - model output, monitoring data or expert opinion - must be documented. This is a first qualification of uncertainty. Secondly, when entering values, experts must also document quartiles or confidence intervals around them. These confidence intervals are used to perform parametric bootstrap simulations to get confidence intervals around NI values. These two points help to document uncertainty around what we know.

However, in the Arctic, there is a lack of knowledge in some areas e.g. some indicators might be sampled only at very restricted locations or seasons and this knowledge might not be sufficient even to provide an expert opinion for other, unsampled areas. It is therefore of crucial importance that the NI framework can explicitly report lack of knowledge.

Within the website, lack of knowledge for a given indicator is documented where there is not enough relevant information to document the indicator. It is important to document lack of knowledge as this is a key aspect of the management of natural systems that needs to be communicated to managers and to other target audiences. This will help managers to identify monitoring needs.

3.5.5 How does the ANI involve indigenous communities?

Indigenous communities are an essential part of nature management in the Arctic. The NI process of selecting scientific experts that document ecological information for indicators is not well designed to include these communities at first sight. Therefore, further developments are required in order to allow this knowledge to be included within the ANI. This could take the form of indicators dedicated to the indigenous communities, within which knowledge gathered on the state of particular species or areas could be entered and visualized in the same way as indicators documented by scientists. Within the ANI-website it is possible to include specific indicators to be filled with information from traditional knowledge. By adopting such an approach the ANI could be used as a platform to illustrate potential differences between traditional knowledge holders and scientists in the perception of the state of particular indicators or ecosystems, providing a support for discussion, offering an equal way for both opinions to be communicated and perhaps helping the to facilitate resolution in the case of conflicts. Prior to information from traditional knowledge and scientists being included within a common index, there are some fundamental questions that need to be resolved

4 Conclusion

The work presented in this report clearly demonstrates that the NI framework can be implemented within the Arctic. Its implementation depends on the motivation and interest of the members of the MOSJ and CAFF expert networks. The NI framework offers a standardized way of storing and displaying ecological information on various ecological indicators. The advantages of such standardization are clear in terms of communication and outreach. All maps and trends from the NI are expressed over the same spatial and temporal scales, thereby facilitating comparison, integration and understanding of ecological information coming from many sources.

In addition from being a “store-and-display” platform at the indicator level, the NI framework offers also a means to discuss and test the implementation of reference states for indicators. Many experts are very sceptical with regards to the concept of a reference state. However, this concept is repeatedly asked for by managers and will ultimately need to be developed and applied. It is therefore useful to have a tool allowing its exploration, helping experts to identify consistent sets of reference values across indicators.

The standardization of ecological information within the NI allows for averaging indicators together in the form of thematic indices. This is a mathematical property of the NI framework, offered through the scaling of indicators by their reference values. But aggregation is not mandatory. It is possible to keep the framework at the indicator level, without attempting any aggregation, e.g. when expert groups do not agree that enough relevant information is available to permit the calculation of meaningful thematic indices.

To summarize, a successful implementation of the NI framework requires a strong willingness to contribute from the different expert groups. Such willingness can come from the broad consensus that communicating information about ecological indicators in a standardized way across marine and terrestrial ecosystems, on similar spatial and temporal scales, together with lack of knowledge, can trigger quicker more appropriate management responses. The cost is, for the expert, to log on the website, and document information. Helping experts to do so by organizing dedicated workshops might be a solution to lift the weight of reporting from expert’s shoulders.

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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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