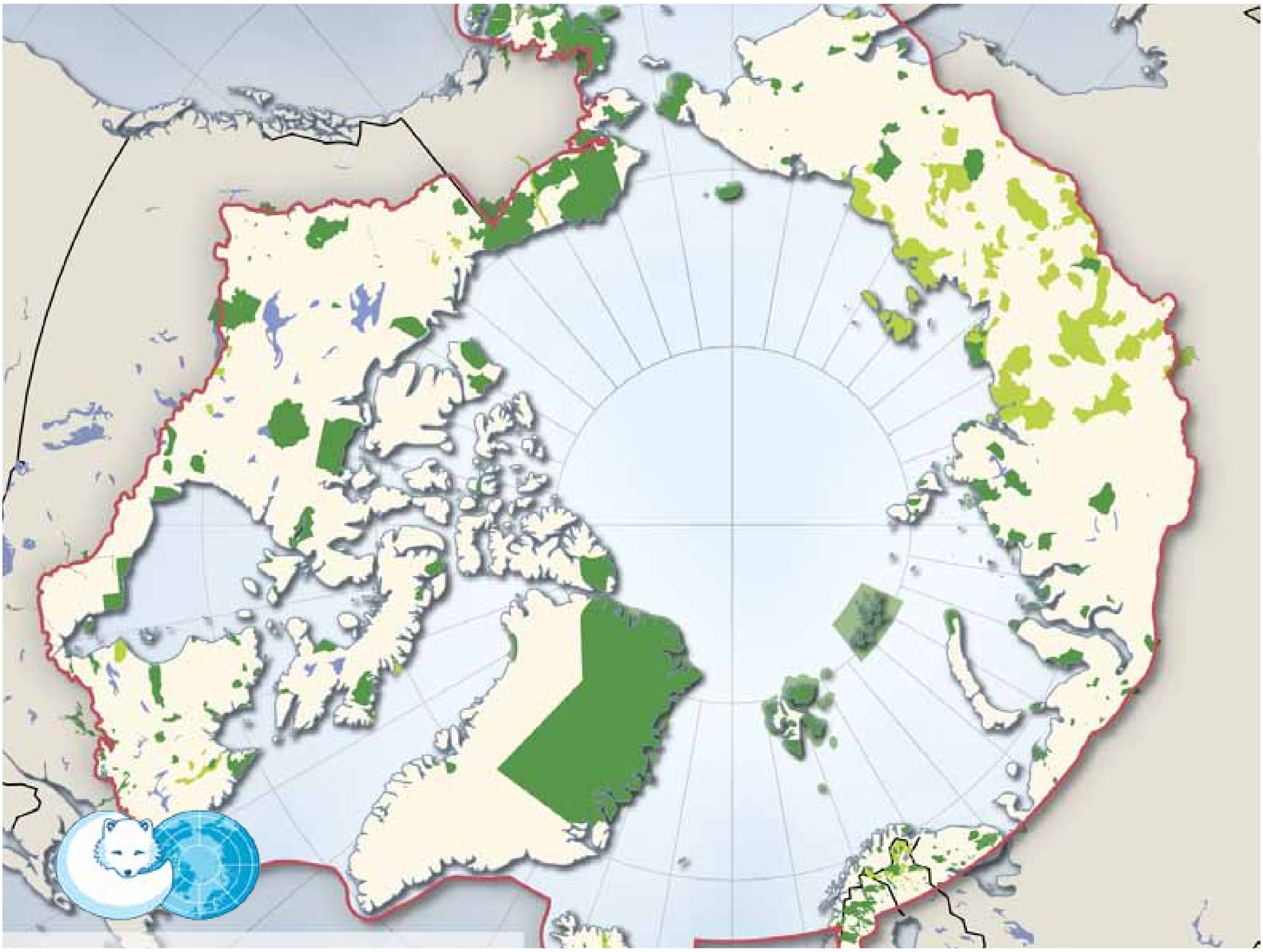
Conservation of Arctic Flora and Fauna

CBMP

CAFF Monitoring Series Report Nr. 5
March 2011

Circumpolar Protected Areas Monitoring

Arctic Protected Areas Monitoring Scheme Background Paper



Acknowledgements

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- Directorate for Nature Management, Trondheim, Norway
- Environment Canada, Ottawa, Canada
- Faroese Museum of Natural History, Tórshavn, Faroe Islands (Kingdom of Denmark)
- Finnish Ministry of the Environment, Helsinki, Finland
- Icelandic Institute of Natural History, Reykjavik, Iceland
- The Ministry of Domestic Affairs, Nature and Environment, Government of Greenland
- Russian Federation Ministry of Natural Resources, Moscow, Russia
- Swedish Environmental Protection Agency, Stockholm, Sweden
- United States Department of the Interior, Fish and Wildlife Service, Anchorage, Alaska

CAFF Permanent Participant Organisations:

- Aleut International Association (AIA)
- Arctic Athabaskan Council (AAC)
- Gwich'in Council International (GCI)
- Inuit Circumpolar Council - (ICC)
- Russian Indigenous Peoples of the North (RAIPON)
- Saami Council

This publication should be cited as: Livingston, D. (*et al*). 2011. Circumpolar Protected Areas Monitoring. Arctic Protected Areas Monitoring Scheme Background Paper. CAFF International Secretariat, CAFF Monitoring Series Report Nr. 5. ISBN: 978-9935-431-10-3

Back cover photo: NOAA

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CAFF Designated Area

Conservation of Arctic Flora and Fauna

CBMP

Contents

Executive Summary

The Circumpolar Biodiversity Monitoring Program (CBMP) is an international forum of leading scientists and conservation experts from the eight Arctic countries, the Indigenous organizations of the Arctic Council, and key global conservation organizations. As the cornerstone program of the Arctic Council's Conservation of Arctic Flora and Fauna (CAFF) Working Group, the CBMP (www.cbmp.is) aims to improve detection and reporting trends in Arctic biodiversity by harmonizing and integrating biodiversity monitoring efforts across the Arctic. The CBMP has been endorsed by the Arctic Council and is the biodiversity component of the Sustaining Arctic Observing Networks (SAON).

The CBMP focuses on five key program areas: coordination and integration of Arctic monitoring; data management; capacity building; communications, education, and outreach; and, reporting. With respect to the first of these focus areas, coordination and integration of Arctic monitoring; the CBMP is facilitating an integrated, ecosystem-based management approach to monitoring through the development of Expert Monitoring Groups representing four major Arctic biomes (marine, coastal, freshwater and terrestrial). The CBMP is also exploring, with representatives from various agencies responsible for national and regional arctic protected area management, the identification of a suite of biodiversity measures that would be commonly monitored across the Arctic and implemented in a standardized way by each agency. This initiative is intended to enable coordinated reporting of biodiversity in Arctic protected areas and to provide a circumpolar understanding of change occurring within protected areas around the arctic region.

This report:
- Summarizes the background and context for a Arctic Protected Areas Monitoring Scheme (APAMS)
- Describes current biodiversity monitoring programs of Arctic Council member states;
- Reviews the role of protected areas in existing biodiversity monitoring programs;
- Identifies differences between the European and North American approaches;
- Outlines challenges and opportunities for an Arctic Protected Areas Monitoring Scheme
- Summarizes current and projected issues facing protected areas;
- Proposes an approach for integrating circumpolar protected areas monitoring;
- Outlines factors that should be considered for the development of an Arctic Protected Areas Monitoring scheme.

Finally, the report outlines factors that should be considered for the development of an Arctic Protected Areas Monitoring Scheme.

1.0 Background

The Arctic is experiencing pressure from numerous sources. Local pollution, long-range contaminant transport, habitat fragmentation, melting of sea-ice and permafrost due to climate change, over-harvesting, invasive species and the effects of regional and economic development and subsequent transport are among the many factors affecting Arctic biodiversity.

While the effects of changes to Arctic biodiversity are of common concern, status and trend data are inconsistent and available on a sporadic basis or not at all. National and regional information is often lacking, not well shared and gathered using different methodologies and protocols. Although there are numerous biodiversity monitoring programs in place in the circumpolar Arctic there is little coordination of efforts among them. As a consequence, our understanding of the larger picture of ecosystem integrity in the Arctic and the status and trends of Arctic species and their habitats is incomplete.

1.1 The Circumpolar Biodiversity Monitoring Program (CBMP)

The CBMP is being developed by the Conservation of Arctic Flora and Fauna Working Group of the Arctic Council (CAFF) in response to directives by the Arctic Council ministers, numerous international agreements and conventions promoting the vital importance of biodiversity conservation and preservation of ecosystems. The need for clear, comprehensive, consistent and integrated Arctic environmental monitoring and reporting has also been recommended by the authors of the Arctic Climate Impact Assessment report and other studies.

Figure 1: Arctic conservation area topographic map

Source: CAFF

CAFF´s mandate is to address the conservation of Arctic biodiversity, and to communicate the findings to the governments and residents of the Arctic, helping to promote practices which ensure the sustainability of the Arctic´s resources. Within this context, the CBMP is intended to: allow for better coordination for the implementation and analyses of monitoring activities in the Arctic region; facilitate more effective transfer of information to various stakeholders; enable wider access to monitoring results and associated research; and facilitate joint activities such as combining logistical and financial resources, common analyses and assessments of data over the entire circumpolar region.

The CBMP has initiated two linked approaches: the **Expert Monitoring Groups (EMGs)** and the **Arctic Protected Areas Monitoring Scheme (APAMS)**. Once APAMS has identified the monitoring activities that could apply across circumpolar Arctic protected areas, the design and implementation of these activities should be consistent with, indeed identical to, the relevant monitoring protocols developed by the EMGs. Both programs are described below.

1.2 Expert Monitoring Groups (EMGs)

The enormous geographical and biophysical scope of Arctic biodiversity necessitates a targeted and streamlined approach to monitoring. In order to achieve a comprehensive, cost-effective pan-Arctic monitoring approach with the ability to detect large-scale trends, the CBMP has identified the creation of four EMGs as key deliverables (freshwater, terrestrial, marine, and coastal EMGs). .

Each EMG is comprised of scientists and community experts from network-based research and monitoring programs currently active in the Arctic. The primary tasks of each group are to design and implement on-the-ground monitoring in the respective area of expertise and to develop strategies to overcome critical monitoring gaps. In carrying out these tasks, the EMGs utilize existing monitoring data, consult with experts from both within and outside the Arctic, draw from other disciplines, incorporate both community and science-based approaches, develop standardized protocols, optimal sampling schemes and analytical tools, and utilize existing and emerging technologies as needed.

A major focus of the EMGs is organisms (and indicators) of critical importance to the integrity of Arctic ecosystems. Special attention is being given to community-based observations and citizen science, recognizing the valuable and significant contributions that people living in the region can make in monitoring Arctic biodiversity.

The first step EMGs often complete is an inventory of existing biodiversity monitoring programs and biodiversity trend information, focusing on both historical data and knowledge. The results of the inventory provide the information necessary to assess what the current Arctic monitoring capacity is and enable the establishment of historical baselines and trends for Arctic biodiversity. The second step EMGs complete entails a technical gap analysis. Using the inventory results and linking to the work of the EMGs, the gap analysis will pinpoint the current elemental and geographic coverage of biodiversity and monitoring and identify statistical design deficiencies and inefficiencies. Together, the inventory and gap analysis will provide the foundation for the completion of a comprehensive Arctic Biodiversity Monitoring Scheme.

1.3 Arctic Protected Areas Monitoring Scheme

The CBMP is also charged with the development of a set of monitoring programs that can be applied consistently and effectively across Arctic protected areas. Because protected areas represent relatively undisturbed landscapes characteristic of many important Arctic ecosystems they can serve as important benchmarks or control sites for monitoring programs, as compared to more disturbed landscapes outside the protected area boundaries.

The Arctic Protected Areas Monitoring Scheme (APAMS) is being led by Arctic country representatives familiar with the Arctic protected areas and with the monitoring programs within their respective jurisdictions. The objective is to develop a suite of indicators which will be monitored across the Arctic protected areas network. This will involve an inventory of existing programs, the identification of common themes and programs, the identification of gaps and the design of a common approach to monitoring biodiversity in circumpolar protected areas

APAMS needs to take into account a number of factors including current and projected issues facing Arctic protected areas, current monitoring capacity in those areas and opportunities for a set of common parameters to be implemented across the protected area network within existing monitoring capacity and mandates.

2.0 Context

2.1 Protected areas: what and why?

Protected areas represent relatively undisturbed landscapes. They are created and maintained, primarily,

- to support the conservation of biodiversity, including the protection of rare and endangered species;
- for the protection of important cultural heritage; and
- for the protection of special physical features

Many protected areas combine all three attributes and are important for recreation, education and economic development.

Protected areas are important for research and monitoring because they can serve as important biophysical "benchmarks" or "control sites" where human-caused stresses are minimal, or at least well defined. These sites offer the opportunity to measure "ecological integrity" (defined by Parks Canada as: "a condition that is determined to be characteristic of its natural region and likely to persist, including abiotic components and the composition and abundance of native species and biological communities, rates of change, and supporting processes"), and to monitor changes in key attributes, indicators and values.

"Protected areas are recognized by all the Arctic countries as effective and necessary means of conserving Arctic biodiversity and supporting the sustainable use of biological resources". (CAFF Circumpolar Protected Area Network (CPAN) expert group). While this expert group is currently dormant, its work to date is a valuable source of information to inform and guide the CBMP.

The International Union for Conservation of Nature (IUCN) defines a protected area as "an area of land and/or sea especially dedicated to the protection and maintenance of biological diversity, and of natural and associated cultural resources, and managed through legal or other effective means." One premise is that protected areas be secure in perpetuity. Another is that to be successful, protected areas must be designed and networked in the broader regional landscape, allowing for buffers and migration corridors and careful management outside (and inside) the protected areas themselves. This is one of the principles of the European Union's Natura 2000 program, which relies on a mix of protected areas on state-owned and private lands, which are set in a context of broader environmental stewardship.

2.2 Circumpolar protected areas: where are they?

CAFF has updated the circumpolar protected area network index in the report *Arctic Biodiversity Trends 2010 – Selected indicators of change*. The first protected areas dataset for the Arctic was created by CAFF in 1994 and most recently updated in 2010. This updated dataset has been submitted as an Arctic component to United Nations Environment Programme (UNEP) World Protected Areas Database. Iceland is leading a project focusing on those protected areas which have a marine/coastal component. This project will further develop the information on these areas and compile a dataset detailing the nature and extent of the protection afforded.

2.3 Monitoring and monitoring programs in protected areas

2.3.1 Monitoring in Europe and North America: different approaches

It is important to understand the circumpolar and regional context of protected areas, and understand the historical differences in the European and North American approaches to the establishment and monitoring of protected areas.

One of the main aims of the European Union is to stem the loss of biodiversity. The Natura 2000 network is one of the main tools to achieve this goal. Natura 2000 is composed of Special Protected Areas designated under the EU Birds Directive and Special Areas of Conservation designated under the EU Habitats Directive. Protected areas in the Natura 2000 network are established on a mix of privately owned lands and state-owned lands in Europe, although in some Scandinavian countries most protected areas are on state-owned land. In the rest of Europe, protected areas are part of a broad planning framework that includes both privately owned land and nationally-designated formally protected areas on public land. As a consequence, monitoring programs in Europe often do not distinguish between protected areas and the broader landscape.

The approach is different in North America, where protected areas are largely located on federal or state-owned land and are formally designated. Also in contrast to much of Europe, many North American protected areas are very large, particularly in the Arctic. Thus they may, for a time, maintain ecological integrity because of their size and because of the relatively underdeveloped nature of their surroundings. In effect, many protected areas in the North American Arctic are representative of the broader landscape, as opposed to "islands" of protection in otherwise disturbed landscapes as they are in much of Europe.

Monitoring programs in the North American Arctic are at different stages of development, depending on the managing agency and the national jurisdiction. The U.S. National Park Service has a strong program focused on monitoring change across a variety of biotic and abiotic metrics. The U.S. Fish and Wildlife Service is in the process of developing an inventory and monitoring program that will address both local and ecoregional information needs. Newly developed conservation science partnerships in the form of Landscape Conservation Cooperatives will provide coordination among agencies, universities and private stakeholders to ensure a focus on broader issues and the role protected areas play in the conservation landscape.

In the Canadian Arctic, Parks Canada (responsible for national parks) and the Canadian Wildlife Service (responsible for National Wildlife Areas, Migratory Bird Sanctuaries and Marine Wildlife Areas) focus monitoring efforts on the designated protected areas while considering broader regional issues. Regional monitoring efforts in the Canadian Arctic are relatively limited and are not well coordinated among responsible agencies (federal and territorial). Given that many protected areas in the Canadian Arctic are very large and the surrounding region is relatively undisturbed, monitoring in protected areas in the Canadian Arctic is, for now at least, also generally indicative of conditions outside those protected areas.

2.3.2 Observations about monitoring

A principle reason for creating protected areas is to conserve the special biodiversity values within them. Maintaining the relatively undisturbed landscapes and ecosystems will help ensure that the important values are conserved; at the same time, these landscapes and ecosystems offer important biodiversity monitoring opportunities. In the context of a APAMS program, protected areas offer the opportunity to serve as biodiversity monitoring locations where natural ecosystem processes continue relatively undisturbed, in contrast to areas where industrial and other developments are the norm. Arctic protected areas are subject to relatively few disturbances and therefore provide important benchmarks or baselines for biodiversity monitoring.

Monitoring programs are essential in determining whether internal or external pressures to the protected area are affecting the biodiversity values. They are also essential in assessing the significance of changes, and facilitating mitigating action if such actions are determined to be necessary. In other words, monitoring results help to determine what is changing and what management actions, if any, should be taken. Monitoring can also determine the effectiveness of those management actions.

Monitoring programs should have specific purposes tied to specific objectives in order to be effective. Otherwise, resources may be wasted in collecting unnecessary data. Nor should monitoring programs be confused with research programs. As noted earlier, monitoring programs should be designed to evaluate changes in targeted indicators ("what is happening?"); research programs are designed to determine how and why something is happening. The two are clearly linked and iterative.

Long-term monitoring is essential in determining baseline conditions and trends, and research is critical to understanding why things are the way they are and why changes are occurring. Monitoring tools range from long-term sampling at consistent sites to satellite imagery (including the use of historical imagery) to extrapolation and interpolation from the existing database. Research approaches vary as well, according to the need, interest, and resources available. In the end, effective, integrated and long-term research and monitoring programs will tell us what is changing, why it is changing, why we might be concerned, and what we might do about it, if anything.

To ensure that monitoring programs are effective, it is critical that we be clear about the questions we are trying to answer (e.g., what are the changes we are looking for and why), the appropriate indicators and how the monitoring programs will be carried out. Both physical and temporal scales are important in the case of the APAMS: the physical scale is circumpolar while the temporal scale is historical, current and ongoing.

Each protected area is unique. Each area represents a unique collection of ecosystems and habitats, flora and fauna, human uses, and vulnerability to changing conditions and circumstances. This is true whether an area is one of several in a particular ecoregion /ecozone or stands alone. This obviously presents challenges in the development of a common monitoring scheme for all circumpolar protected areas. Further adding to the challenge, most European monitoring programs are regional in nature and not focused specifically on protected areas. In North America, protected area-specific monitoring programs are the norm, although coverage is far from complete or comprehensive.

This challenge is compounded by the tendency for the "stove-piping" of monitoring programs, i.e., the tendency of different organizations to develop their own approaches to monitoring, thus creating compatibility obstacles. There are many examples of this. It is important that as the work being undertaken by the Expert Monitoring Groups is advanced, it be appropriately linked to the work of the APAMS network as well as to the activities of and other relevant programs. Clearly, a thorough review of related initiatives will be essential before any final decisions are taken with respect to APAMS implementartion.

Further adding to the challenge is the absence of integrated monitoring programs in many protected areas, where programs exist at all. Finally, not all monitoring programs can be relevant to all protected areas.

All that said, the opportunity to create a standardized set of monitoring activities for protected areas within the Arctic that will yield comparable results is an exciting one. There is enormous potential for improving our individual and collective abilities to identify and track trends in key biodiversity indicators in a changing climate and on a circumpolar scale, using protected areas as benchmarks or control sites. In this context, monitoring programs will serve two purposes: individually, each monitoring program will track changes in key components of ecosystems within each protected area; collectively, the monitoring programs will provide an indication of changes in biodiversity occurring on a circumpolar scale. The challenge is to select a set of monitoring programs most relevant to each protected area and indicative of changes in circumpolar diversity. This requires the identification of common themes and a set of common indicators that can be monitored consistently and relatively easily across the circumpolar protected area network.

In some cases, the necessary monitoring programs are already being implemented. In other cases, there may be opportunities to develop new programs. The challenge for the APAMS network is to develop a monitoring program that effectively and efficiently leverages existing programs, utilizes common methodologies and enables an understanding of circumpolar biodiversity change in response to a suite of stressors.

3.0 Current and projected issues facing Arctic protected areas

There are many pressures facing protected areas worldwide. Most of these relate to increased human activity within and adjacent to protected areas. In the Arctic, climate change is a major factor. The following sections overview many of the pressures that Arctic protected areas are experiencing generally. As one specific example, Table 1 highlights pressures identified by Finland with respect to its protected areas.

Table 1: Key issues affecting protected areas in Finland

Issues refer here to threats and pressures to biodiversity conservation objectives or challenges in management. Issues vary with protected area type and location. (Source: Heikki Eeronheimo, Metsahallitus).

Protected area type and management\ protection objectives	Key Issues
Established protected areas Arctic-alpine, forest and peatland habitats and their species: Mainly maintaining or to lesser extent improving the status of the habitats and species, (active management e.g., some threatened species, semi natural grasslands).	Tourism, recreational use (hiking): mainly in National Parks.
	Hunting permitted (also in some Strict Nature Reserves) at least for local people. Commonly, commercial hunting permitted, but regulated and managed by the state authority Metsähallitus, Natural Heritage Services (NHS).
	Recreational (commercial) fishing usually permitted. Restrictions for types of fishing (fishing nets, etc.) in most areas.
	Existing gold mining is a pressure in some protected areas. Mining is also a future threat, except in Strict Nature Reserves and National Parks, where new mines are not permitted.
	Reindeer herding: overgrazing by reindeers is a problem in many areas. Local erosion by recreational vehicles.
Wilderness areas Arctic-alpine, forest and peatland habitats and their species: Established for safeguarding wilderness character, Saami culture, traditional nature-based livelihood culture (e.g., reindeer herding, hunting, fishing) and promoting multiple use of nature.	Forestry permitted in some areas and in small scale, but is not practiced in recent years nor will be in the near future.
	Managing the level of nature-based livelihood.
	Reindeer herding: overgrazing by reindeers is a problem in many areas. Local by recreational vehicles.
State areas reserved for protection Area belonging mainly in national conservation programmes. Arctic-alpine, forest and peatland habitats and their species.	See all protected areas above.
	Not yet established > regulations partly missing, and thus unclear (for individual persons, some types of land use, e.g., mining).
Natura 2000 network Habitats and species which are listed in EU habitats directive (proposed = Sites of Community Importance and established = SPeeecial Area of Conservation) or birds directive (Special Protected Area): Mainly maintaining or to lesser extent improving the status of the habitats and species in the EU-directives (active management e.g., some declining species, semi natural grasslands).	Challenge: Management of areas, which are managed by other measures than nature conservation areas. This is of minor importance since in Finnish Arctic area most of the Natura-areas are state owned by PAs or areas reserved for protection and managed NHS. Other key issues are much the same in protected areas.

3.1 Climate change

In many, if not all, Arctic protected areas, climate change is having widespread and profound effects on habitats, biotic communities, human activities, accessibility, disease and other aspects of biodiversity. The consequences will include changes in the characteristics of protected areas, the nature of human use in those areas and the types of management actions required to maintain protected area values and mission. Climate change may result in the disappearance or dramatic modification of key features of a protected area (e.g., glaciers and permafrost features), threats to wildlife populations and endemic species, the introduction of non-native species and new diseases, reduction of river flows and so on, with consequent ecosystem effects. Offshore, the loss of sea ice will have significant and wide-ranging effects on the ecology of most Arctic marine mammals.

Changes are occurring rapidly in many areas. Sea ice is disappearing at an accelerated rate. Other examples include increased melting of glaciers, unprecedented outbreaks of invasive and harmful insects (e.g., the mountain pine beetle) and expansion north (and into higher elevations) of the normal ranges of "southern" mammals, reptiles, vegetation and birds. Table 2 summarizes climate change concerns in four ecoregions in Alaska. Monitoring programs will need to be innovative, robust, sufficiently detailed and flexible if they are to capture these changes.

Table 2: Climate change concerns in four Ecoregions of Alaska

Polar	Bering Coast	Interior Alaska	North Pacific Coast
Altered management of harvested species	Change in plant and animal community composition and structure	Altered fire regimes (increased drying likely to cause more frequent and intense fires)	Altered phenology (better understood in terrestrial ecosystems)
Altered distribution of invasive species (relating to detection and control)	Drying of wetlands	Changes in invasive species diversity and distribution	Water quality, especially melting of glaciers, surface water flow, water chemistry, and timing & quality of fresh water entering marine systems (and consequent local effects on salinity).
Altered water quality and quantity	Changes in amount and timing of precipitation	Altered subsistence management (population sizes, reproduction and demography; harvest regulations; phenology)	Altered animal community dynamics (terrestrial and marine), due to species' differential responses to climate change.
Effects on biological diversity (including legal and statutory ramifications)	Alterations to terrestrial hydrology	Effects on rare and declining species and habitats (identify losses, determine conservation actions needed)	Changes in ocean dynamics (upwellings, acidification, altered currents, impacts on marine food webs, nutrient flows, effects on seabirds)
	Changes in the types, levels and spatial distribution of anthropogenic activities	Alterations to water quality and quantity (including management of upstream activities)	Change in plant community composition and structure
		Effects on species covered by treaties (for which broad-scale coordination is essential)	Alterations to migratory and invasive species.

Source: Woodward, A., and E. Beever. 2010. Framework for ecological monitoring on lands of Alaska National Wildlife Refuges and their partners: Anchorage, Alaska. US Department of the Interior, US Geological Survey, Open-File Report 2010-xxx. V+88 pgs DRAFT 14 Dec 09

3.2 Increasing human use

As human populations continue to increase, protected areas everywhere are coming under increased direct human pressure from simple visitation, recreation, harvesting and other uses (including research and monitoring). In some areas backcountry use is increasing. recreational vehicle traffic in European protected areas, and causing concern. Day-use of protected areas is likely to increase with potential consequences for easily accessible areas. Overall, human activities will have increasingly significant impacts on ecosystems, archaeological resources and traditional cultural uses. Monitoring programs must capture these and other changes resulting from changes in human activities.

3.3 Development within and surrounding protected areas

Protected area ecosystems are necessarily directly linked to surrounding areas. Boundaries are transparent to wildlife and plants and the effects of activities outside protected areas (and within protected areas) will have consequent effects on the other side. As human pressures increase and climate change effects become more acute, fragmentation, contamination, loss of habitat and overuse in areas adjacent to protected areas are likely to increase, creating pressures on the protected areas themselves. Within some European protected areas, reindeer overgrazing is already a serious threat to ecosystem integrity.

Pressures from forestry, pipeline development, mining, roads and community growth are among those expected to grow significantly as populations increase and demands for natural resources, particularly minerals, oil and gas, grow apace. The direct and indirect effects of industrial development adjacent to protected areas are significant but the pressure to open protected areas to development is perhaps the greater concern.

3.4 Global and local contaminants

Long-range atmospheric and oceanic transport mechanisms are bringing contaminants to protected areas. Contaminants are also being introduced through development of local natural resources (e.g., mining, oil and gas development) and access by motorized vehicles. Contaminants cause numerous and varied chronic and acute effects, some subtle and long-term, some obvious and immediate. Monitoring programs need to be designed accordingly.

3.5 Non-native invasive species
As air and water temperatures increase, non-native species are increasingly appearing and persisting in areas where they did not previously exist. These non-native species compete with (and sometimes displace) native species for prey or habitat, bring with them new diseases and parasites and alter the ecosystem in significant ways. Increased human access to protected areas also brings the risk of introducing new species, with consequent ecosystem changes.

3.6 Loss of traditional knowledge

Traditional knowledge (TK) related to protected areas is diminishing globally as a consequence of many factors including inadequate documentation, the passing on of TK holders, inappropriate integration of TK in analyses and decision-making, inadequate institutional structures, political disregard or disrespect for the value of TK, and other reasons (e.g., loss of linguistic diversity). Improved mechanisms are needed to ensure that TK is fully incorporated in protected area decision-making (including the design and implementation of monitoring programs and the application of the results of these programs). The effectiveness of these measures will require sound monitoring programs and adaptive management.

3.7 Capacity, administration and coordination

In addition to the needed adjustment of monitoring programs so they accommodate rapidly changing conditions, these programs also face "administrative" challenges. For example, effective monitoring programs require sustained funding and retention of expert staff, which is always a difficult challenge. Monitoring programs must also be compatible and therefore should be developed collaboratively among Arctic nations so that methodologies are consistent, the results are comparable and consistently and quickly reported and the technical and logistical issues are addressed pragmatically.

The different approaches to monitoring in Europe and North America referenced earlier present significant challenges. In Europe, the EU directives form the basis of much monitoring and that monitoring tends to be regional or nationwide rather than focused on the protected areas, versus the North American approach where protected area-specific monitoring is often the norm.

Sustained effort by member nations will be required to overcome the tendency for each to go its own way and to overcome the tendency of agencies to work separately rather than collaboratively when it comes to biophysical research and monitoring programs (and other activities).

Investment in human capacity is vital. Effective long-term monitoring relies on highly trained scientists staffed in positions where they can do their jobs effectively and efficiently and where they can work with trained and knowledgeable local people.

Finally, while it is relatively simple to develop a set of monitoring programs that could be implemented across circumpolar protected areas, it will be far more challenging to implement and sustain this commitment.

4.0 Current monitoring programs

In every jurisdiction—state, provincial, territorial, federal—there is a multiplicity of environmental monitoring programs. In Canada's Northwest Territories alone there are at least 278 monitoring programs, most of which are uncoordinated and the results of which are often incompatible. Unfortunately, this situation appears to be the norm nationally and internationally. Compounding the challenge of developing a comprehensive understanding of changes in circumpolar biodiversity is the difficulty in identifying and inventorying existing (and past) monitoring programs, an exercise which in turn pales in comparison to cataloguing the data captured in the respective programs in a manner that is consistent across programs and readily available to other users.

The generically different approaches taken in North America and Europe with respect to monitoring of protected areas present a further complication. Broadly, the former (Canada and the U.S.) have agency-driven monitoring programs specifically targeting protected areas. On the other hand, European countries tend to have regional programs driven in large part by European Union directives. These programs often do not focus on protected areas per se but do include protected areas.

The following sections overview the protected area monitoring programs and approaches currently in place in Arctic countries.

4.1 U.S. (Alaska)

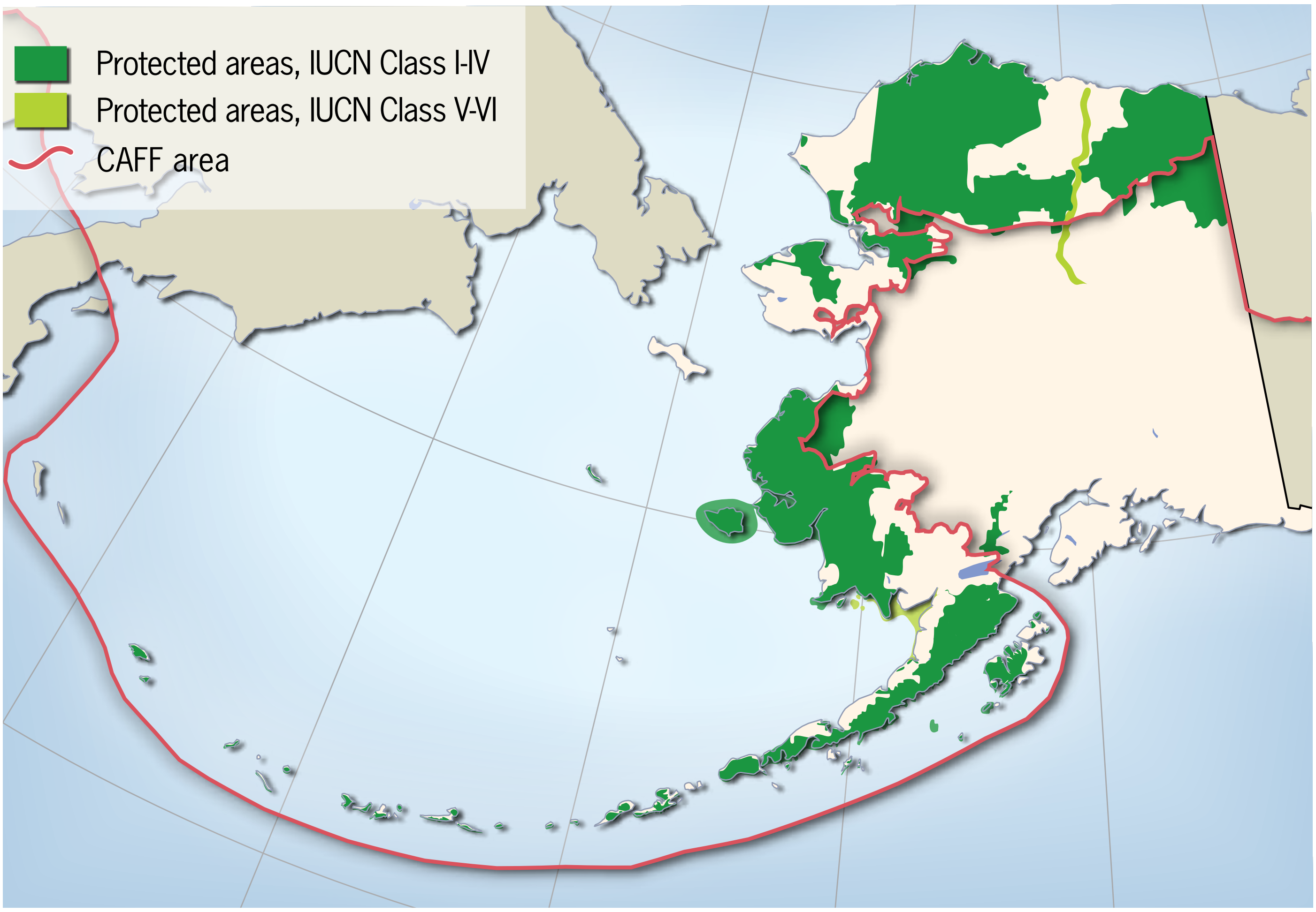
Ecological monitoring in Alaskan protected areas has a long history. It is broad-ranging and in the case of government-run monitoring programs, is undertaken by numerous agencies, notably the U.S. Fish and Wildlife Service (USFWS), the Alaska Department of Fish and Game, the U.S. Forest Service, the U.S. National Park Service and the Bureau of Land Management. However, as with many other jurisdictions, monitoring and research efforts are often undertaken by separate agencies or non-governmental entities independently of one another. Different organizations may follow different monitoring protocols and the programs themselves are often not well integrated across or within. State and federal authorities in Alaska are working to improve this situation, in part through the advent of Landscape Conservation Cooperatives (LCCs) and programs such as the North Slope Science Initiative so that collectively agencies and organizations are better able to track changes in biodiversity at various special resolutions (refuge, ecoregion and state-wide).

In this context, the U.S. National Park Service has designed and implemented an integrated monitoring program for Alaskan national parks, the results of which are intended to improve understanding of park ecosystems, inform wise park management and to be shared with other jurisdictions, particularly those in the Arctic.

The Arctic Network Monitoring Program includes several core inventories: a natural resource bibliography; base cartographic data; geology and soils maps; weather data; air quality data and air quality station locations; water body location, classification and water quality data; vegetation map; species list (including vertebrates and vascular plants); and species distribution and status data.

National park vital signs monitoring tracks a subset of physical, chemical and biological elements and processes of park ecosystems selected to represent the overall health or condition of park resources, known or hypothesized effects of stressors, or elements that have important human values. Table 3 summarizes the U.S. National Park Service Arctic Network Monitoring Program.

Figure 2 Protected Areas of Alaska



Only protected areas overlapping or north of the CAFF boundary are displayed

Table 3: Vital signs of the Alaskan National Park Service Arctic Network

National Parks lised include: Bering Lands Bridge (BELA), Cape Krusenstern (CAKR), Gatres of the Arctic (GAAR), Kobuk Valley (KOVA), and Noatak (NOAT).

Monitoring Framework	Vital Sign	Parks Where Monitored				
		BELA	CAKR	GAAR	KOVA	NOAT
Air and Climate	Airborne contaminants			●		
	Climate	●	●	●	●	●
	Snowpack	●	●	●	●	●
Geology and Soils	Coastal erosion	●	●			
	Sea ice	❍	❍			
	Permafrost	●	●	●	●	●
Water	Lake communities and ecosystems	●	●	●	●	●
	Lagoon communities and ecosystems		●			
	Stream communities and ecosystems	●	●	●	●	●
	Surface water dynamics					
Biological Integrity	Land birds	●	●	●	●	●
	Yellow-billed loons	●	●			
	Brown bears	●	●	●		●
	Dall's sheep			●	●	●
	Muskox	●	●			
	Caribou	❍	❍	❍	❍	❍
	Moose	❍	❍	❍	❍	❍
	Fish assemblages	💻	💻	💻	💻	💻
	Small mammal assemblages	💻	💻	💻	💻	💻
	Terrestrial vegetation and soils	●	●	●	●	●
	Invasive / exotic species	💻	💻	💻	💻	💻
Human Use	Subsistence / harvest	❍	❍	❍	❍	❍
	Point source human effects	💻	💻			💻
Landscapes	Fire extent and severity	❍	❍	❍	❍	❍
	Landscape patterns and dynamics	●	●	●	●	●

Source: Robert A. Winfree, National Parks Service Alaska

● Vital signs for which the network will develop protocols and implement monitoring with funding from the vital signs or water quality monitoring program.

❍ Vital signs that are currently being monitored long-term by a network park, another NPS program or by another federal or state agency. The network will collaborate with these other monitoring efforts where appropriate but will not use vital signs or water quality monitoring program funds.

💻 Vital signs for which monitoring will likely be done in the future but which cannot currently be implemented due to limited staff and funding.

The USFWS has developed a strategic plan and an operational blueprint for inventory and monitoring of national wildlife refuges. This will enable the USFWS to assess the vulnerability of wildlife refuges to climate change and associated stressors, including changes in precipitation patterns, water shortages, increased fire risk, contaminants, land use changes and increases in weed species, pests and disease pathogens. The inventory and monitoring program should also enable the USFWS to detect changes in biodiversity (e.g., changes in biomes and species ranges, migration patterns and extinction rates), to assess the vulnerability of coastal refuges of sea level rise, rising ocean temperatures and ocean acidification and to assess the vulnerability of Arctic refuges to climate changes. Ultimately this information will inform adaptation strategies.

Proposed USFWS monitoring indicators (Table 4 and Table 12) are intended, among other things, to enable the USFWS to determine trends in population size of species used for subsistence; to determine whether intact ecosystems and natural processes are being conserved within and across refuges; to determine population trends in focal species; and to determine trends in water quality and water quantity.

Collaborative landscape conservation has been identified as an important step in addressing conservation concerns by Alaska and the federal departments of the Interior, Commerce and Agriculture. Partner agencies in LCCs are beginning to consider how to share expertise and capacity to achieve common landscape conservation goals. LCCs will bring together federal, state, tribal, and local governments with private landowners, academia and organizations to develop strategies for understanding and responding to landscape-level impacts

The North Slope Science Initiative (NSSI) was developed by federal, state and local governments with trust responsibilities for land and ocean management to facilitate and improve the collection and dissemination of ecosystem information pertaining to the Alaskan North Slope region, including coastal and offshore regions. It will improve scientific and regulatory understanding of terrestrial, aquatic and marine ecosystems for consideration in the context of resource development activities and climate change.

Table 4: Potential Alaskan monitoring indicators

Indicator	Ecoregion			
	Polar	Bering Coast	Interior Alaska	North Pacific Coast
Air and Climate	Beaufort Gyre Sea ice distribution Phenology, Shorefast ice distribution Phenology	Marine climate Sea ice distribution Phenology Shorefast ice distribution Phenology Ocean currents	CO2 levels (release by melting permafrost and peat degradation, fires; sequestration by plant growth)	Sea ice distribution Phenology
Geology and Soils	Marine-derived nutrients	Marine-derived nutrients	Marine-derived nutrients Permafrost distribution and melting	Marine-derived nutrients Isostatic rebound Volcanism
Water Quality and Quantity	Marine conditions	Marine conditions Aspects of Kuskokwin River water Aspects of Yukon, Kobuk Rivers	Marine conditions River flow and flood risk River-ice breakup	Marine conditions (pollutants, acidification, climatic influence)
Biological Integrity	Migratory birds Caribou herds Phenology (insects, sea ice, vegetation, green-up, migratory birds)	Beluga whales, Other migratory large marine mammals Migratory birds Anadromous fishes Caribou herds Phenology (ice, vegetation, green-up, migratory birds)	Migratory birds Anadromous fishes Caribou herds Phenology (insects, river ice, vegetation, green-up, migratory birds, fire season)	Whales Northern fur seals Other migratory large marine mammals Marine food web Phenology (whale migrations, vegetation green-up, migratory birds)

Indicator	Ecoregion			
	Polar	**Bering Coast**	**Interior Alaska**	**North Pacific Coast**
Anthropogenic Stressors	Harvest of migratory animals Fire management	Harvest of migratory animals Fire management	Harvest of migratory animals Fire management	Harvest of migratory animals Fire management Oil and gas development

Source: Woodward, A., and E. Beever.2010. Framework for ecological monitoring on lands of Alaska National Wildlife Refuges and their partners: Anchorage, Alaska. US Department of the Interior, US Geological Survey, Open-File Report 2010-xxx. V+88 pages DRAFT 14 Dec 09)

4.2 Canada

As noted earlier, there is a multiplicity of monitoring programs occurring within protected areas in Canada. Parks Canada monitoring programs for Western Arctic National Parks are summarized in Table 5.

Table 5: Canadian Western Arctic National Park Monitoring Report, 2008

Monitoring	Aulavik NP	Ivvavik NP	Tuktut Nogait NP	Pingo Canadian Landmark
Wildlife				
Wildlife cards	●	●	●	●
NWT-Nunavut bird checklist	●	●	●	●
Aquatic invertebrate monitoring	●	●	●	
Lemming winter next monitoring	●			
Bluenose-west caribou monitoring			●	
Porcupine caribou monitoring		●		
Habitat				
Satellite monitoring of northern ecosystems	●	●	●	
Pingo monitoring				●
Human Use				
Firth River campsite monitoring		●		
Human use monitoring	●	●	●	
Cultural Resources				
Tuktut Nogait NP cultural resource monitoring			●	
Environmental Processes				
Weather monitoring	●	●	●	
River flow monitoring		●	●	
Water quality monitoring	●	●	●	
Fresh surface water mapping and monitoring (RADARSAT)			●	
Solid Waste				
Groundwater monitoring at Komakuk Beach		●		

The primary goal of Parks Canada is to ensure "ecological integrity" within its park system. Parks Canada has selected indicators through which it measures trends in ecosystem integrity, including abiotic components (e.g., water, rocks); landscape diversity components (e.g., tundra, rainforest, grasslands); species diversity components (e.g., bears, trees, birds); and ecosystem process components (e.g., fire, floods, predation).

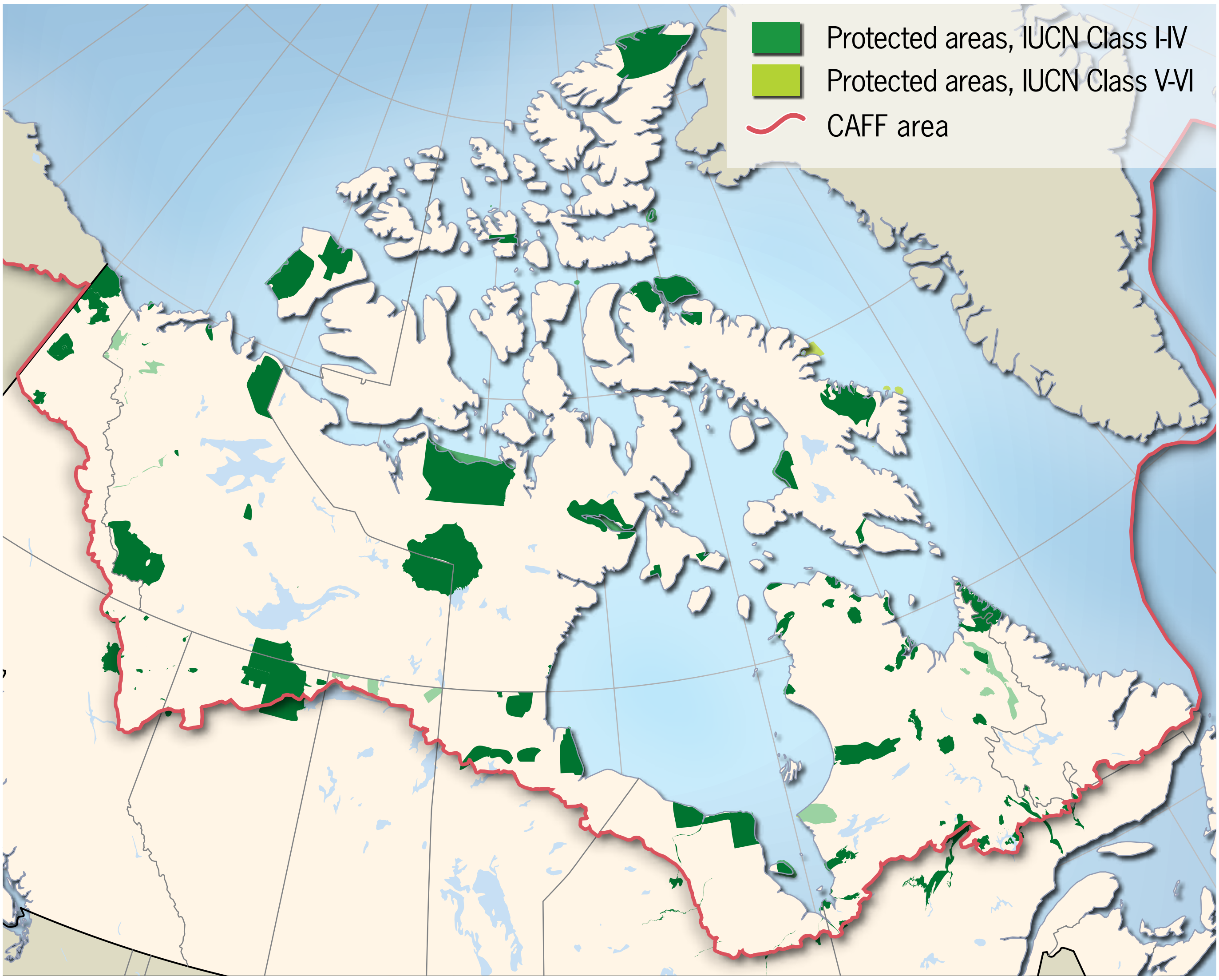
Parks Canada uses the following breakdown:

Indicator: glaciers and permanent ice
Measure: glacier mass balance
Measure Assessment and Trend: improving, stable, or declining (as appropriate)
Data Quality: deficient, fair, good (as appropriate)

The maintenance of ecosystem integrity is guided by discrete objectives relevant to the particular park. For example, an objective may be to maintain all native species within a park at viable population levels, to maintain forest ecosystem productivity that optimizes representation and habitat requirements or to maintain lake and stream water quality and quantity at predefined levels. With climate change it may well be impossible to maintain "ecological integrity" as defined by Parks Canada as that particular definition assumes a level of stationarity that likely no longer applies but the approach clearly allows trends to be identified and tracked on a national scale.

Monitoring to determine ecological integrity in national parks is carried out on the ground by Parks Canada and its partners, by remote sensing through Canada's ParkSpace program, through other agencies and through the application of traditional ecological knowledge.

Figure 3 Protected Areas of Canada



Only protected areas overlapping or north of the CAFF boundary are displayed

4.3 Greenland

Greenland does not have specific protected area monitoring programs. Nor does it have a national monitoring strategy although one is under development.

Currently, government-monitoring efforts are focused on harvested resources, threat monitoring in response to pressures from industrial development (including mining, oil and gas exploration, and increased shipping), wildlife monitoring and observations by the Danish Army. Some monitoring activities do focus on species that occur in protected areas and thus provide information to support biodiversity assessments (Table 6).

Greenland's monitoring programs currently include the following:

- Greenland Ecosystem Monitoring (GEM) at two sites, of which one is at the Zackenberg Research Station in Northeast Greenland National Park and the other near Nuuk (not within a protected area); Greenland Institute of Natural Resources, monitoring of harvested species (some in protected areas), threat monitoring (some in protected areas), and local monitoring by non-scientists (some in protected areas). The Zackenberg monitoring program has been underway since 1995 and includes monitoring on five themes: climate, marine, geological, glacial, and biological. The latter includes monitoring of the dynamics of a large variety of organisms and biological processes in the local ecosystems;

- Monitoring of harvested species, in some cases dating back over 100 years, including narwhal, other whales, walrus, harbour seal, polar bear, muskox, reindeer, fox, hare, guillemot, eider, grouse, cod, halibut, lumpsucker, salmon, red fish, crab, shrimp and mollusks. Many of these species occur in protected areas although the monitoring effort varies with the species;

- Threat monitoring including monitoring the number of expeditions/visitors (East Greenland National Park and other protected areas), monitoring ad hoc visits to at least one protected area, monitoring harvested species in protected areas with quotas (e.g., polar bear, walrus, narwhal, beluga, muskox and caribou) and monitoring grazing effects at two sites, neither of which are in protected areas; and,

- Local monitoring by non-scientists including patrol-based recording of wildlife by Sirius Sledge Patrol in East Greenland National Park, community-based monitoring of selected species, threats and climate parameters (under development) and a public observation database (under development) where members of the public can report sightings of species, climate observations and observations of other environmental matters.

Table 6: Monitoring programs in Greenland

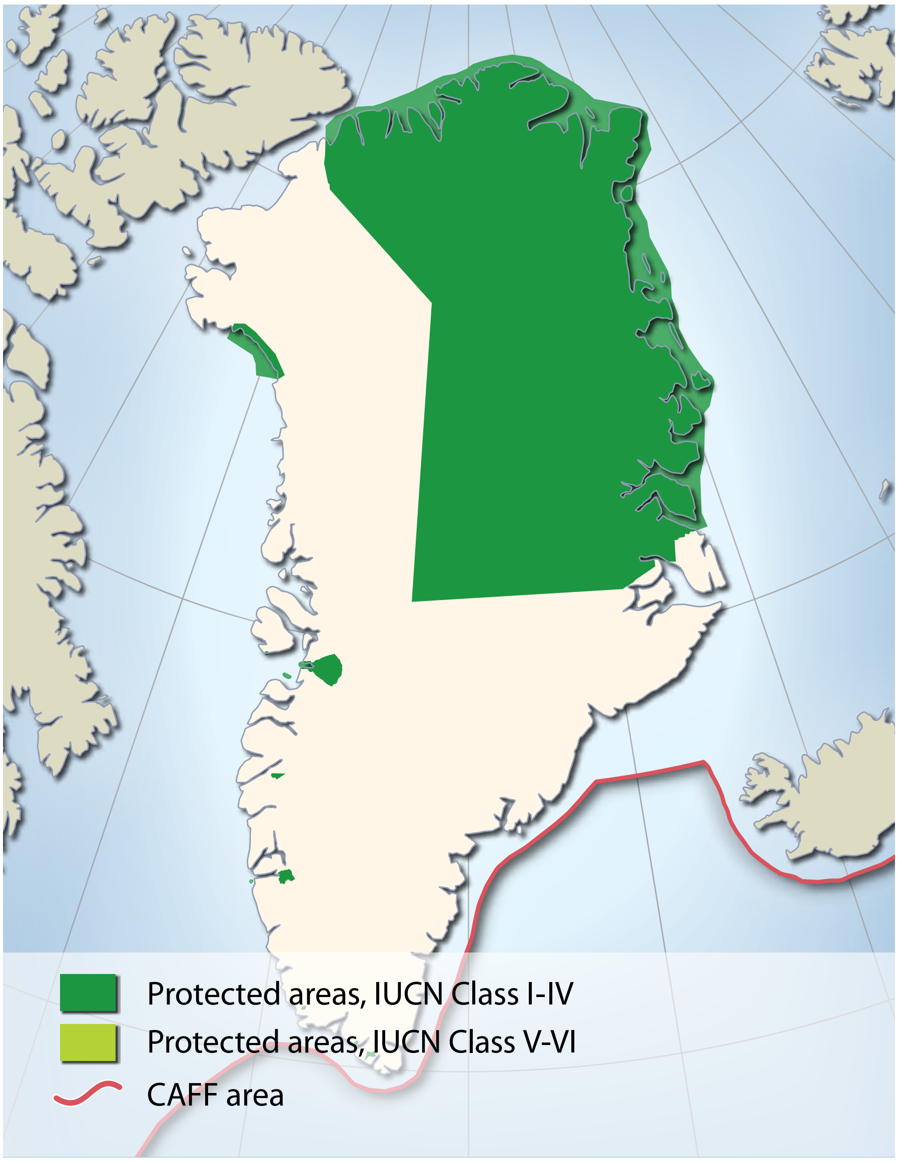
Protected Areas	Key Ecosystem Components	Key Issues	Monitoring Program(s)	Indicator(s)	Other Issues
Melville Bay Nature Reserve	Narwhal Polar bears	Population status	Marine mammal monitoring programme (GINR)	Population size	
Ilulissat Icefiord, World Heritage Site	Glacier Ice Halibut	Erosion	Fish monitoring programme (see GINR) Ad hoc visits by site manager Erosion monitoring (non- data-based)	Halibut population size	

Protected Areas	**Key Ecosystem Components**	**Key Issues**	**Monitoring Program(s)**	**Indicator(s)**	**Other Issues**
Unnartoq Hot Springs		Tourism	Ad hoc visits by NNPAN		
Klosterdalen	Birch forest		Ad hoc visits by NNPAN		
Tiningnertoq	Birch forest		Ad hoc visits by NNPAN		
Akilia	Old rock formations		Ad hoc visits by NNPAN		
North and East Greenland National Park / UNESCO Biosphere Reserve	Vegetation zones Wildlife	Climate change Oil and mineral exploration Tourism	1. Zackenberg Ecological Research Operations http://www.zackenberg.dk/monitoring. Site specific, covering less than one per cent of the National Park. Five subcomponents: - ClimateBasis - MarineBasis - GeoBasis - GlacioBasis - BioBasis 2. Wildlife recordings during patrol activities (non-scientist) 3. Ad hoc bird and mammal surveys 4. Impact monitoring 5. Ad hoc visits by NNPAN	1. Various 2. Number ofobservations 3. Population size / health / distribution 4.Expeditions and visitor numbers	National Park includes two Ramsar sites
Qinnguadalen	Birch forest		Ad hoc visits by NNPAN Ad hoc visits by NNPAN		
Ikka fjorden	Ikkait Bacteria Fungi		Ad hoc visits by NNPAN		
Austmannadalen	Sheep Reindeer	Hunting	Terrestrial mammal monitoring prgogramme (GINR)	Reindeer population size, sex and age Structure	
Arnangarnup Qoorua / Paradisdalen n.	Muskox Vegetation	Hunting	Terrestrial mammal monitoring programme (GINR)	Population size, sex and age Structure	
Kitsissunnguit (GrønneEjland)	Lumpsucker Arctic tern Eider Other bird species	Hunting and fishing	Ad hoc population assessment (GINR)	Population size (birds)	Also Ramsar site
Arctic Research Station			Ad hoc visits by NNPAN		
Other Protected Areas					
Thirteen Bird Protection Areas	Guillemot Eider Other bird species	Hunting	Sea Bird Monitoring Programme (GINR) Ad hoc population assessment	Population size	
Eleven Ramsar sites	Geese Arctic tern Eider Other bird species	Hunting	Ad hoc population assessment (GINR)	Population size	

Protected Areas	Key Ecosystem Components	Key Issues	Monitoring Program(s)	Indicator(s)	Other Issues
Bird colonies protection zones	Guillemot Razorbill Little auk Kittiwake Fulmar Cormorant Eider Kings Eider Black guillemot Puffin Arctic tern Gulls	Hunting	Population size (not all species)		

Source: Elmer Topp-Jørgensen, Department of Domestic Affairs, Government of Greenland

Figure 4 Protected Areas of Greenland



Only protected areas overlapping or north of the CAFF boundary are displayed

4.4 Iceland

Iceland does not have specific protected area monitoring programs. As with many other countries, monitoring in Iceland is not as well developed or structured as it might. There are few inhabitants; it is a relatively big country; limited funding and expertise. Different bodies including academia, government institutes, and local institutes carry out monitoring. Gathering and collating data is complicated and relies to a large extent on individual researchers.

Monitoring programs in Iceland often do not differentiate protected areas from the rest of the country and in some cases monitoring programs only include a portion of protected areas (Table 7). The focus of monitoring programs is mainly birds and fish stocks and then plants and vegetation. Whales and seals get little attention and terrestrial mammal monitoring is limited although reindeers (not native for Iceland) have been monitored for many years. Good hunting and fishing statistic is in place and annual monitoring of plankton.

Iceland has plans in place to reorganize its environmental monitoring programs and to refocus collaborative efforts. This includes encouraging the different institutes and agencies to work together and have common or accessible databases, starting with plants and birds. A new monitoring scheme for all naturally occurring bird species including arctic passage birds and other migratory species is underway. In the meantime, existing bird-related databases include mid-winter bird counts, the Bird Ringing Scheme and databases for individual species (sea eagle, ptarmigan, Slavonian grebe, Brent goose, eider, etc). Iceland also holds databases for invertebrates, insects, marine fish, plankton (phyto- and zooplankton) whales and plants, including habitat-type and vegetation maps. Drawing from all available data, Iceland has prepared a draft report on birds which includes data quality assessments, species population size and trends and revisions to the Red List. A complete, quantitative and repeatable survey of cliff-breeding seabirds in Iceland was first carried out in 1983-1985 and replicated in 2006-2008, providing a new baseline for improved monitoring.

With respect to marine areas, the BIOICE project to determine distribution of benthos in Icelandic waters has concluded after 19 expeditions. Results included 1390 samples taken from 579 locations from 20-3000 m depth, 4.5 million animals collected and the identification of 28 previously unknown species. This was a baseline study with very limited follow up.

Iceland has completed an inventory of geothermal areas and has mapped habitat types in the mid highland and is preparing to define and map habitat types for lowland areas including freshwater and coastal areas. Iceland will do this using the same methodology as is used in Natura 2000 as Iceland is a member state in the Bern convention where Emerald Network is a parallel program. This will give the opportunity to monitor natural habitats and species in accordance with EU countries as described in Table 11 and will also give opportunity to use remote sensing for long-term monitoring of habitat types. Iceland also participates in international, monitoring programs such as collecting moss samples every five years for heavy metal analyses and is a member of the NOBANIS-European Network on Invasive Alien Species. This project is developing a common database on alien species and invasive species including those in Iceland.

Several governmental institutions are involved in monitoring of biodiversity (research) in Iceland and keep databases in their field, among them are: **The Icelandic Institute of Natural History** (the Institute conducts basic and applied research and monitoring on the nature of Iceland with emphasis on botany, ecology, taxonomy geology and zoology, maintains scientific specimen collections and databases, operates the Icelandic Bird-Ringing Scheme, advises on sustainable use of natural resources and land development, and assesses the conservation status of species, habitats and ecosystems). **The Marine Research Institute** (research / monitoring on the marine environment around Iceland and its living resources with special emphasize on commercial fish stocks), **The Environment Agency** (management and supervision of designated protected areas, monitoring of environmental quality, wildlife management). **The Met Office** (conducting monitoring / research on the physics of air, land and sea, specifically in the fields of hydrology, glaciology, climatology, seismology and volcano logy), **The Institute of Freshwater Fisheries** (research / monitoring on freshwater fish stocks and supervise and advise river and lake fisheries associations concerning fisheries management and enhancement of fisheries), **The Soil Conservation Service of Iceland** (monitoring / research / combating desertification, sand encroachment and other soil erosion, promotion of sustainable land use and reclamation and restoration of degraded land) and the Iceland forest Service (research, development, consultation and distribution of knowledge within forestry). There are several local **natural history centres** located around Iceland that conduct scientific research / monitoring on Iceland's nature in their region, as well as collect data regarding the natural history in the region and participate in nature conservation and environmental education). Beside the institutions mentioned above the universities in Iceland, especially **University of Iceland** and **The Agricultural University of Iceland**, conduct wide variety of monitoring and research on natural history both inside and outside protected areas. Further there are individual local natural history research centers that focus on certain areas like the **Natural History Museum of Kópavogur** (research / monitoring in freshwater ecology), **The Icelandic Seal Center** and **The Arctic Fox Center** or focus on specific area like **The Lake Myvatn Research Station** that monitor and research on the natural history of the protected area of Lake Mývatn and the river Laxá and surrounding area.

Table 7 gives an overview over some of the monitoring programs, specially aimed at biodiversity, conducted inside protected areas in Iceland but is by no means exhaustive.

Table 7: Iceland protected areas with monitoring programs

Protected Area	Key Ecoystem Components	Key Issues	Monitoring Program	Indicator	Other Issues	Comment
National Park						
Snæfellsjökull	Mink (Mustela vision)			Numbers hunting Statis-tics	invasive species	
Þingvellir	Freshwater fishes Arctic charr Trout Plankton	Population status	Harvet	Numbers (fish-ing statistics) Condition	Four variants (subspecies) of Arctic charr	Protected by special Act
Vatnajökul-sþjóðgarður	Reindeer Ptarmigan Gyrfalcon Plants	Population status	Population size	Number Harvest (hunt-ing statistic)		Protected by special Act
Nature Reserve						
Ástjörn	Slavonian grebe	Population status	Breeding pairs	Numbers	Part of monitor-ing the species around the country, Lake Mývatn etc.	
Dyrhólaey						Partly marine
Eldey	Gannet		Population size	Numbers		Partly marine
Flatey	Black guillemot Phalathrope		Population size	Numbers		Partly marine area. Inside Breiðafjörður
Grótta						Partly marine area

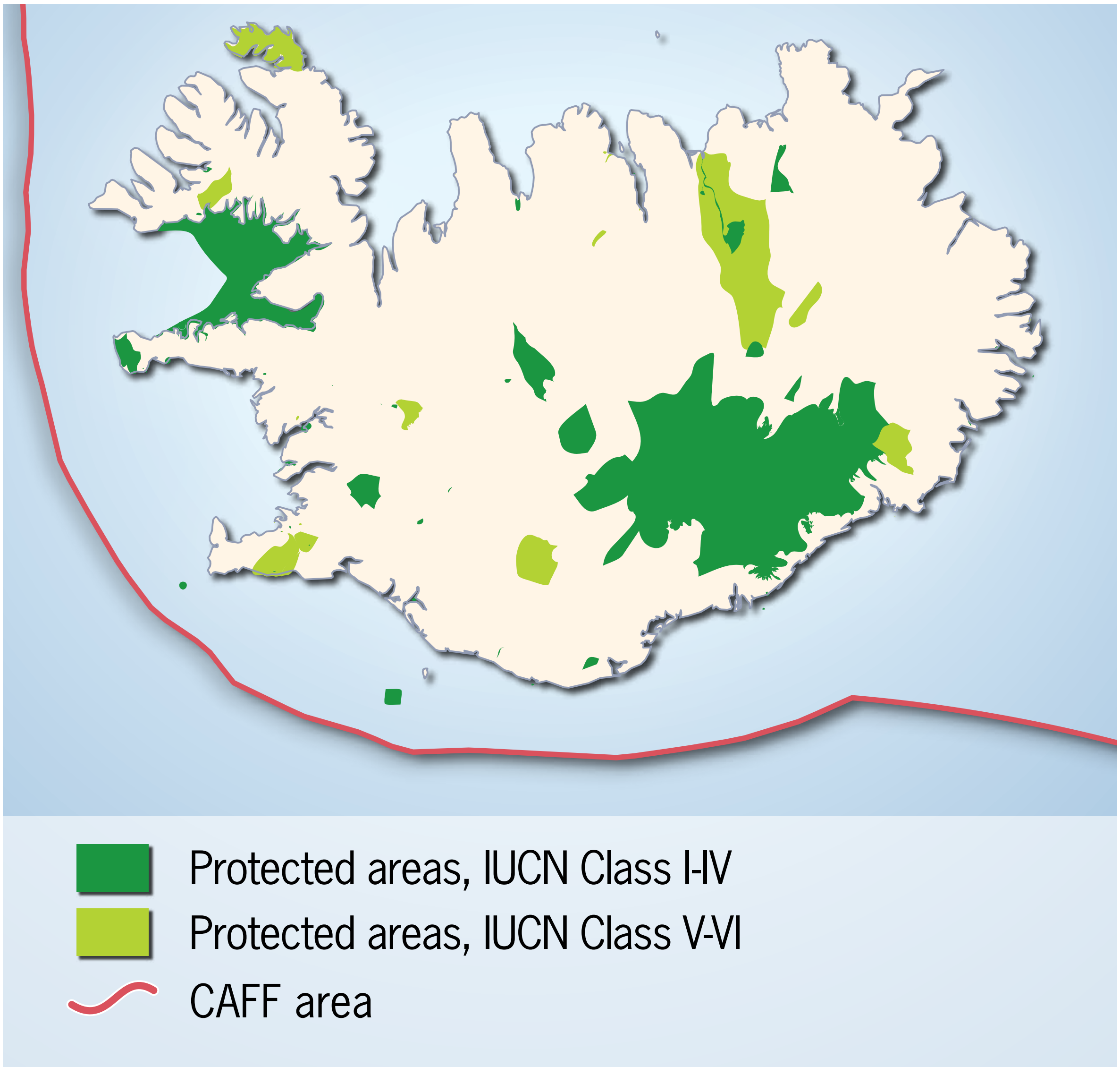
Protected Area	Key Ecoystem Components	Key Issues	Monitoring Program	Indicator	Other Issues	Comment
Grunnafjörður	Brent Goose		Population size		Part of internal population estimation- other areas in Iceland included	
Guðlaugstungur	Pink footed goose, waders		Population size, Breeding pairs		Part of internal population estimation – other areas in Iceland included	
Hornstrandir	Arctic fox	Population status			Hunting statistics exist for Arctic fox in Iceland	Arctic fox protected in the area
Hrísey						Partly marine area. Inside Breiðajörður area
Kringilsárrani	Reindeer	Population status	Population size	Number Harvest (hunting Statistic)	See also Vatnajökulsþjóðgarður NP	
Lónsöræfi	Reindeer					
Melrakkæy						Partly marine area. Inside Breiðajörður area.
Miklavatn	Whooper swan Greylag Tufted duck Scaup	Population status	Population size	Numbers		
Skrúður	Seabirds		Population size		Irregularly	Partly marine area
Surtsey	Ecosystem development	Plant, bird and insect colonization Population status	Succession monitoring	Numbers Harvest	New island since 1963, geological research	Partly marine area
Varmárósar						Partly marine area
Vatnasfjörður						Partly marine area
Vífilsstaðavatn	Lake Some freshwater monitoring				Subspecies of stickleback	
Þjórsárver	Pink-footed goos Plant community	Population status	Populaiton size, breeding pairs Plant.com, ITEX	Numbers Plant.com Density	Habitat type map exists	Wetland area Ramsar area
Natural Monument/Mostly Geological Formations						
Arnarnesstrítur						Hot springs Cones/geothermal chimneys
Eldborg í Bláfjöllum						Inside Bláfjallafólkvangs

Protected Area	Key Ecoystem Components	Key Issues	Monitoring Program	Indicator	Other Issues	Comment
Eldborgir undir Geitahlið						Inside Reykjanesfólkvangs
Fossvogsbakkar						Partly marine area
Háubakkar						Partly marine area
Hverastrýtur á botni Eyjafjarður						Hot springs Cones/geotermal chimneys
Skútustaðagigar						Inside the Mývatn Laxa area
Country Park						
Ástjörn og Ásfjall	See Ástjörn					
Hleinnar						Partly marine area
Hilð						Partly marine area
Hvaleyrarión og Hvaleyrarhöfði						Marine area
Kasthúsatjörn fjaran						Coast and marine
Reykjanes	Seabirds	Population status	Population size	Numbers	Kýísuvíkurbjarg bird cliff	
Habitat Protection Area						
Hvanneyri	White fronted goose	Population status	Population size	Numbers		Wetland
Skerjafjörðurinnan Garðabæjar	Brent goose	Population status	Population size	Numbers	Part of international population estimation- other areas in Iceland included	Coast and marine area
Protection by Special Act						
Breiðafjörður	Seabirds Sea eagle Eider Other wild bird species Whales (fishing grounds) Mink (Mustela vision) Also pollutants	Popuation status	Population size Harvest	Numbers Condition	Species of concern, eider colonies (eider down utilization)	Coast Islands Marine area
Lake Mývatn and River Láxa	Wetland area Lake and river Freshwater fishes Bird species (ducks, gyrfalcon, Slavonian grebe) Plankton Midge Aquatic plants	Population status	Harvest	Numbers (breeding pairs) Condition	One of the best monitored areas in Iceland, species of concern	Ramsar area
Other Protection						

Protected Area	Key Ecoystem Components	Key Issues	Monitoring Program	Indicator	Other Issues	Comment
Plant species	Aegagropila linnaei					

Source: Trausti Baldursson, Icelandic Institute of Natural History

Figure 5 Protected Areas of Iceland



Only protected areas overlapping or north of the CAFF boundary are displayed

4.5 Norway

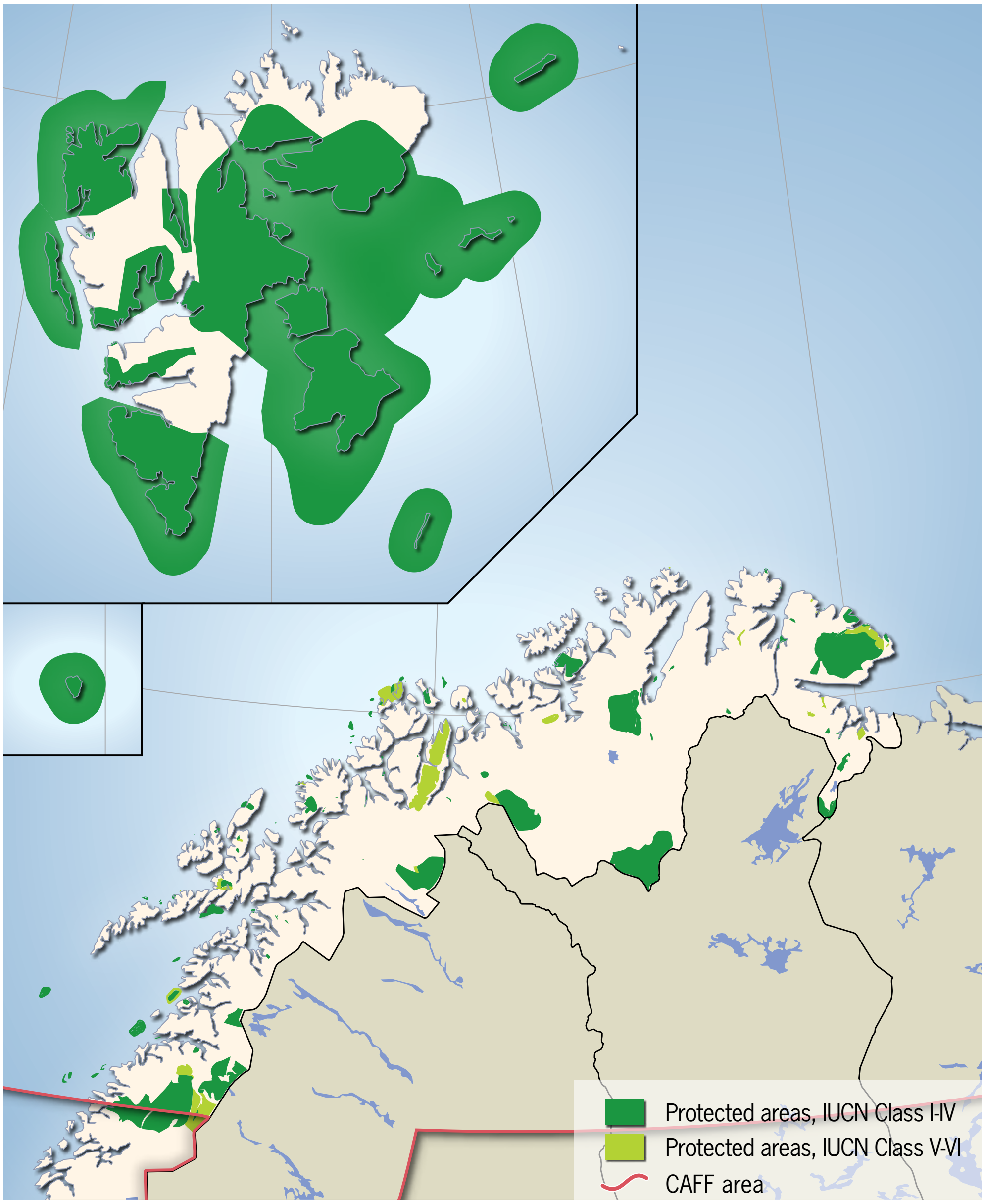
Norway's monitoring effort is extensive and well documented (Table 8). However, as with other European countries, Norway does not have a protected areas-specific monitoring framework and conducts general monitoring independent of protected areas. Regional monitoring programs of particular relevance to Norwegian protected areas include large carnivores, arctic fox, golden eagle, moose, palsa peatlands, freshwater pearl mussel, air quality, seabirds, vegetation (NDVI imagery) and physical disturbance by industrial developments.

Norway does conduct extensive monitoring of the environments of Svalbard and Jan Mayen, and an integrated monitoring program, "Environmental Monitoring of Svalbard and Jan Mayen," (MOSJ) is in place for these areas.

MOSJ began in 1999 and is designed to evaluate how the environment of these two regions is faring relative to national goals for the environment in the Polar region. It presents the results from 69 separate monitoring programs in a standardized manner and follows five general themes: climate, human influence/disturbance, fauna, flora and cultural heritage. Each theme is subdivided into indices, e.g., there are 12 indices for climate, 16 for disturbance, 25 for fauna, etc. Many of the time series date from the 1980s.

While Norway does not plan to develop a protected area-specific program for Arctic protected areas, much of the Norwegian Arctic Islands are protected and included in MOSJ. There is also an ongoing process to establish a protected area-specific monitoring program for mainland Norway which will be closely related to the EU directives.

Figure 6 Protected Areas of Norway



Only protected areas overlapping or north of the CAFF boundary are displayed

Table 8: Monitoring programs in Norway

Marine Programmes	Broad Objectives of the Program	Specific Species and/or Ecosystems included	Geographic coverage	Contact Person\ Project Leader	Implementaed or related to CAFF\MAP
Seabird Population Program / SEAPOP (2005) Includes several projects specified in the list (see below)	Monitoring of breeding and wintering seabird populations	See interlinked programmes and projects below	Norwegian coast from Lofoten and Northward The sea area around Svalbard (incl. Bear Island)	Brit Veie-Rosvoll Morton Ekker (DN) Tycho Anker-Niilssen (NINA), Hallvard Strøm (NPI)	CAFF
Monitoring Program for Svalbard and Jan Mayan (MOSJ)	Monitoring	See interlinked projects below	Svalbard Archipelago Jan Mayan	Birgit Njåstad, NPI	CAFF\AMAP
Norwegian National Monitoring Program on Breeding Seabirds (1998)- From 2005 incl. in SEAPOP	Trend of monitoring of Norwegian breeding seabirds	- *Fulmarus glacialis* - *Morus bassanus* - *Phalacrocora x Carbo* - *Phalacrocora x aristotelis* - *Somateria mollissima* - *Catharacta skua* - *Larus canus* - *Larus fuscus* - *Larus argentatus* - *Larus marinus* - *Rissa tridactyla* - *Sterna hirundo* - *Sterna paradisea* - *Alca torda* - *Uria aalge* - *Uria lomvia* - *Fratercula arctica*	Norwegian coast	S.H. Lorenstsen, NINA	CAFF
National Monitoring of the Marine Environment and Living Resources	Monitoring of sea environment with special focus on sustainable fisheries management	- Physical and chemical parameters - Zooplankton - Phytoplankton - Fish eggs and larvae - Several fish species - Prawn - Lobster - Benthic ecosystems	Barents Sea Norwegian Sea	Lead: Norwegian Institute of Marine Research (IMR)	AMAP/CAFF

Marine Programmes	Broad Objectives of the Program	Specific Species and/or Ecosystems included	Geographic coverage	Contact Person\ Project Leader	Implementaed or related to CAFF\MAP
Integrated Mapping Programme for the Norwegian Seas and Coastal Areas (MAREANO)	Map the seabed	- Bathymetry - Geology - Biology - Contaminants	Seabed in Norwegian waters	Ole Jørgen Lønne and Lene Buhl-Mortensen, IMR Trond Skyseth, SK Terje Thorsnes, NGU	CAFF/AMAP
National Coastal Monitoring	Monitoring of the state of environment related to nutrients and biodiversity	- Hydrology – chemistry and plankton - Soft and hard bottom ecology	Coastal areas in Norway	Karen Fjøsne, SFT (Frithjof Moy, NIVA)	AMAP/CAFF
Screening and survey projects in the Arctic as a part of the Norwegian State Pollution Monitoring Program	Monitoring of pollutants in seabird eggs and adult seabirds	Glaucous gull a.o.	Northern Norway and Svalbard	Ingunn Skaufel Simensen Jon L. Fuglestad, SFT NPI	AMAP
Joint Assessment and Monitoring Programme (JAMP) under OSPAR (incl. contaminants and biodiversity elements) - (1981 -)	Analyses of contaminants in sediments & organisms	Sediments and benthic organisms	Norwegian coastal waters	Per Erik Ivversen, SFT (Normal Green, NIVA)	AMAP/CAFF
The EU Water Framework Directive (WFD) – when started (probably in 2008)				Jo Haleraker, DN	AMAP/CAFF
Offshore monitoring of the Norwegian petroleum activities	Monitoring of pollutants and species diversity in sediments in the vicinity of offshore installations Monitoring of uptake and effects of pollutants in mussels and fish	Seabed fauna / biodiversity / ecosystems. Fish and caged blue mussels in water column	The whole Norwegian self where there is oil and gas activities	Nina Marie Jørgensen, SFT	AMAP
Rocky bottom research along the coasts of Northern Norway, Svalbard, and Jan Mayan	Mapping and state monitoring	Benthic ecosystems	Along the coasts of Northern Norway, Svalbard and Jan Mayan	Bjørn Gulliksen, University of Tromsø	CAFF

Marine Programmes	Broad Objectives of the Program	Specific Species and/or Ecosystems included	Geographic coverage	Contact Person\ Project Leader	Implementaed or related to CAFF\MAP
The Sea Mammal Research Program	Population registration and monitoring	- Whales (mainly Balaenoptera acutorostrata, but also others) - Pagophilus groenlandicus - Cystophora cristata - Phoca vitulina - Phoca hispida - Halichoerus grypus - Odobaenus rosmarus	Whales: North Sea, Norwegian Sea and Barents Sea Seals: Greenland Sea and Norwegian coast, Spitsbergen (ringed seal) Svalbard (walrus	IMR, NPI	AMAP/CAFF
Contaminants in Polar bear in the Svalbard area NPI (1991-2005)	MOSJ	Ursus maritimus	Svalbard	Geir W. Gabrielsen, NPI	AMAP
Population ecology of Polar bear in the Svalbard area (1967 -)	MOSJ	Ursus maritimus	Svalbard	Magnus Andersen, NPI	CAFF
Polar bear population in the Barents Sea (Russian/ Norwegian monitoring) – (2005-)	Long-term monitoring of population size by aerial line transect surveys	Ursus maritimus	Barents Sea Svalbard Franz Joseph Land Novaya Zemlia	Jon Aars, NPI	CAFF
Puffin population ecology in Røst (1964 -)	Monitoring of the largest seabird colony on the European mainland	Fratercula arctica	Røst Archipelago	Tycho Anker-Nilssen, NINA	CAFF
Black guillemot population ecology in Røst (1990 -)	Comparative monitoring to the Puffin monitoring	Cepphus grille	Røst Archipelago	Tycho Anker-Nilssen, NINA	CAFF
Monitoring of seabird populations on Bear Island	Population trend monitoring of the two largest seabird species in the Barents Sea and the marine ecosystem that these species belong	- Uria aalge - Rissa tridactyla - Fulmarus glacialis - Stercorarius skua - Alle alle - Larus hyperboreus	Bear Island	Hallvard Strøm, NPI	CAFF
Population development of Eider in Kongsfjorden, Svalbard (1981 -)	Population monitoring	- Somateria mollissima	Kongsfjorden, Spitsbergen	Geir Wing Gabrielsen, NPI	CAFF
Contamination in Glaucous gull in Bear Island (1995-2002)	Tissue levels and effects of contaminants	- Larus hyperboreus	Bear Island	Jan Ove Bustnes, NINA	AMAP

Marine Programmes	Broad Objectives of the Program	Specific Species and/or Ecosystems included	Geographic coverage	Contact Person\ Project Leader	Implementaed or related to CAFF\MAP
Ivory gull (MOSJ) (2007 -)	Breeding colony monitoring and blood sampling / contamination	- Pagophila eburnean	Svalbard Archipelago (+ cooperation with Russia)	Hallvard Strøm, NPI	AMAP/CAFF
Contaminants in glaucous gulls from Bear Island (1995-2005)	Blood samples	- Larus hyperboreus	Bear Island	Geir Wing Gabrielsen, NPI	AMAP
Norwegian National Monitoring Program (NNMP) on wintering Seabirds (1980-) – from 2005 incl. in SEAPOP	Monitoring of wintering seabirds and waterfowls in defined wintering areas	- Gavia stellata - Storlom (Gavia arctica) - Islom (Gavia immer) - Horndykker (Podiceps auritus) Gråstrupedykker, (Podiceps grisei-gena) - Storskarv (Phalacrocora x carbo) Toppskarv (Phalacrocora x aristotelis) - Kanadagås (Branta enelopes) - Brunnakke (Anas enelope) - Krikkand (Anas crecca) - Stokkand (Anas platyrhynchos) - Toppand (Aythya fuligula) - Bergand (Aythya marila) - Somateria mollissima - Somateria spectabilis - Polysticta stelleri - Clangula hyemalis - Melanitta nigra - Melanitta fusca - Bucephala clangula - Mergus merganser	Defined locations / areas (included areas in three northernmost Norwegian counties north of the Polar Circle.	S.H. Lorentsen, NINA	CAFF

Marine Programmes	Broad Objectives of the Program	Specific Species and/or Ecosystems included	Geographic coverage	Contact Person\ Project Leader	Implementaed or related to CAFF\MAP
Svalbard seabird monitoring program (1988 -)	Monitoring of trends, demographic parameters and diet of some seabird species in Svalbard	- Uria aalge - Uria lomvia - Alle alle - Fulmarus glacialis - Somateria mollissima - Rissa tridactyla - Stercorarius skua - Larus hyperboreus	Svalbard	Hallvard Strøm Harald Steen, NPI	CAFF
Population development and ecology of seabirds in Hornøya, Eastern Finnmark (1980 –)	NNMP	- Rissa tridactyla - Uria aalge - Uria lomvia - Fratercula arctica - Phalacrocorax aristotelis	Hornøya (Island)	Rob Barrett, University of Tromsø	CAFF
Population development of Northern Gannet in Norway (1947 –)	NNMP	- Morus bassanus	Breeding localities (cliffs) in Norway	Rob Barrett, University of Tromsø	CAFF
Population development of Seabirds in Southern Varanger, Eastern Finnmark (1966 -)	Breeding population monitoring	- Rissa tridactyla - Phalacrocorax carbo - P. aristotelis - Uria aalge - Alca torda	Southern Varanger	Rob Barrett, University of Tromsø	CAFF
Contaminants in seabird eggs from Northern Norway and Svalbard (1983, 1993, 2003)	Egg samples	- Larus argentatus - Fratercula arctica - Rissa tridactyla - Larus hyperboreus	- Hornøya - Røst - Bear Island - Kongsfjorden	Geir Wing Gabrielsen, NPI	AMAP
Population development of Kittiwakes in Kongsfjorden (1998-)	Population monitoring	- Rissa tridactyla	Kongsfjorden	Geir Wing Gabrielsen, NPI	CAFF
Long-term variations in arctic soft-bottom benthos I (1920s-)	Benthic community composition	- Benthic ecosystems	Open Barents Sea	Akvaplanniva	CAFF
Long-term variations in arctic soft-bottom benthos II (1980-)	Benthic community composition	- Benthic ecosystems	Svalbard fjords	Akvaplanniva	CAFF
JAMP, Northwest Russia (2002-)	POPs level in marine sediments	- Benthic ecosystems	Coastal areas of Northwest Russia	Akvaplanniva	AMAP

Marine Programmes	Broad Objectives of the Program	Specific Species and/or Ecosystems included	Geographic coverage	Contact Person\ Project Leader	Implementaed or related to CAFF\MAP
Monitoring of sedimentary environments in Isfjorden, Svalbard (1992–) (time interval between surveys is 5 years)	POPs level in sediments and benthic organisms	- Benthic ecosystems	Selected fjords in the Isfjorden complex, Svalbard	Akvaplanniva (plus others) contracted by Sysselmannen Svalbard	AMAP
Monitoring of Norwegian fjords	Contaminants in sediments	- Benthic ecosystems	Norwegian fjords	Mats Waday, NIVA	AMAP
Ships of opportunity and remote sensing	Oil in sediment contamination	- Benthic and pelagic ecosystems (mostly algae)	Along coastal sailing transect of the Norwegian "Hurtigruten" up to Kirkenes, Finnmark, and from 2007 the sailing transect from Tromsø to Longyearbyen	Dominique Durand, NIVA	AMAP/CAFF

Limnic Programmes	Broad Objectives of the Program	Specific Species and/ or Ecosystems Included	Geographic Coverage	Contact Person/ Project Leader	Implemented or related to CAFF / AMAP
Monitoring program for long range transport of air pollutants and their effects	Document deposition and effects in relation to critical loads and international agreements	- Freshwater ecosystems - Fish - Invertebrates	Whole Norway	Tor Johannessen, SFT	AMAP
Persistent organic pollutants and heavy metals in sediments and fish from lakes in Northern Norway and Svalbard	POPs and heavy metal levels in sediments and fish	- Freshwater ecosystems	Northern Norway Svalbard	Guttorm N. Christensen, Akvaplan-NIVA	AMAP
National monitoring of lakes; effects of long range transport of contaminants	POPs and heavy metal levels in sediments, water quality	- Freshwater ecosystems	Norway	Brit Lisa Skjelkvåle, NIVA	AMAP
EU Water Framework Directive	Directive not yet implemented and no specific monitoring started				
Monitoring of breeding waders and Arctic Skua in Sletnes (Gamvik), Finnmark (1989-)	Monitoring of breeding populations	- Waders - Stercorarius	Sletnes, Finnmark county	K.B. Strann, University of Tromsø	CAFF
Monitoring of breeding waders in Kautokeino, Finnmark (1996-)	Monitoring of breeding populations	- Waders	Kautokeino, Finnmark county	K.B. Strann, University of Tromsø	CAFF

Limnic Programmes	Broad Objectives of the Program	Specific Species and/ or Ecosystems Included	Geographic Coverage	Contact Person/ Project Leader	Implemented or related to CAFF / AMAP
Spring migration monitoring of Red Knot in Balsfjord, Troms and Porsangen, Finnmark (2002-)	Monitoring of spring migration	- Calidris canutus	Balsfjord, Troms and Porsangen, Finnmark	K.B. Strann, University of Tromsø	CAFF
Waterfowl counting in Pasvik Zapovednik and Pasvik Nature Reserve (1996-)	Density and distribution of waterfowls	- Ducks - Geese -Waders	Pasvik River within Pasvik Zapovednik & Pasvik Nature Reserve	Paul Aspholm, BioForsk	CAFF
Population composition of adult Atlantic salmon in rivers and sea – NINA (1989-)	Monitoring of escaped salmon farm fish in sea and rivers	- Salmo salar	Salmon fjords and rivers	Peder Fiske, NINA	CAFF
Repparfjord River in Finnmark. Scale tests of adult Atlantic salmon – NINA (1932-)	Monitoring of escaped salmon farm fish	- Salmo salar	Repparfjord, Finnmark county	Arne Jensen, NINA	CAFF
Atlantic salmon and sea trout in Saltdal River (1975-)	Long-term monitoring	- Salmo salar - Salmo trutta	Saltdal River, Nordland county	Arne Jensen, NINA	CAFF
Migration of anadromous salmon in Halselva River, Finnmark – NINA (1987-)	Monitoring of migration and population structure	- Salmo salar - Salmo trutta - Salvelinus alpinus	Halselva, Finnmark county	Arne Jensen, NINA	CAFF
Impacts of fish farming on sea trout and Atlantic salmon – University of Life and Science (UMB) (1988-)	Long-term effects of fish farming on wild populations	- Salmo trutta - Salmo salar	Salmon fjords and rivers	Reidar Borgstrøm, UMB and Oystein Skaala, IMR	CAFF
Monitoring of fish and zooplankton in Pasvik River – (1991-)		- Coregonus lavaretus - C. albula - Salmo trutta - Perca fluviatilis - Esox lucius - Lota lota		Per-Arne Amundsen, University of Tromsø	CAFF
Long-range impacts of fish thinnings in Stourajavri (1981-)	Monitoring of a polymorphic population	- Coregonus lavaretus	Stourajavri, Finnmark county	Per-Arne Amundsen, University of Tromsø	CAFF
Monitoring of Pearl mussel in Norway (1999-)	National-wide monitoring	-Margaritifera margaritifera		Bjørn Mejdell Larsen, NINA	CAFF

Limnic Programmes	Broad Objectives of the Program	Specific Species and/ or Ecosystems Included	Geographic Coverage	Contact Person/ Project Leader	Implemented or related to CAFF / AMAP
Monitoring of crustacean in 100 Norwegian lakes, national contamination monitoring (1996-)	Status and development of acidification	- 135 species of Cladocera and Copepoda	National network	Ann Kristin Schartau, NINA	AMAP/CAFF
Monitoring of Gyrodactylus salaries in 120-130 rivers in Norway (1980-)		- Gyrodactylus - Salmo salar	National network	Ann Kristin Schartau, NINA	AMAP/CAFF
Monitoring of Gyrodactylus salaries in 120-130 rivers in Norway (1980-)				Norwegian Food and Safety Authority	CAFF
Norwegian National Eutrophication Investigation 1988-2001, of 405 lakes (1988-2001)				NIVA	AMAP
Lake Takvatn in Troms, Aquatic fauna (1980 -)				University of Tromsø	CAFF

Terrestrial Programmes	Broad Objectives of the Program	Specific Species and/ or Ecosystems Included	Geographic Coverage	Contact Person/ Project Leader	Implemented or related to CAFF / AMAP
Terrestrial Monitoring Program (TOV), Fauna	Population and reproduction monitoring and effects of LTRAP	- Passeriformes spp. - Ficedula hypoleuca - Lagopus lagopus - Aquila chrysaetos - Falco rusticolus - small rodents	Within CAFF area: Dividalen, Troms county	John Atle Kålås, NINA	CAFF
Terrestrial Monitoring Program (TOV), Birch forest	Monitoring of LTRAP on ground vegetation in birch forest		Within CAFF area: Dividalen, Troms county	Vegar Bakkestuen, NINA	CAFF
Terrestrial Monitoring Program (TOV), epiphyte vegetation	Monitoring of LTRAP on epiphyte vegetation in birch forest	- Lichens - Alga - Bryophyte	Within CAFF area: Dividalen, Troms county	Inga E. Bruteig, NINA	CAFF

Terrestrial Programmes	Broad Objectives of the Program	Specific Species and/ or Ecosystems Included	Geographic Coverage	Contact Person/ Project Leader	Implemented or related to CAFF / AMAP
Monitoring of palsa peatlands	Monitoring of long-term development of edaphic structure, permafrost & vegetation	- Peat land	Ferdesmyra and Goatteluobbal, Finnmark Ostojeaggi, Troms Haugtjørnin and Leirpullan, Sør-Trødelag Haukskardmyrin Oppland	Annika Hofgaard, NINA	CAFF
Polar fox monitoring (1900 -)	Population monitoring	- Alopex lagopus	Norway	Olav Strand, NINA	CAFF
Population monitoring of Polar fox in Svalbard (1982 -)	MOSJ	- Alopex lagopus	Brøggerhalvøya/ Kongsfjorden Sassen / Adventdalen	Eva Fuglei, NPI	CAFF
National Monitoring Program for Large Carnivores (1990-)	Population monitoring	- Lynx - Wolverine - Wolf - Brown bear	Norway	Henrik Brøseth, NINA	CAFF
Svalbard caribou population monitoring in Adventdalen (1979-)	Identify mechanisms for the persistent instability of a natural population of reindeer	- Rangifer tarandus - platyrhynchus	Adventdalen, Spitsbergen	Nicholas Tyler, University of Tromsø	CAFF
Svalbard caribou in Brøgger Peninsula (1978-) – project of MOSJ	Population monitoring	- Rangifer tarandus - platyrhynchus	Brøgger Peninsula, Ny-Ålesund, Spitsbergen	Ronny Aanes, NPI	CAFF
Svalbard (jaws from hunting, monitoring) (1984-)	Population monitoring	- Rangifer tarandus - platyrhynchus	Nordenskiöld Land, Spitsbergen	Øystein Wiig, University of Oslo	CAFF
Cuobbojeaggi Project (1991 -)	Fecundity of female reindeers	- Rangifer tarandus - tarandus	Finnmark county	Nicholas Tyler, University of Tromsø	AMAP/CAFF
Muskrat (Ondatra zibeticus) in the Pasvik River (1994-)	Population development of an invasive species	- Ondatra zibetica	Pasvik River	Steinar Wikan, BioForsk	CAFF
Microtus rossiaemeridionalis dynamics in Svalbard (1991-)	Monitoring on an introduced species	- Microtus rossiaemeridionalis	Colesbay, Croumant, Longyearbyen in Spitsbergen	Nigel G. Yoccoz, NINA	CAFF
Monitoring of Lesser White-fronted Goose in Norway (1991-)	Migration monitoring	- Answer erythropus	Valdak, Finnmark county	Ingar Øien, NOF	CAFF

Terrestrial Programmes	Broad Objectives of the Program	Specific Species and/ or Ecosystems Included	Geographic Coverage	Contact Person/ Project Leader	Implemented or related to CAFF / AMAP
Population dynamics & studies of Black and White Flycatcher in Northern Scandinavia (1986-)	Monitoring of population dynamics	- Muscicapidae	Ammarnes, Sweden (Norwegian areas only South of the Polar Circle)	Per Gustav Thingstad, NTNU	CAFF
Norwegian Breeding Bird Census (1995-)	Biodiversity monitoring	- All Norwegian bird species		Magne Husby, HINT	CAFF
Population Monitoring of Svalbard Ptarmigan (1999-) project of MOSJ	Population monitoring	- Lagopus mutus hyperboreus	Central area of Spitsbergen	Eva Fuglei, NPI	CAFF
Pink-footed goose in Vesterålen (2000-)	Migration monitoring	- Anser branchyrhynchus	Vesterålen	Ingunn M. Tombre, NINA	CAFF
Barnacle goose in Ny Ålesund – NINA (1992-1998)	Reproductive behavior	- Branta leucopsis	Ny-Ålesund, Spitsbergen	Ingunn M. Tombre, NINA	CAFF
Brown bear registrations in Pasvik (1972-)	Population monitoring	- Ursus arctos	Pasvik	Martin Smith, BioForsk	CAFF
Bear in Pasvik; spring observations (annually)	Monitoring time of cave leaving	- Ursus arctos	Pasvik	Martin Smith, BioForsk	CAFF
Cesium 137 measures in body tissues of reindeer herders (Sami people) (1996-)	Radiation from Tsjernobyl accident		Finnmark county and mid-Norway	Tone D. Bergan, Norwegian Radiation Protection Authority	AMAP
Monitoring of population development, fitness and reproduction of seven Moose populations (1967-)	Population conditions	- Alces alces	Troms county	Erling Solberg, NINA	CAFF

Source: Bård Øyvind Solberg, Directorate for Nature Management

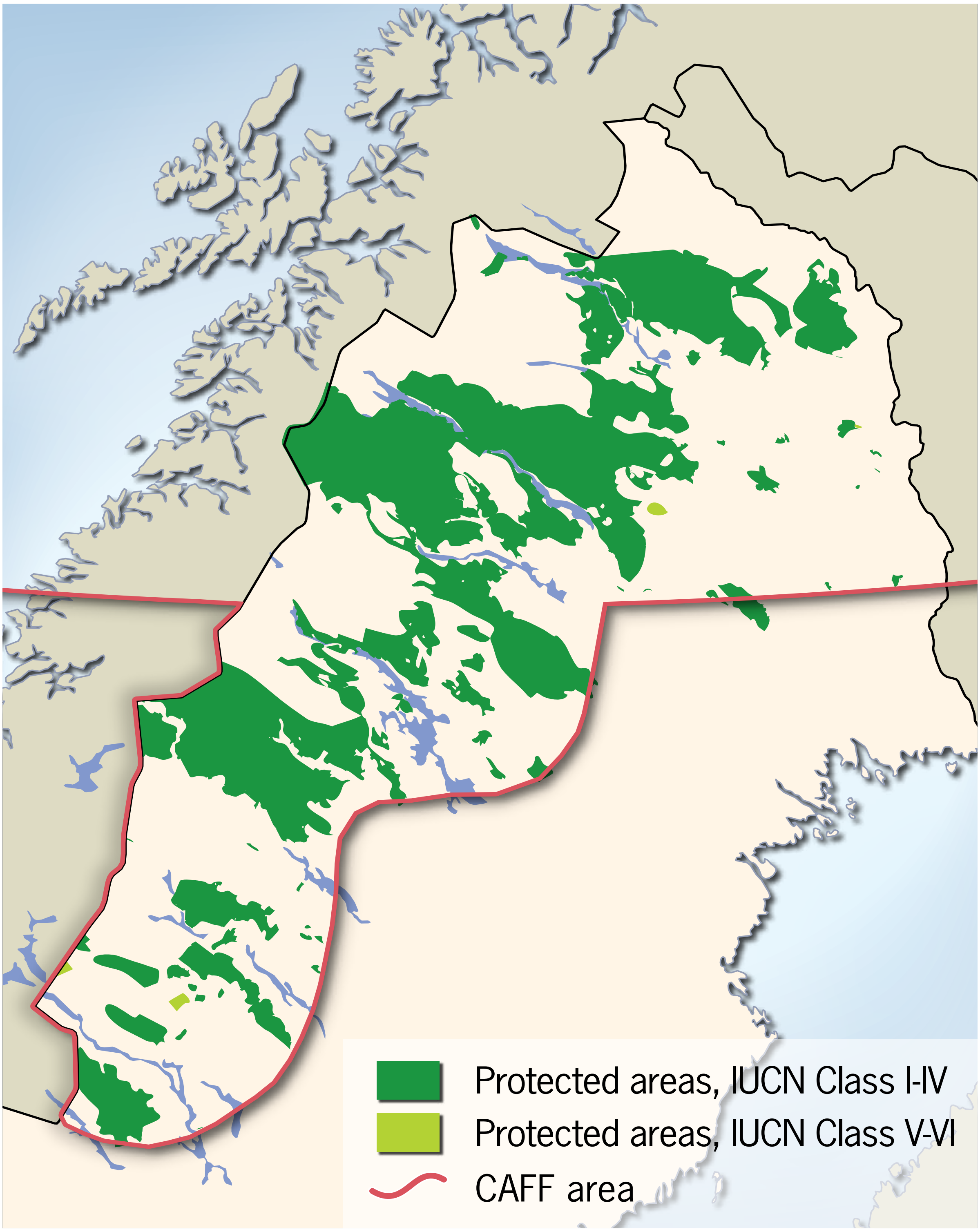
4.6 Sweden

The Swedish monitoring program is outlined in Table 9 and follows the European Union Habitats Directive and the Birds Directive. To a large extent this monitoring is coordinated with already existing national monitoring programs (e.g., national landscape inventory, national forestry inventory). Protected areas are not necessarily separated from other areas in these national monitoring programs. While regional lake, water course and bird monitoring efforts in Sweden can be applied to protected areas fairly readily, more could be done with wetlands, large carnivores, small mammals and climate datasets.

The limited monitoring programs occurring specific to Swedish protected areas now focus on the particular values of the protected area (especially those that can be protected and or developed by management), the effects of conservation measures, visitation and damages caused by recreational vehicle traffic. Some programs are network-wide and others are limited to certain protected areas. All are constrained by very limited budgets and staff.

Sweden is interested in enhancing its protected area monitoring and is considering several approaches, including extracting protected area-specific data from regional monitoring programs, adding variables to existing monitoring programs, increasing the sample size in protected areas in the context of regional monitoring and conducting more protected area-specific monitoring.

Figure 7 Protected Areas of Sweden



Only protected areas overlapping or north of the CAFF boundary are displayed

Table 9: Monitoring programs in Sweden

Program	Broad Objectives of the Program	Specific Species and/or Ecosystems Included	Geographic Coverage
Monitoring of habitats and species in Habitats Directive (92/43/EEG) on bio-geographical scale (alpine/ boreal/ continental)	To meet the requirements of Articles 11 and 17 in habitat directive For habitats the following will be measured: Range Area Structure and function incl typical species For species the following will be measured: Population size and Range Area	Terrestrial habitats have an ongoing monitoring program. Aquatic habitats and monitoring of species will be developed within the coming two years.	Entire territory
Monitoring of Natura 2000 Network	To meet the requirements of Articles 11 and 17 in habitat directive	Program to be launched this year. The following will be monitored: Habitats: - Area (all areas, but infrequent) - Structure and functions (a small no. of parameters, e.g., Forest: forest fires, tree species composition, CWD; Wetlands: Hydrology; Watercourses: Hydromorphology); Typical species (very few of these will be monitored) Species: Population size & habitat	All protected areas (most are Natura 2000)

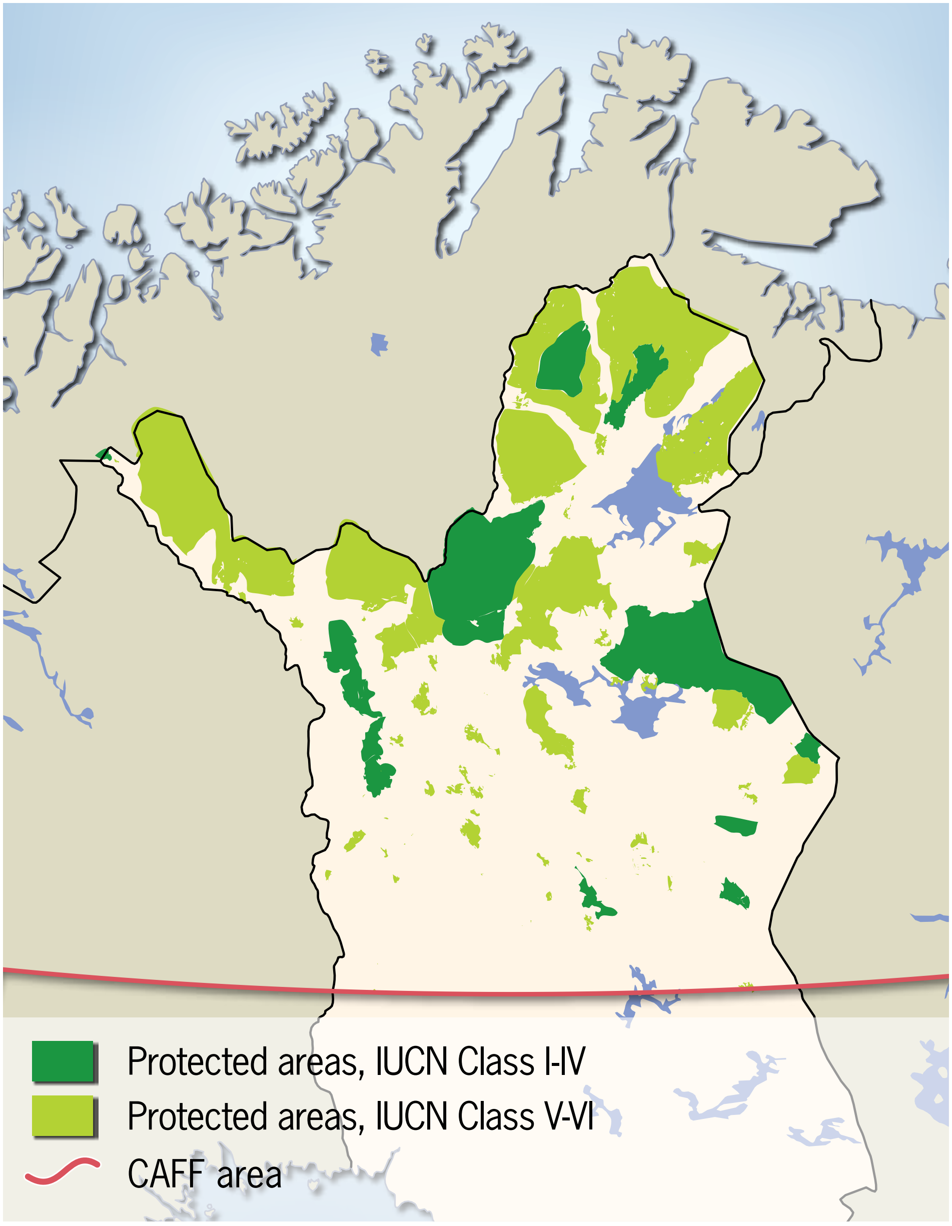
Source: Erik Hellberg, Naturvardsverket

4.7 Finland

Similar to other European nations, Finland does not have much in the way of monitoring programs directed specifically at protected areas. In addition, Finland considers "protected areas" to include not just those areas legislated as such but also state land reserved for nature protection by government decision but not yet formally established by law. It also includes its Natura 2000 Network, sites established for the purpose of protecting and managing certain species and habitats, though not formally protected. In most cases the Natura 2000 areas overlap with established protected areas or areas reserved for nature protection. Table 10 broadly describes the monitoring programs in Finland where protected area managers are responsible or important partners. Monitoring carried out in protected areas is normally conducted in the context of national biodiversity and natural resources monitoring programs, of which there are about 60 programs and many of those are conducted by or in conjunction with NGOs. Finland uses more than 100 biodiversity indicators grouped into different categories, mainly by habitat, and including indicators for pressures, state, impacts and responses.

Monitoring programs in Finland tend to fall into two broad categories: those intended to monitor broad changes in biodiversity at the species, habitat and landscape levels; and more specific programs which focus on rare or endangered species and habitat types. Some surveys are specific to protected areas but most tend to be part of the national monitoring program framework which is driven largely by the Habitats Directive and the Birds Directive. The proportion of the species populations and habitat area and their trend and within the Natura 2000 network must be reported for the first time in 2013. Key Arctic species being monitored in Finland include golden eagle, peregrine falcon, gyrfalcon, lesser white-fronted goose, Arctic fox, white-tailed eagle, freshwater pearl mussel and wolverine.

Figure 8 Protected Areas of Finland



Only protected areas overlapping or north of the CAFF boundary are displayed

The protected area component of national monitoring programs has been analyzed in some research projects and conservation assessments but not on a regular basis. These analyses are usually led by research institutes or universities. Protected area visitation is monitored and periodic surveys are conducted. Finland is planning to assess periodically the state of all Natura 2000 areas including status and trend assessment of habitats, species, recreational and subsistence values, key threats and so on.

Table 10: Monitoring programs in Finland

Only the monitoring programs where protected area managers in the Arctic area are involved are listed. Source: Heikki Eeronheimo, Metsahallitus

Monitoring Program(s)	Indicator(s)	Standard
Golden eagle (*Aquila chrysaetos*) population monitoring	Information collected: nest locations, occupancy, breeding results	Nordic countries
Peregrine falcon (*Falco peregrinus*) population monitoring	Information collected: territory locations, occupancy, breeding results	National, adapted from Golden eagle monitoring
Gryfalcon (*Falco rusticolus*) population monitoring	Information collected: nest locations, occupancy breeding results	National, adapted from golden eagle monitoring
Lesser white-fronted goose (Anser erythropus) population monitoring	Information collected: nest locations, occupancy, breeding results	National
Arctic fox (*Alopex lagopus*) population monitoring	Information collected: den location, its characteristics, and occupancy	National / Nordic countries
White-tailed eagle (*Haliaeetus albicilla*) population monitoring	Information collected: nest locations, occupancy, breeding results	National, partly adapted from Golden eagle monitoring
Freshwater pearl mussel (*Margaritifera margaritifera*) population surveys	Information collected from localities: status, abundance, location, description of habitats	(National?)
Breeding land-bird line transect censuses in protected areas (survey / monitoring)	Summaries by protected area: observation numbers, estimated densities and population sizes for each observed species and for different species groups	Standardized widely used method (at least National)
Species surveys in protected areas (mainly polypores in the Arctic area)	Information collected: species observations (location, abundance), survey methods, surveyed areas	Within NHS, developed by NHS for different species group and survey target
Monitoring / surveys of threatened and/or habitat directive's species	Information collected from known localities: status, abundance, location, description of habitats, management needs	Partly under preparation, Target National / EU
Monitoring/surveys of threatened and/or habitat directive's species (NHS national coordination responsibility	Information collected from known localities: status, abundance, location, description of habitats, management needs	Under preparation, Target National / EU
Wildlife triangle counts (game species)	Abundance levels and changes of species	National
Monitoring of large carnivores	Abundance levels and changes of species	National / Regional
Habitat survey of protected areas	Information collected by compartment (polygon feature): habitat characteristics, tree composition (plus dead wood), Natura-habitats, management needs, other biodiversity values, etc	National protected areas
Assessment of conservation status of species and habitats in Habitats Directive	Habitats: assessment of range, area covered by habitat, specific structures and functions (including typical species), future prospects and overall assessments Species: assessments of range population, habitat for the species, future prospects and overall assessment. Assessments include information on size, trend, reason for trend, pressures, and threats when relevant	EU-scale
Assessment of contribution of Natura 2000 Network (and other conservation measures) on the conservation status of the habitats and species in Habitats Directive	Proportion (area/population size) in network, trend in network, conservation measures and their effects)	EU-scale

Monitoring Program(s)	Indicator(s)	Standard
Assessment on the state of Natura 2000 areas	Under preparation, pilot phase: status and trend assessments of conservation values, management activities and needs, pressures and threats, definition of other main values	National
IUCN Red List assessments: species	Threat classes and their changes; threats and pressures, etc.	IUCN
IUCN Red List assessments: habitats	Threat classes and their changes; Threats and pressures, etc.	National scale

4.8 Russia

Environmental monitoring programs in Russia vary according to the category of protected area. "Strict reserves" have ecological monitoring as one of their main functions. National parks normally do as well and while wildlife reserves have no such requirements, "ad hoc" observations are conducted by outside agencies including research institutes, universities, hunting and fishing agencies and meteorological agencies.

Ecological monitoring in the strict reserves is conducted within the context of the Nature Chronicles Program, which describes monitoring themes, monitoring methodologies and the format of presentation and analyses of results.

Themes include relief, soil, weather, water, flora and vegetation, animals and anthropogenic impacts. Within each theme are discrete components or indices, e.g., flora and vegetation indices include new species, rare species population, phenology, productivity and yield of berries, nuts, etc.

There are some challenges inherent in the Nature Chronicles Program including a very formal structure without prioritization (i.e., all components and indices are considered to be of equal importance), a design intended largely for forested areas and lack of resources (both financial and expertise).

That said, Russia does have extensive monitoring observations for Arctic and Subarctic reserves. The best series include weather, phenology, endangered bird and mammal species, harvested mammals, waterfowl, seabirds, lemmings and reindeer. Significant gaps include permafrost, sea ice, freshwater fish, marine fish, marine mammals and insect observations.

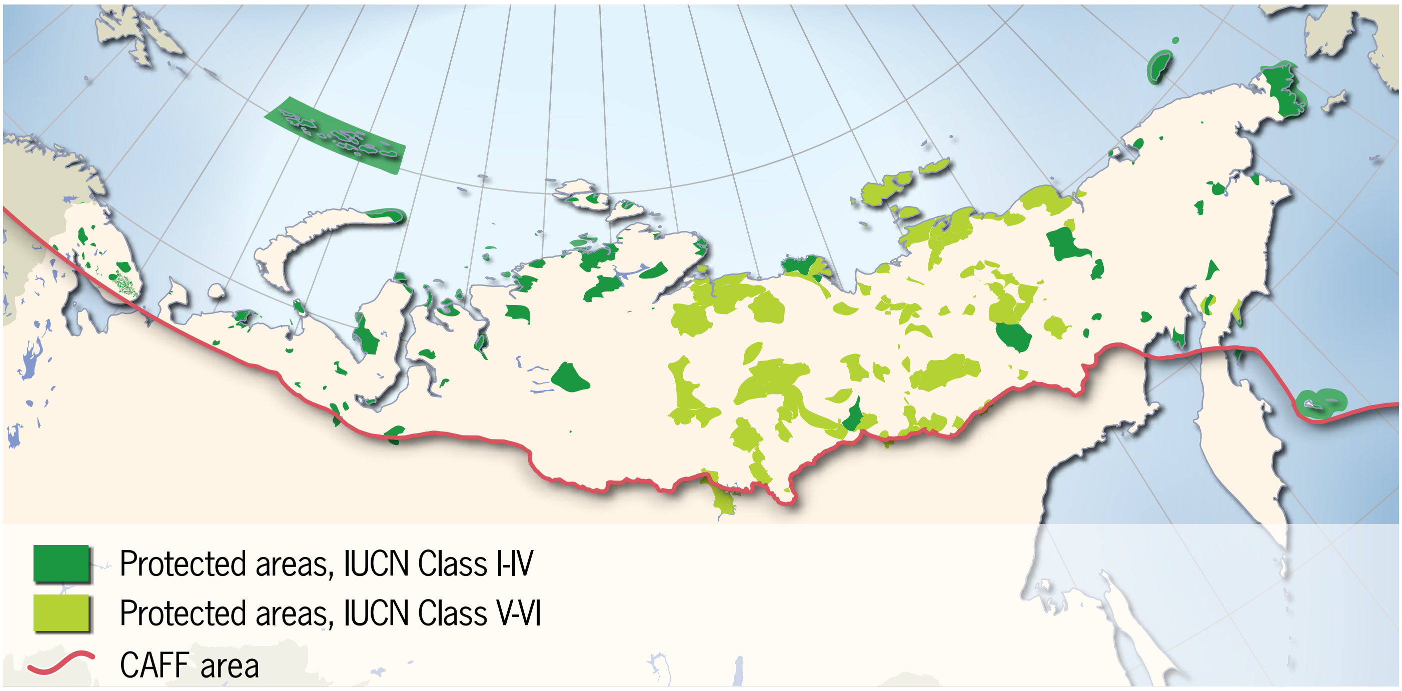
To address the inconsistencies among strict reserve monitoring programs and to enable better assessment of biodiversity conditions and current and possible threats to protected area integrity, Russia decided to develop a more standard approach to monitoring, focusing on the following themes:

- local flora and fauna
- landscape or vegetation structure
- most important abiotic processes
- weather and phenology
- endangered species
- species of socioeconomic importance
- species of biocentric importance
- major ecosystems
- most important anthropogenic impacts

Each theme is subdivided into monitoring indices. For example, major ecosystem indices include permafrost, snow cover, ground water, ice cover, vegetation structure and productivity, phytoplankton, invertebrate population, zooplankton, bird populations, rodent populations and fish populations. Each index is further subdivided into monitoring indicators (e.g., species population indicators include abundance, area and distribution, sex-age structure, physiological condition and habitat conditions).

However, while the design for comprehensive protected area monitoring in Arctic and Subarctic Russia is in place, implementation has been postponed due to lack of resources and management challenges.

Figure 9 Protected Areas of Russia



Only protected areas overlapping or north of the CAFF boundary are displayed

5.0 Themes, key ecosystem components, and indicators

5.1 European Union (EU)

The EU Habitats Directive, the Birds Directive, the Water Framework Directive and the Natura 2000 Network together form the foundation for Europe's Nature Conservation Policy. The Water Framework Directive focuses on the protection of European waters and biota including fish, benthic invertebrates, macrophytes and plankton. The Habitats Directive concentrates on the conservation of important habitats and associated species and the Birds Directive concentrates on the state of all European bird species. Natura 2000 is the centerpiece of EU nature and biodiversity policy. It is an EU-wide network of nature protection areas established under the Habitats Directive and is intended to ensure the long-term survival of Europe's most valuable and threatened species and habitats. It is comprised of Special Areas of Conservation designated by EU states pursuant to the Habitats Directive and Special Protection Areas designated pursuant to the Birds Directive.

European Union states are required to monitor natural habitats and species in accordance with these directives with particular attention to priority habitat types and priority species. Monitoring is to be carried out for the entire territory and not just the specific protected areas. Member states are required to report every six years (the next report is due in 2013). In particular, the reports include information concerning conservation measures taken, the effectiveness of those measures and the main results of the respective monitoring programs.

Table 11 summarizes the EU biodiversity themes and indicators.

Table 11: EU biological diversity themes and indicators

FOCAL AREA: STATUS AND TRENDS OF THE COMPONENTS OF BIOLOGICAL DIVERSITY
European Headline Indicator: Trends in abundance and distribution of selected species Abundance and distribution of selected species
European Headline Indicator: Change in status of threatened and/or protected species Red List Index for European species Species of European interest
European Headline Indicator: Trends in extent of selected biomes, ecosystems and habitats Ecosystem coverage Habitats of European interest
European Headline Indicator: Trends in genetic diversity of domesticated animals, cultivated plants, fish species trees of major socioeconomic importance Livestock genetic diversity
European Headline Indicator: Coverage of protected areas Sites designated under the EU Habitats and Birds Directives
FOCAL AREA: THREATS TO BIODIVERSITY
European Headline Indicator: Nitrogen deposition Critical load exceedance for nitrogen
European Headline Indicator: Trends in invasive alien species Invasive alien species in Europe
European Headline Indicator: Impact of climate change on biodiversity Occurrence of temperature-sensitive species
FOCAL AREA: ECOSYSTEM INTEGRITY AND ECOSYSTEM GOODS AND SERVICES
European Headline Indicator: Marine Trophic Index Marine Trophic Index of European seas
European Headline Indicator: Connectivity / Fragmentation of ecosystems Fragmentation of natural and semi-natural areas Fragmentation of river systems
European Headline Indicator: Water quality in aquatic ecosystems Nutrients in transitional, coastal, and marine waters
FOCAL AREA: SUSTAINABLE USE
European Headline Indicator: Area of forest, agriculture, fishery and aquaculture ecosystems under sustainable management Forest: growing stock, increment and fellings Forest: deadwood Agriculture: nitrogen balance Agriculture: area under management practices potentially supporting biodiversity Fisheries: European commercial fish stocks Aquaculture: effluent water quality from finfish farms
European Headline Indicator: Ecological Footprint and biocapacity of European countries Ecological Footprint of European countries

5.2 North America

The U.S. and Canadian approaches to monitoring in Arctic-protected areas tend to be agency and area-specific and not well integrated. The respective themes, key ecosystem components and indicators used by Alaskan (both federal and State) and Canadian agencies are described for Alaska and Canada in Section 5. That said, Alaskan (and Canadian, in a separate but similar initiative) authorities are working to develop an integrated, cascading monitoring scheme whereby certain themes would be monitored at state-wide, ecoregion or refuge scales, as follows:

Statewide:	Climate Air quality, precipitation chemistry Phenology Water quality and quantity Deformities and contaminants in organisms
Ecoregion:	Habitat mosaics Migratory species Permafrost-related events and resources Shoreline changes Other landscape processes
Refuge:	Subsistence resources Ecological keystones, ecosystem engineers or key landscape modifiers Local stressors and responses Refuge-significant species not covered at ecoregional extent Special plant and animal communities individual refuges

Table 12 illustrates how the key ecosystem components could be monitored using various indicators (attributes).

Table 12: Proposed Alaskan monitoring regime

Indicator	Measure / Attribute
Climate	Accumulate data from existing weather stations and other climate networks; supplement by filling gaps that will improve climate models at various extents; attributes include temperature, precipitations, snow depth, snow-water equivalent, freeze-thaw event, length of growing season
Air quality, precipitation chemistry	Accumulate data from existing air-quality stations; fill gaps to improve model accuracy
Landcover	Include attributes of vegetation mosaic, distribution of water bodies, glaciers, sea ice; create a seamless map every five to seven years (perhaps with panel design using satellite imagery, ground-truthing, or maybe a systematic grid of ground plots; collaborate with US Forest Service's Forest Inventory and Analysis program
Phenology	This is already being done by others; surrogate for other species' dynamics; example attributes include vegetation greening and browning using NDVI ice-out and ice-in, and other metrics organized by the National Phenological Network (e.g., budburst, arrival of migrants, first nesting dates)
Water quality and quantity	Most cost-effective to organize at statewide extent, but may need to parameterize at ecological or finer resolution; includes wetlands, riparian areas, and lentic systems
Deformities and contaminants in organisms	Bird beaks, amphibians; contaminants in seabirds, other taxa
Habitat mosaics	Composition of habitat types important to primary monitoring entities in the ecoregion (e.g., as determinants of distributions of species monitored by those entities)
Migratory species	Includes birds, large mammals (ungulates, carnivores, anadromous fishes, and marine species)
Permafrost-related events and resources	Example attributes: thermokarst, filling and draining of lakes & wetlands
Shoreline changes	May need local-scale normalization
Other landscape processes	Examples: fire and subsequent succession
Subsistence resources	Examples: plant parts, animals
Ecological keystones, ecosystem engineers or key landscape modifiers	Examples: sea otters, beavers, moose, and (cyclically) lagomorphs
Local stressors and responses	Examples: roads, snow-machine use, non-subsistence harvest, localized sites of recreation, etc.
Refuge significant species not covered at ecoregional extent	Examples include species in refuges purposes and other statutes with home ranges smaller than the refuge (e.g. furbearers)

Special plant and animal communities	Examples: Eelgrass, rare habitat, endemic or narrowly distributed animals

Source: Woodward, A., and E.A.Beever. 2010. Framework for ecological monitoring on lands of Alaska National Wildlife Refuges and their partners, Anchorage, Alaska. U.S. Geological Survey, Open-File Report 2010-1300, 94 p.

5.3 Selection considerations

Each Arctic country and virtually every agency approaches monitoring in its own way although there are common features.

Most monitoring agencies capture monitoring programs according to theme (e.g., wildlife, climate, habitat, human uses, species composition, etc.). While there is little consistency among agencies in labeling themes, key ecosystem components and indicators, there is sufficient common ground to draw out a consensus list.

In the end, selected key ecosystem components should be:

- relevant to most protected areas (not all monitoring programs can apply to all protected areas given the diversity of ecoregions represented and the need to develop a relatively short list of common monitoring programs);
- relevant to key biodiversity issues (responsive to the stressors identified in 3.0, above);
- responsive to change (not too sensitive, not too resilient);
- measurable across extremely broad scales (but at the same time sensitive enough to yield useful data);
- measured by multiple Arctic countries (relevant to specific concerns in specific protected areas and at the time yield data and information relevant to the circumpolar Arctic);
- amenable to use of standard protocols that can be compared across large areas (one of the key challenges is the standardization of monitoring protocols so that data can be compared from jurisdiction to jurisdiction);
- easily established, inexpensive and readily maintained (otherwise the programs will require too much time and resources to be sustained). In this context, satellite-based remote sensing offers considerable opportunity for cost-effective, efficient and effective long-term monitoring of some indicators.

Finally, wherever possible, the overall monitoring scheme should utilize existing resources and programs and build on other initiatives rather than proceeding separate and apart from them. Arctic countries are unlikely to agree to take on significant new monitoring programs given resource constraints.

6.0 Proposed approach for an APAMS

The ideal monitoring scheme—one set of monitoring programs that all Arctic countries would implement at the same time using the same protocols—is unlikely in the short term, if at all. Resource shortfalls, different monitoring approaches at the national level, multiple agencies and organizations exacting individual programs, the fact that not all protected areas contain a common set of key ecosystem components – all these factors lead to the conclusion that a "one-size-fits-all" approach is not immediately feasible.

A "modular" approach should be adopted. This "modular approach" should combine monitoring programs conducted at different scales, which may focus on differing key ecosystem components, but compliment all countries. Different key ecosystem components may act as surrogates; monitoring done at a state-wide scale may compliment (or substitute for) monitoring in formal protected areas. Results of monitoring programs that do not focus explicitly on protected areas may be interpolated or extrapolated to protected areas. In some cases, monitoring takes place in locations outside protected areas that are indistinguishable in biodiversity and disturbance levels from those that are protected (e.g., Greenland and Sweden; see Figures 10 and 11, and 13-15 respectively). Monitoring results from these locations are as valid as those from formal protected areas for the purpose of tracking changes in biodiversity in the Arctic. The key will be to select representative appropriate ecosystem components and surrogates; to interpolate or extrapolate using sound methodologies; and to ensure that monitoring programs conducted at all scales follow standard protocols to ensurecomparative results.

6.1 Terminology

One of the first steps in developing an effective APAMS program is the adoption of clear monitoring program terminology.

The CBMP approach to Arctic biodiversity indices and indicators is described in Table 2 of the CBMP Implementation Plan Overview Document where the following definitions are used:

Theme: overarching landscape, biological or policy category. Examples include: species composition; ecosystem structure; habitat extent and change in quality, ecosystem functions and services; human health and well-being; and policy responses.

Index: theme subcategory considered central to the protected area ecosystem .Examples include: the Arctic Species Trend Index; the Arctic trophic level index; the Arctic land cover change index; , the Arctic human health well-being index; coverage of protected areas; and trends in extent, frequency, intensity and distribution of natural disturbances..

Indicator: specific elements associated with indices that, when carefully monitored, are indicative of the overall condition of the index. Examples include:, trends in abundance of key species and trends; key trophic level indicator; trends in extent of biomes, habitats and ecosystems; trends in patch size distribution of habitats; trends in extent, frequency, intensity and distribution of natural and human-induced disturbances; trends in availability of biodiversity for traditional food and medicine; changes in protected area coverage.

In this example, each indicator would have a sub-element or elements that would be representative of the overall theme and the focus of a monitoring program (e.g., species composition/Arctic Species Trend Index/trends in abundance of key species, orterrestrial fauna/caribou/female caribou body fat condition in winter). Statistics could be obtained through harvester surveys, which could provide a number of other measures such as hunter effort, weather conditions, snow depth and so on.

In comparison, the U.S. National Park Service uses the terms "monitoring framework," (e.g., air and climate) and "vital signs," (e.g., airborne contaminants). The U.S. Fish and Wildlife Service uses "indicator" and "measurement" or "attribute" respectively. The Northwest Territories Cumulative Impact Monitoring Program (NWT CIMP) uses "valued component" (e.g., climate and climate change), and "indicator" (e.g., snowpack depth). Parks Canada uses "ecosystem integrity indicators", where the NWT CIMP uses "valued components," and so on.

For the purposes of this discussion paper, the terms "CBMP bio-theme", "monitoring theme", "focal ecosystem component" ,"indicator" and "measure" will be used to describe a cascading approach (from the very broad and general, to the narrow and precise) to a common monitoring protocol. This approach follows that of the

An example:

CBMP ecosystem: terrestrial fauna
Monitoring theme: ungulates
Focal ecosystem component: caribou
Indicator: breeding success
Measure: cow/calf ratio

Expert Monitoring Groups established by the CBMP. The application of traditional knowledge in Arctic biodiversity monitoring has been added as a separate theme.

6.2 APAMS program - monitoring scheme components

The APAMS program scheme must answer the broad question: How is Arctic protected area biodiversity responding to the key challenges and stressors identified earlier in this paper?

Once a common terminology has been accepted, the next step is to agree on what will be monitored. To be effective, each monitoring program should target and track a specific measure that reliably represents the state of a specific indicator chosen as an accurate gauge of the state of a particular focal ecosystem component, which in turn is representative of a key monitoring theme. Consistent monitoring of the selected measures will over time will yield trends in indicators, focal ecosystem components and perhaps monitoring themes. Monitoring will also determine the feasibility of using different focal ecosystem components as surrogates for others and the feasibility of using a particular indicator as a surrogate for other indicators, thus increasing the overall effectiveness and efficiency of the monitoring programs.

The overarching monitoring themes were derived from current circumpolar monitoring programs. Focal ecosystem components were likewise drawn from existing programs, but also because of their associated values and sensitivity to the stressors identified earlier in Section 4.0. Additionally, the report "Arctic Biodiversity Trends 2010 – Selected indicators of change" (CAFF International Secretariat, Akureyri, Iceland. May 2010) identified the following indicators:

- Polar bears
- Wild reindeer and caribou
- Shorebirds – red knot
- Seabirds – murres (guillemots)
- Seabirds – common eiders
- Arctic char
- Invasive species (human-induced)
- The Arctic Species Trend Index
- Arctic genetic diversity
- Arctic sea-ice ecosystem
- Greening of the Arctic
- Reproductive phenology in terrestrial ecosystems
- Appearing and disappearing lakes in the Arctic and their impacts on biodiversity
- Arctic peatlands
- Effects of decreased freshwater ice cover duration on biodiversity
- Changing distribution of marine fish
- Impacts of human activities on benthic habitat
- Reindeer herding
- Seabird harvest
- Changes in harvest
- Changes in protected areas
- Linguistic diversity

Table 13 summarizes some of the key values of each monitoring theme and the linked stressors. Because each focal ecosystem component for each monitoring theme should fulfill the same values and respond to the same stressors, they are not listed separately here.

Table 13: CBMP ecosystem, monitoring theme, key values and key linked stressors

Ecosystem	Monitoring Theme	Value	Linked Stressor
Terrestrial fauna	ungulates	central ecosystem component, cultural importance	climate change, increasing human use, development
	predators	iconic species, top predators, some at risk	climate change, increasing human use, development
	small mammals	important keystone species in ecosystem food chains	climate change, development
	passerines and shore-birds	indicators of change, some at risk	climate change, development, contaminants, invasive spp
	waterfowl	indicators of change, cultural importance, some at risk	climate change, increasing human use, development
Freshwater	fish	indicators of change, cultural importance, some at risk	climate change, increasing human use, development
	water	indicator of change, fundamental ecosystem importance	climate change, development, contaminants
	ice cover	indicator of change, ecosystem function, important habitat	climate change
Terrestrial vegetation	phenology	indicator of change, important habitat	climate change, invasives
	landscape change	indicator of change, important habitat	climate change, increasing human use, development
Marine	marine mammals	indicator of change, cultural importance, some at risk	climate change, increasing human use, contaminants
	fish	indicator of change, cultural importance, some at risk	climate change, increasing human use
	seabirds	indicator of change, cultural importance, some at risk	climate change, increasing human use, development
	ocean circulation	indicator of change, ecosystem function	climate change
Coastal	coastal dynamics	indicator of change, ecosystem function	climate change
Traditional knowledge	traditional knowledge	knowledge of ecosystem processes, at risk	loss of traditional knowledge

Table 14 summarizes the proposed APAMS program. It lists the abiotic and biotic monitoring themes for each CBMP ecosystem. Each monitoring theme includes several focal ecosystem components (perhaps interchangeable and at least complementary).The suggested indicators are common for each focal ecosystem component, i.e., the indicators all apply to each focal ecosystem component in that particular monitoring theme, e.g., breeding success applies to all ungulate focal ecosystem components. Each indicator in turn has a discrete measure, e.g., the indicator of breeding success is the cow/calf ratio.

Suggested key ecosystem components are themselves indicators of various aspects of biodiversity, for example:

- wolverine, grizzly bear, golden eagle – indicators of range quality
- lemmings – keystone species, indicators of ecosystem functioning
- caribou numbers – indicators of ecosystem recovery
- endangered species or those at range limits – indicators of uniqueness
- vegetation cover – indicator of diversity
- species sensitive to climate change, increasing or decreasing ice cover – indicators of resilience
- invasive species – indicators (and agents) of change

The selection of appropriate measures is important. Appropriate measures should include those:

- where there are existing programs and standardized protocols (e.g., aerial census)
- where there are long-term, standardized, universal data bases (e.g., sea ice records)

- that are amenable to satellite or other remote sensing technologies (e.g., sea ice distribution and thickness)
- that can be implemented easily (e.g., NDVI)

Table 14: Draft APAMS

1. CBMP ecosystem: Terrestrial Flora and Fauna

1 (a) Flora

Monitoring theme	Focal ecosystem component	Indicator	Measure	Expert agency
Phenology	Plant community structure	Species composition, ratios	Spp identification, spp ratio calculation, invasive spp, year to year comparison	UNEP GRIDA, IUCN arctic plant bryophyte specialist groups, IUCN Red List authorities
	Plant growth	Spring green-up	NDVI	ITEX, GLORIA, IUCN specialist groups
Landscape change	permafrost	Ground temperature, ground slumping nature and extent	Temperature measurements, landscape mapping	Universities, government agencies
	Infrastructure development	Roads, buildings, trails	Mapping of new infrastructure development, year to year comparison	Protected area management authority
	Human use	Nature and frequency of visitation	Surveys, observations, visitor reports	Protected area management authority

1(b) Fauna

Monitoring theme	Focal ecosystem component	Indicator	Measure	Expert agency
Ungulates	Caribou Wild reindeer Moose Muskox Wild sheep and goats	Abundance, distribution, breeding success, population trend, herd health	census, seasonal movements, cow/calf ratio, fat condition, harvest statistics, year to year comparison	CARMA, IUCN Caprinae Specialist Group, wildlife agencies
Predators	Brown/grizzly bear Wolf Wolverine Red fox White fox	Abundance, distribution, breeding success, population trend	census, seasonal movements, litter success, harvest statistics, year to year comparison	Brown Bear Network, IUCN wolf, bear, canid, small carnivore specialist groups, wildlife agencies
Small mammals	Lemmings Voles Mice Hares Pikas shrews	Abundance, distribution, breeding success, population trend	census, seasonal movements, litter success, year to year comparison	Parks Canada, Finland, Russia, IUCN small mammal, lagomorph specialist groups.
Passerines and shorebirds	Passerine species Shorebird species, e.g., red knot, phalarope spp	Abundance, distribution, breeding success, population trend	census, seasonal movements, nesting success, year to year comparison	IUCN bird specialist groups
Waterfowl	Brent goose Slavonian grebe white-fronted goose	Abundance, distribution, breeding success, population trend	census, seasonal movements, nesting success, harvest statistics, year to year comparison	Wetlands International, IUCN goose duck specialist groups, wildlife agencies
Endangered species	Red Book (unless noted above)	Abundance, distribution, breeding success, population trend	census, seasonal movements, reproductive success, year to year comparison	IUCN Bird Red Book authorities, IUCN Threatened Waterfowl Specialist Group

2. CBMP ecosystem: Freshwater

Monitoring theme	Focal ecosystem component	Indicator	Measure	Expert agency
Fish	Whitefish species Arctic char Red Book species	abundance, distribution, spawning success, year to year trends	census, seasonal movements, young of year, harvest statistics, year to year comparison	Fisheries Joint Management Committee (NWT), IUCN/WI Freshwater Fish Specialist Group, IUCN Salmonid Specialist Group, IUCN Red Book authorities, fisheries management agencies
Water	Water quality	benthic invertebrates, chemistry temperature, turbidity	benthic community structure, key chemical constituents (e.g., nutrients), temperature measurements, turbidity measurements, year to year comparison	Parks Canada, Freshwater Biodiversity Network, National Water Research Institute (Environment Canada)
	Water quantity	seasonal flow, surface cover/extent	Water levels and volumes, surface mapping, year to year changes	Canadian Meteorological Service/Water Survey of Canada
Ice	Ice cover	Ice distribution, ice thickness	Surface mapping, thickness measurements, year to year comparison	Canadian Ice Service, NOAA

3. CBMP ecosystem: Marine

Monitoring theme	Focal ecosystem component	Indicator	Measure	Expert agency
Marine mammals	Seal species Walrus Polar bear Whale species	Abundance, distribution, breeding success, population trend	census, seasonal movements, reproductive success, harvest statistics, year to year comparison	IUCN cetacean, polar bear, pinniped specialist groups
Fish	Shrimp Turbot Salmon Invasive spp	Abundance,distribution, spawning success, year to year trends	census, seasonal movements, spawning success, harvest statistics year to year comparison	IUCN Salmonid Specialist Group, fisheries management agencies
Seabirds	Murre Eider Guillemot species	Abundance,distribution, breeding success, population trend	census, seasonal movements, nesting success, year to year comparison	Circumpolar Seabird Group
Endangered species	Red Book (unless noted above)	Abundance, distribution, breeding success, population trend	census, seasonal movements, reproductive success, year to year comparison	IUCN Bird Red Book authorities, IUCN Threatened Waterfowl Specialist Group

4. CBMP ecosystem: Coastal

Monitoring theme	Focal ecosystem component	Indicator	Measure	Expert agency
Coastal dynamics	Coastline change	coastal erosion or deposition	Coastline mapping, current regime monitoring (speed, direction, volume) year to year comparison	Government agencies, universities
	Ice cover	seasonal distribution, thickness	sea ice cover mapping, thickness measurement, year to year comparison	Canadian Ice Service

5. Additional theme: local knowledge

Monitoring theme	Focal ecosystem component	Indicator	Measure	Expert agency
Use of traditional knowledge	Application of traditional knowledge in environmental monitoring programs	Traditional knowledge holder satisfaction	Surveys, participation by traditional holders in monitoring programs	Aboriginal governments, authorities and individuals

Table 15 shows which Arctic countries are currently monitoring the themes identified above. NA (not applicable) applies in cases where the theme is not relevant or possible in a country. In some cases monitoring is specific to protected areas (PA); in other cases monitoring is on a state-wide scale (S) not specific to but including protected areas. In some cases monitoring occurs on both scales. Protected area-specific information can also be extracted from state-wide (EU) programs; it's probable that these programs could also be expanded within protected areas without significant additional cost.

Table 15: Current Arctic protected area monitoring programs

Monitoring theme	Indicator	Alaska	Canada	Greenland	Iceland	Norway	Sweden	Finland	Russia
CBMP ecosystem: Terrestrial									Uncertain: Monitoring programs have been designed but specific information on their application is missing
Ungulates	abundance, distribution, herd health, breeding success, population trend	S PA	S PA	S PA	S PA	S PA	S PA	S (moose)	
Predators	abundance, distribution, breeding success, population trend	S PA	S PA	S	S PA	S PA	S	S	
Small Mammals	abundance, distribution, breeding success, population trend	S PA	S PA	S PA	S PA	S PA	S PA	S PA	
Passerines and shorebirds	abundance, distribution, breeding success, population trend	S PA	S PA	S	S PA	S PA	S PA	S PA	
Waterfowl	abundance, distribution, breeding success, population trend	S PA	S PA	S PA	S PA	S PA	S PA	S	
Endangered species	abundance, distribution, breeding success, population trend	S PA	S PA	S	S PA	S PA	S	S PA	
Phenology	species composition	S PA	S PA	S	S PA	S	S PA	S	Uncertain: Monitoring programs have been designed but specific information on their application is missing
	green-up	S PA	S PA	S PA	S PA	S	S		
Landscape change	permafrost temperature	PA	S PA	S PA	S	S PA	S		
	infrastructure	S PA	S PA	PA	PA		PA	PA	

Monitoring theme	Indicator	Alaska	Canada	Greenland	Iceland	Norway	Sweden	Finland	Russia
CBMP ecosystem: Freshwater									Uncertain: Monitoring programs have been designed but specific information on their application is missing
Fish	abundance, distribution, spawning success, population trend	S PA	S PA	S	S PA	S PA	S	S	
Water quality	benthic invertebrate health, chemistry, temperature, turbidity	S PA	S PA	S	S	S	S PA	S	
Water quantity	seasonal flows, surface extent	S PA	S PA		S PA	S	S	S	
Ice cover	ice distribution, thickness	S	S	S	S	S	S	S	
CBMP ecosystem: Marine									
Marine mammals	abundance, distribution, breeding success, population trend	S	S	S PA	S PA	S		NA	
Fish	abundance, distribution, spawning success, population trend	S PA	S PA	S	S PA	S PA	S	NA	
Seabirds	abundance, distribution, breeding success, population trend	S PA	S PA	S PA	S PA	S PA		NA	
Ocean circulation	temperature, salinity, current flow	S	S	S	S	S		NA	
CBMP ecosystem: Coastal									
Coastal dynamics	coastal erosion/deposition	S PA	S PA					NA	
	current flow	S	S	S	S	S		NA	
	seasonal ice coverage, thickness, character	S PA	S PA	S	S	S		NA	
Traditional knowledge									
Application in monitoring	Application in monitoring programs	S PA	S PA	S		S	S	PA	

7.0 Additional considerations and next steps

The challenge of creating a consistent and common circumpolar protected areas monitoring program is significant for a number of reasons, among them: very different approaches to protected areas monitoring in Europe and North America; frequent absence of consistent monitoring and reporting protocols; limited communication and coordination among responsible agencies within and among Arctic countries; funding and personnel constraints and so on. All that said, it can be done. The challenge is not so much the absence of monitoring programs – there are few significant gaps – but in the management of the data and knowledge derived from the numerous monitoring programs.

The most efficient approach to developing a common set of monitoring programs is to derive from existing programs the common themes, focal ecosystem components, indicators and measures and to construct from them a circumpolar scheme. An examination of existing protected area and state-wide monitoring programs suggests that relatively minor improvements and enhancements to existing programs would fill the remaining gaps. Where countries are not monitoring the suite of focal ecosystem components, sufficient surrogates are available; similarly, where protected area-specific monitoring programs are not being conducted, data from state-wide programs can be extrapolated or interpolated effectively. Finally, relatively minor adjustments to the state-wide programs to provide more data specific to protected areas can be done with relatively little effort. In the end, the objective of monitoring biodiversity on a circumpolar scale using protected areas as controls or baselines can largely be achieved with minor improvements to existing monitoring programs and greater effort directed to information management.

Once consensus is reached by the APAMS network on a draft set of monitoring themes, focal ecosystem components, indicators and measures, the next step should be consultation with the Expert Monitoring Groups. While the various groups are following different timelines, finalizing the structure of the APAMS program should be relatively straight-forward.

Following this, a APAMS program implementation plan will be required. The plan will need to address two key aspects: first, creation of an information management system that can "mine" existing databases for the information necessary to report on the state of Arctic biodiversity as seen through a protected area lens; and second, filling the remaining gaps in monitoring programs to improve the quality of the biodiversity assessments.

8.0 Summary

Agreement on a sustainable suite of circumpolar protected area biodiversity monitoring programs that will effectively and efficiently capture representative key data at the appropriate scale and designing and implementing the appropriate information management system is both doable and arguably necessary.

There are real challenges associated with the development and implementation of a long-term protected area biodiversity monitoring program that crosses national and international jurisdictions and that takes into account different monitoring approaches and philosophies. However, the greater challenge is not the development of the monitoring programs per se but rather collecting, collating and disseminating the information that is already available. There are few significant gaps in current protected area monitoring programs and state-wide programs that include protected areas that would prevent reliable biodiversity assessments. Without an effective information management regime, however, the knowledge gained through those monitoring programs is of limited availability. "Mining" and managing the information already held in numerous databases is a challenge but one that can be overcome with relatively few additional resources.

As is so often the case with environmental monitoring and stewardship programs, the single greatest limiting factor is resources. Trained, professional staff are often in short supply; adequate budgets to enable them to do the necessary work are often in shorter supply. The development and implementation of an effective APAMS program is a relatively straightforward exercise if the resources and commitment are there. As the risks and challenges from climate change, industrial development, long range transport of contaminants, etc. increasingly affect the Arctic, it will be all the more important to ensure that we understand what is happening, why it is happening and what the implications are. A robust and effective biodiversity monitoring program utilizing all available information and particularly information from circumpolar Arctic protected areas is essential now more than ever.

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ISBN: 978-9935-431-10-3