Circumpolar Biodiversity Monitoring Program

Circumpolar Biodiversity Monitoring Program

Five-Year Implementation Plan

OVERVIEW DOCUMENT

Meeting of Senior Arctic Officials
Tromsø, Norway
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CAFF
Conservation of Arctic Flora and Fauna

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I. Executive Summary

In response to the global importance of the Arctic's biodiversity, the increasing pressures on Arctic biodiversity and human communities, and our limited capacity to monitor and understand these changes, the Arctic Climate Impact Assessment (ACIA) recommended that long-term Arctic biodiversity monitoring be expanded and enhanced. In its acceptance of the findings and projections from the ACIA, the Arctic Council directed the Conservation of Arctic Flora and Fauna Working Group (CAFF) to examine the ACIA findings related to biodiversity conservation and develop follow-up programmes and activities to address key projections for the future of the Arctic. A primary response has been the implementation of the Circumpolar Biodiversity Monitoring Program (CBMP).

The CBMP is a mechanism for harmonizing and enhancing long-term biodiversity monitoring efforts across the Arctic in order to improve our ability to detect and report on significant trends and pressures. The resulting information will be used to assist policy and decision making at the global, national, regional and local levels.

The circumpolar Arctic, as defined by CAFF, covers 14.8 million km^2 of land and 13 million km^2 of ocean. It encompasses highly complex ecosystems, due in part to the interplay between terrestrial and marine species, habitats, and ecosystems both inside and outside the region. Considering the size and complexity of the circumpolar Arctic, it is essential that the CBMP promote and develop an integrated ecosystem-based approach to monitoring.

The delivery of an ecosystem-based approach involves monitoring that bridges ecosystems, habitats, and species. It demands information not only on the status and trends in Arctic biodiversity, but also on their underlying causes. It is critical that this information be collected and made available to generate effective strategies for adapting to the changes now taking place in the Arctic —a process that ultimately depends on rigorous, integrated, and efficient monitoring programs that have the power to detect change within a reasonable time frame.

Towards this end, the CBMP will facilitate the integration and coordination of a multidisciplinary, integrated ecosystem-based approach through the development of five integrated Expert Monitoring Groups (Marine, Coastal, Freshwater, Terrestrial Vegetation and Terrestrial Fauna). Each group will be comprised of existing site-based and network-based research and monitoring programs, representing a diversity of expertise including both community-based monitoring and scientific-based monitoring capabilities. Special attention will be paid to community-based observations and citizen science, understanding the value and significance of local people living in the Arctic environment and their contribution to the monitoring of Arctic biodiversity.

To facilitate effective reporting, the CBMP has chosen a suite of indices and indicators that can be used to report on the current state of Arctic biodiversity at various scales and levels of detail to suit a wide range of audiences. The current and planned CBMP biodiversity monitoring underpins these indices and indicators.

Over the next five years, the CBMP will focus its efforts on the following key areas:

- Developing a strategy for building and maintaining a comprehensive and cost-effective circumpolar monitoring program that addresses current deficiencies;
- Coordinating and integrating biodiversity monitoring programs and promoting standardized measures and harmonized data protocols;
- Assessing current monitoring capacity and design to identify elemental, geographic, and statistical design deficiencies and inefficiencies;
- Interpreting, integrating, and communicating existing biodiversity information (establishing statistical baselines and retrospective assessments);
- Developing data-management structures and a Web-based data portal for the synthesis, analysis, and dissemination of biodiversity information;
- Identifying and initiating pilot monitoring projects, where clear gaps exist;
- Reporting on the status of Arctic biodiversity and the issues facing it, using diverse formats for communication, education and outreach at the global, national, regional and local levels.

II. Introduction

A. The Challenge

Global Significance of Arctic Biodiversity

The Arctic's contribution to global biodiversity is substantial. Its brief summers are intensely productive and attract hundreds of migratory species. Two hundred and seventy-nine species of migratory birds breed in significant numbers in the Arctic; of these, 30 reach southern Africa, 26 reach Australia and New Zealand, 22 reach southern South America, and several pelagic species reach the southern oceans. Several species of land and marine mammals, including gray and humpback whales, also participate in the global migration, traveling long distances to the Arctic each year.

While the Arctic has relatively few species compared to the mega-diverse tropics, Arctic biodiversity is notable for its high genetic diversity, reflecting the many unique adaptations species have developed in response to extreme environmental conditions. The Arctic also supports globally significant populations, including more than half of the world's shorebird species, 80 percent of the global goose population, several million reindeer and caribou (which are critical to human communities in the Arctic), and 28 percent of the world's commercial marine-fish harvest.

The circumpolar Arctic, as defined by CAFF, covers 14.8 million km^2 of land and 13 million km^2 of ocean. The emerging economic importance of Arctic ecosystems often conflicts directly with conservation values, as the region has some of the world's few remaining pristine, undeveloped environments. Vast wilderness areas where ecosystem processes continue to function in a largely natural state play a key role in the physical, chemical, and biological balance of the planet. The Arctic is also home to diverse, vibrant, and unique societies whose indigenous cultures maintain close ties to the land and represent hundreds of distinct languages.

Under Pressure

Dramatic changes now underway in the Arctic are threatening the resilience and sustainability of its living resources. Of greatest concern is climate change, as its impacts on Arctic biodiversity are already being seen and much larger impacts (with significant regional variation) are expected to take place over this century. By 2100, the Arctic is expected to warm 3-5°C over land and 7°C over the oceans, contributing to dramatic changes in its ecosystems[1]. Predicted impacts include a more than 50 percent decline in the extent of summer sea-ice and the displacement of existing Arctic species and ecosystems (e.g., polar deserts and tundra) as southern species and ecosystems expand northward.

Although climate change is placing increasing challenges on the resiliency of the Indigenous Peoples of the North, it is not the only pressure on Arctic biodiversity. Others include environmental contaminants, habitat fragmentation, invasive species, increased shipping and air

[1] *Arctic Climate Impact Assessment*, 2004.

traffic, and regional development such as oil-and-gas exploration and production, forestry, hydroelectric development, and urbanization.

Our Current Understanding

Information on Arctic biodiversity, human stressors, and natural changes is currently available in a piecemeal fashion and on an irregular basis. An integrated picture of the status of and trends in species, habitats, and ecosystem integrity in the Arctic and along migratory routes is not fully known. Although numerous monitoring efforts are currently underway, a lack of coordination and integration has resulted in limited links between monitoring and policy making. A better way of communicating results so that they are more useful to policy is urgently needed in order to successfully manage and conserve Arctic biodiversity and adapt to inevitable changes.

B. Purpose of the Circumpolar Biodiversity Monitoring Program

The purpose of the Circumpolar Biodiversity Monitoring Program (CBMP) is to strive for the conservation of biological diversity in the Arctic, to halt or significantly reduce the loss of this biodiversity, and to provide information to the indigenous peoples of the Arctic, other Arctic residents, and stakeholders inside and outside the region on the sustainable use of the region's living resources.

The CBMP is, first and foremost, a coordinating entity for

- existing Arctic biodiversity monitoring programs;
- identifying new programs to address gaps in knowledge;
- gathering, integrating, and analyzing data; and
- communicating results.

The CBMP will serve as a mechanism for harmonizing and enhancing monitoring efforts across the Arctic in order to improve our ability to detect significant trends within a reasonable time frame and report on them effectively. The resulting information will be used to influence policy and engage diverse audiences, such as northern communities, scientists, governments, and the global community.

Information on how Arctic species are responding to pressures is widely scattered among scientists, government institutions, and northern communities. With the cooperation of its expert monitoring groups (EMGs), the CBMP has been designed to identify gaps in data, integrate information and efforts aimed at monitoring and communication, and encourage the development of new monitoring efforts to identify the type and extent of changes in the Arctic and improve our understanding of them. A major focus will be organisms of primary importance to the integrity of Arctic ecosystems and the culture and livelihood of Indigenous cultures. Special attention will be paid to community-based observations and citizen science, recognizing the valuable and significant contributions that people living in this environment can make to monitoring Arctic biodiversity.

The CBMP functions as an international forum of key scientists and conservation experts from all eight Arctic countries, the six international indigenous organizations of the Arctic Council,

and a number of global conservation organizations. It is strategically linked to other international conservation programs such as the Arctic Monitoring and Assessment Programme (AMAP), International Polar Year (IPY), the International Arctic Science Committee (IASC), and the Convention on Biological Diversity (CBD), thereby ensuring effective coordination and integration with related global initiatives.

Through the Arctic Council, the results of the CBMP will be translated into effective conservation, mitigation, and adaptation policies in order to promote the sustainability of the Arctic's living resources. To do this, information is needed not only on the status of and trends in Arctic biodiversity at the circumpolar level, but also on the natural and anthropogenic stressors driving trends in Arctic biodiversity at all scales – from local and regional to national and international. Identifying and understanding how and why biodiversity is changing at various scales will enable local communities and regional, national, and international decision-making bodies to develop informed policy and response strategies focused on adaptation, mitigation, and conservation. This information will be provided in a timely fashion using diverse formats.

C. Circumpolar Biodiversity Monitoring Program and the Arctic Climate Impact Assessment

In 2004, the Arctic Council released the Arctic Climate Impact Assessment (ACIA), which recommended that long-term Arctic biodiversity monitoring be expanded and enhanced in response to the global importance of the Arctic's biodiversity, the increasing pressures on this biodiversity, and our limited capacity to monitor and understand changes that are occurring.

In its acceptance of the ACIA findings and projections, the Arctic Council directed two of its working groups—the Conservation of Arctic Flora and Fauna (CAFF) Working Group and AMAP—to examine these findings and develop follow-up programmes and activities, both individually and jointly, to address key projections for the future of the Arctic.

A primary response of the CAFF Working Group was the implementation of the CBMP. The development of the CBMP as the cornerstone program of CAFF received Ministerial endorsement in both 2004 (Reykjavik Declaration) and 2006 (Salekhard Declaration). Iceland led the Program before Canada took over in April 2005. The CBMP was formally launched in September 2005 in cooperation with the United Nations Environment Programme–World Conservation Monitoring Centre (UNEP-WCMC) in Cambridge, England.

The CBMP is the primary vehicle through which CAFF will follow up on ACIA. It can also be used to promote Arctic information in global fora and reports, such as the United Nations Convention on Biological Diversity, the Ramsar Convention on Wetlands, the Biodiversity Information Partnership, United Nations Millennium Development Goals, IPY, and the International Arctic Science Committee.

III. Toward an Integrated Arctic Biodiversity Monitoring Program: Five-Year Plan

A. Monitoring Approach

The CBMP is taking an integrated ecosystem-based approach to monitoring. See Figure 1.

Integrated Ecosystem-based Approach to Monitoring

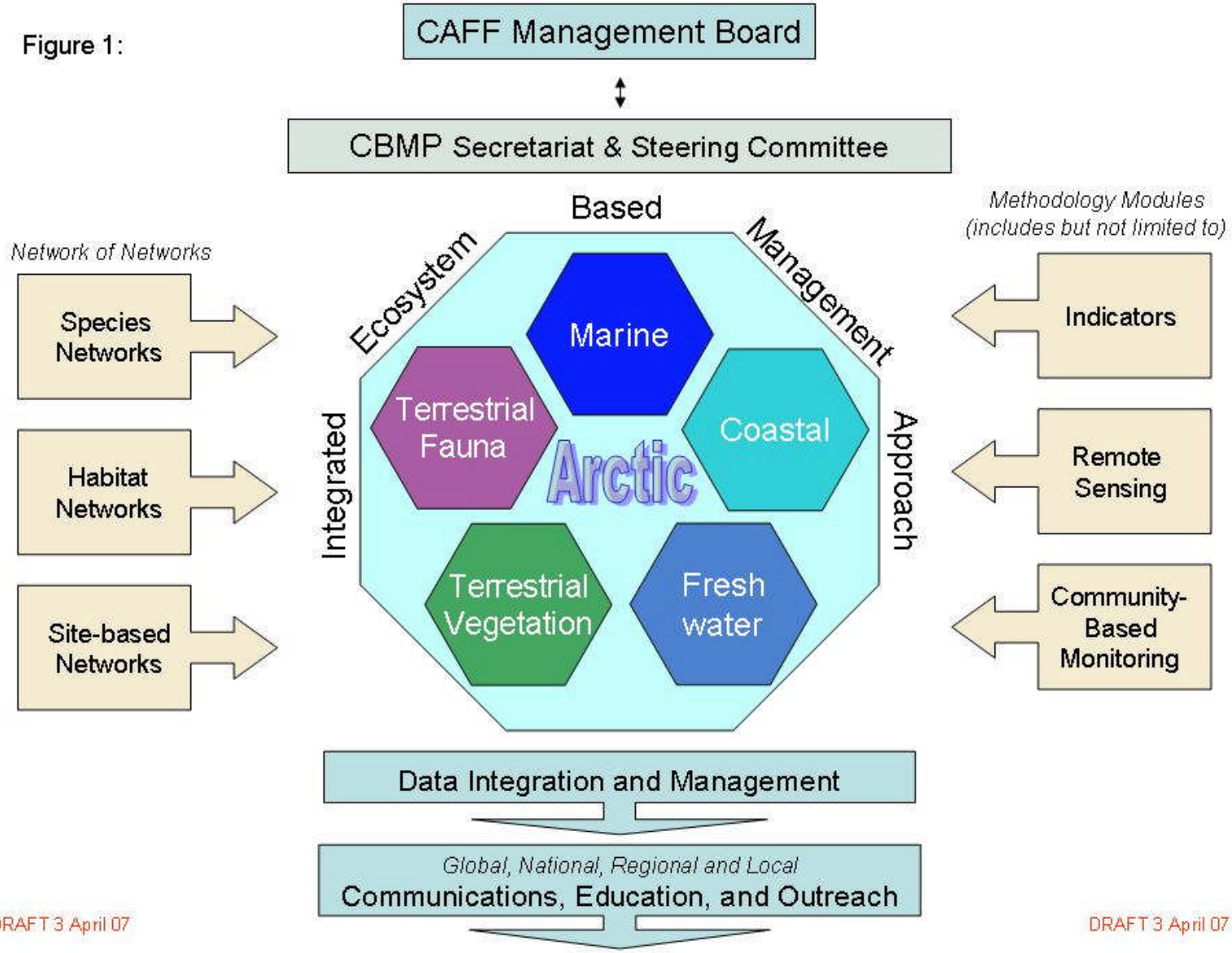
The ecosystem-based approach to monitoring integrates information on land, water, and living resources and lends itself to monitoring many aspects of an ecosystem in a geographic region. Important elements of the ecosystem approach for monitoring Arctic biodiversity include the following:

- Recognition that monitoring all elements of ecosystems—including species, habitats, ecosystem structure (e.g., species assemblages, food webs), processes (e.g., predator-prey cycles, nutrient cycling), functions (e.g., net primary productivity), and stressors to the ecosystems — is necessary to gain a meaningful picture of what is happening to biodiversity;
- A focus on trends, including recognition of the dynamic nature of Arctic ecosystems and the importance of identifying change that is outside the realm of natural variability;
- Recognition of the interplay between terrestrial, freshwater, and marine systems and the way it shapes Arctic ecology and the goods and services that Arctic biodiversity provides; and
- Recognition of the dependence of Arctic biodiversity on conditions outside the Arctic (e.g., high proportion of migratory species, significant impacts of pollutants originating from outside the Arctic).
- Recognition of humans and their cultural diversity as an integral component of many ecosystems[2];
- Monitoring the interactions between people and biodiversity, such as sustainable use and the ability of biodiversity to provide essential goods.

The ecosystem-based approach to monitoring considers the integrity of entire ecosystems and their interaction with other ecosystems. It goes beyond the individual species approach by identifying important relationships. Although this may seem a highly complex and difficult way to study biodiversity that requires more extensive data gathering and analyses than the species approach, the rewards are significant. It provides a bridge between ecosystems, habitats, and species and the impacts of stressors on ecological functions. The resulting information contributes directly to adaptive management, thereby allowing for effective conservation, mitigation, and adaptation actions appropriate to the Arctic.

[2] Convention on Biological Diversity (COP 5, 2000), http://www.biodiv.org/programmes/cross-cutting/ecosystem/description.asp

Figure 1:


CAFF Management Board
CBMP Secretariat & Steering Committee
Ecosystem
Based
Management
Integrated
Approach
Arctic
Marine
Terrestrial Fauna
Coastal
Terrestrial Vegetation
Fresh water
Network of Networks
Species Networks
Habitat Networks
Site-based Networks
Methodology Modules (includes but not limited to)
Indicators
Remote Sensing
Community-Based Monitoring
Data Integration and Management
Global, National, Regional and Local
Communications, Education, and Outreach
DRAFT 3 April 07
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B. Network of Networks

The ecosystem-based approach is being implemented first of all through the establishment of five integrated, cross-disciplinary *expert monitoring groups* (EMGs): marine, freshwater, coastal, terrestrial fauna and terrestrial vegetation. These monitoring groups will be supported by the coordination of a network of networks, drawing on existing species, habitat and site-based monitoring networks.

The CBMP will act as coordinator for this network of networks, supporting standardization of networks across the circumpolar Arctic, integrating information across networks, and providing value-added services in the areas of data management, communications, reporting, and decision-making tools (e.g., remote-sensing products).

The CBMP will work with partners to develop and promote measures for both biotic (e.g., species, humans, habitats) and abiotic (e.g. climate, contaminants, UV radiation) elements across the entire circumpolar Arctic, including expansion to new networks. Coordinating the network of networks includes research on understanding the impacts of ecosystem changes on humans - the societal-biota interface - thereby facilitating the development of effective mitigation and adaptation strategies for Arctic communities. See Figure 1

The network of networks recognizes the following:

- The importance of some species and species groups to the people and biodiversity of the Arctic;
- The importance of building on existing monitoring capacity, which is mostly organized by networks;
- Species-based monitoring is an established and effective method to be standardized across the circumpolar Arctic;
- The relative ease with which non-technical people understand species trends and their implications using this approach (compared to the ecosystem approach);
- The importance of building on the focused use of a multidisciplinary approach by some networks (e.g., Circumpolar Arctic Rangifer Monitoring and Assessment Network [CARMA]); and
- The importance of building on the strong links between scientific and community-based monitoring found in some networks (e.g., CARMA).

Species and Habitat-based Networks

The Arctic has a well-established history of monitoring through species and habitat based networks. A number of these are already active (e.g. seabird, caribou, goose, ITEX) and more than 40 are now partnered with the CBMP. The CBMP is already working with partners to identify and develop new network-based monitoring programs to fill gaps. IPY will provide support to both new and existing networks, including the Freshwater Biodiversity Network and the Arctic Char Monitoring and Research Network.

Site-based Networks

A number of research stations are currently active in the Arctic and more are planned, offering a cost-effective approach to developing integrated, site-based sampling.

Site-based monitoring (e.g., SCANNET), will assist in identifying important gaps, with the possibility of adding new sites to fill those gaps. Some existing research-station networks already employ consistent, repeatable, and standardized measures that span a large bio-geoclimatic gradient.

C. Indices and Indicators

Effective monitoring is the foundation of responsive decision making; however, unless the right information is reported in the right formats to the right audiences, the results of such monitoring are lost. That is why reporting is a cornerstone of the CBMP.

To facilitate effective reporting, the CBMP has chosen a suite of indices and indicators (Tables 2a and 2b) that provide a picture of the state of Arctic biodiversity. They were chosen through an expert consultation process to reflect existing monitoring capacity and expertise.

Criteria used to select the indicators included sensitivity to natural or anthropogenic drivers; understandability to a non-technical audience; scientific validity, relevance to diverse audiences (e.g., local communities, decision makers, global public); ecological relevance; sustainability of monitoring capacity; subjection to targets and thresholds; and practicality. The indices and indicators were also chosen to represent and incorporate information from all major Arctic biomes at various scales, all known Arctic pressures, all major trophic levels, all major Arctic biodiversity components (e.g., genes, species, habitat) including humans, and critical ecosystem services and functions — using both community- and science-based monitoring approaches.

D. Five-Year Work Plan

Building on the capacity of existing Arctic monitoring efforts and working in partnership with these networks, CAFF countries, and the Permanent Participants, the CBMP Secretariat will focus its efforts on the key areas outlined in Figure 2.

Figure 2: Key Areas of Activity

Activity	Description
Coordination	Coordinating and integrating biodiversity monitoring programs
	Developing a strategy for building and maintaining a comprehensive and cost-effective circumpolar monitoring program that addresses current deficiencies
	Linking Arctic monitoring efforts and outputs to global, national, regional, and local biodiversity-monitoring efforts and reporting
Establishment of Expert Groups	Creating five expert monitoring groups that represent the Arctic's major biomes: marine, coastal, freshwater, terrestrial vegetation, and terrestrial fauna
	Developing standardized measures and harmonized data protocols and encouraging the use of new technologies
Assessment of Current Capacity	Assessing current monitoring capacity to identify elemental, geographic, and statistical design strengths and deficiencies
	Interpreting, integrating, and communicating existing biodiversity information, including establishing statistical baselines and retrospective assessments
	Making recommendations
Data Management	Developing data management structures and a Web-based data portal for the dissemination, integration, analysis, and synthesis of biodiversity information
Capacity Building	Developing training modules to support the engagement of Arctic people in monitoring activities
	Partnering with research organizations to fill monitoring gaps and develop new protocols, where needed
Outreach and Education	Nurturing frequent and effective communication among and between experts and communities that are implementing biodiversity monitoring
	Developing and implementing an engagement strategy to nurture current CBMP partners and solicit new partners and funders
Pilot Projects	Experimenting with methodologies for filling monitoring gaps
	Identifying and initiating pilot monitoring projects, where clear gaps exist
	Supporting local monitoring initiatives and linking local monitoring to broader circumpolar networks
Reporting	Frequent, coordinated, and effective reporting on the status of Arctic biodiversity and the issues facing it, using diverse formats to reach diverse audiences
	Providing Arctic biodiversity information to global, national, regional, and local biodiversity monitoring and reporting efforts

Coordination

Canada is committed to leading the implementation of the CBMP for the short term. Coordination involves working closely with many partners: all Arctic countries through CAFF, other Arctic Council working groups (e.g., AMAP, SDWG), the Arctic Council Permanent Participants, partner organizations (e.g., UNEP-WCMC, UNEP/Global Resource Information Base-Arendal, World Conservation Union), and national monitoring programs and networks. It also involves ensuring that program objectives are met and that direct and regular communication is made with partners through meetings, workshops, and conference calls.

Establishment of Expert Monitoring Groups

Five expert monitoring groups representing the Arctic's major biomes—marine, coastal, freshwater, terrestrial vegetation, and terrestrial fauna—will be created to support the scientific and traditional knowledge input into monitoring. These EMGs will be responsible for designing and implementing on-the-ground monitoring in their area of expertise, identifying critical monitoring gaps, and developing strategies to fill gaps. Each EMG will be expected to make full use of existing monitoring, draw on expertise from both inside and outside the Arctic, incorporate both community- and science-based approaches, develop standardized protocols and analytical tools, and use existing and emerging technologies such as remote sensing and genetic barcoding, where appropriate.

Each EMG will be led by a CAFF country and composed of one or, some cases, several funded leads responsible for the overall coordination and development of the group. Terms of Reference will be drawn up to describe EMG responsibilities. The sponsoring country will convene a series of workshops involving the group's experts in order to develop monitoring plans and track progress toward implementation. Each group will include and engage community, scientific, and indigenous experts. They will not only work with existing research stations and monitoring networks to develop integrated, forward-looking monitoring programs but also focus efforts on the retrieval and use of existing historical information, be it traditional knowledge or archived scientific data.

The CBMP Secretariat will be responsible for the overall coordination of the EMGs, ensuring their connectivity, linkages, and compatibility. It will, in cooperation with the EMGs, provide progressive and state-of-the-art data management, assessment, outreach, and communication services. The integrated monitoring plans derived from these groups will be organized around the main pressures facing their particular systems and enable identification of the functional relationships between these systems and the forces driving them. The information from these integrated monitoring activities will not only inform the current CAFF indices and indicators (Tables 2a and 2b) but also provide additional assessments beyond their scope.

Assessment of Current Capacity

In order to serve as an early-warning system, an effective circumpolar biodiversity monitoring program must be able to perform the following functions:

- Detect significant trends in Arctic biodiversity within a reasonable time frame;
- Clearly identify mechanisms driving trends and distinguish them from natural fluctuations;
- Identify key species, populations, habitats, and ecosystems under threat;
- Identify emerging issues/stressors most likely to critically impact Arctic biodiversity;
- Inform predictive modeling in order to identify future scenarios;
- Inform appropriate and effective conservation, mitigation, and adaptation actions;
- Increase public knowledge concerning Arctic biodiversity issues and public support for conservation actions; and
- Build and maintain a cost-effective monitoring capacity (e.g. identify links and overlaps among programs, identify and fill gaps).

One of the first steps in building an effective pan-Arctic biodiversity monitoring program is to conduct a comprehensive assessment of current biodiversity monitoring capacity and existing data. This involves creating an inventory of existing programs and biodiversity trend information (e.g. historical data, traditional knowledge) in order to establish historical baselines and trends for key elements of Arctic biodiversity.

Compared to on-the-ground monitoring, the retrieval and analysis of existing biodiversity trend data can offer tremendous value at a lower cost. For example, Indigenous Peoples have inhabited Arctic regions for many millennia and, through their use of Arctic biodiversity for food and other purposes, have observed changes in plants, animals, and habitats and the relationships within and between Arctic ecosystems over time. This traditional knowledge, preserved through their oral history, represents a unique opportunity to establish historical baselines and trends.

The next step in evaluating current monitoring capacity across the Arctic is to conduct a technical gap analysis. This assesses the current elemental (i.e., biodiversity elements) and geographic coverage of Arctic biodiversity monitoring, design deficiencies and inefficiencies, and the ability to deliver on the bulleted functions described above. This analysis will inform all aspects of the program, from overall design (i.e., which indicators to track, where and at what spatial and temporal scales data collection should occur, opportunities for standardization, methods to ensure timely trend detection, appropriate benchmarks, the identification of causal mechanisms) to how the information can be integrated, analyzed, and communicated.

An inventory and analysis of the current monitoring capacity for different regions and biomes would include all types of Arctic biodiversity monitoring programs and would, ideally, be conducted by a lead country or international organization in close cooperation with the EMGs, CAFF countries, and Permanent Participants in order to ensure accuracy and objectivity. In cooperation with the EMGs, projects involving the acquisition, analysis, and interpretation of existing biodiversity trend information identified in the inventory will be initiated, where relevant. This information will, in many cases, allow for the establishment of historical baseline

conditions, thereby providing valuable and cost-effective assessments of the historical and current status of and trends in key elements of Arctic biodiversity.

Data Management

In collaboration with CAFF and UNEP-WCMC, the work proposed includes developing a Web-based data portal that accesses, integrates, analyzes, and displays biodiversity information from a multitude of stand-alone web servers. The portal will be the main entry point for the CBMP and will provide a common platform for all participating networks and EMGs. It will be accessed from multiple entry points, such as various species networks, and could become part of the Arctic Portal being developed by the Arctic Council.

The data portal will be hierarchical in structure, with all data geo-referenced to allow for analyses at various spatial, temporal, and taxonomic scales (e.g., populations, regions, nations, circumpolar, biomes, habitats). The portal will provide standards and schemas for sharing data; permit data integration, analyses, and correlation; and synthesize biodiversity data (response or dependent variables) and physical data (independent variables) to enable the exploration of relationships and the factors driving change.

The Web-based data portal will also generate suggested policy responses for conservation actions and will report on efforts by national and international bodies to conserve Arctic biodiversity. It will provide access to and the integration and communication of available trends in Arctic biodiversity and will be continually updated as new information becomes available. The management of this data will be in accordance with the data policy of the Conservation Commons and the IPY Data Policy. As such, international standards and procedures for data archiving and metadata documentation will be used in consultation with the IPY Data Information Service.

Capacity Building

The CBMP will foster capacity building for biodiversity monitoring. Priority capacity building can focus on Russia, where the amount of Arctic territory and biodiversity is significant and the needs are great. The Arctic also leads the world in developing and employing community-based monitoring approaches, thereby presenting the CBMP with an opportunity to draw from and fully employ this method alongside science-based approaches to develop a more complete understanding of Arctic biodiversity trends and their underlying causes. A number of programs are currently underway that use community-based approaches to understand changes in Arctic biodiversity (e.g., traditional knowledge in Snowchange Yakutia; and citizen-based science in PlantWatch North).

The CBMP will foster the further development and use of community-based approaches using two strategies. One will be to develop these approaches and capacities within the EMGs as equal partners with other science-based approaches; the other will be to work with existing community-based biodiversity-monitoring programs to further develop these approaches, integrate them with science-based approaches, and expand them to other areas of the Arctic.

In collaboration with its partners, the CBMP will perform the following roles:

- Identify existing community-based monitoring programs and gaps in coverage (as part of the inventory and analysis of current Arctic monitoring capacity);
- Develop and promote common monitoring protocols and specific indicators that can generate circumpolar-scale status and trends;
- Develop and promote regional programs and monitoring approaches in other areas (build cooperation and linkages);
- Promote coordination and integration of existing community-based monitoring programs; and
- Provide an avenue for communicating local and regional information on Arctic biodiversity trends to global audiences using multiple formats.

Pilot Projects

The CBMP will take a phased approach to filling gaps in monitoring as they are identified. Pilot projects will be encouraged to test new methodologies and engage both researchers and local communities in the development of new monitoring components.

Communications, Education and Outreach

One of the key challenges facing the CBMP is to make collected information relevant to decision making and helpful in adapting to the drastic changes taking place in the Arctic. As such, a comprehensive *CBMP Communications Strategy* has been developed that identifies the main audiences for biodiversity information in the Arctic and develops approaches to reach these audiences.

While scientists will benefit from the increased integration of monitoring information, it will be northern communities and decision makers who stand to gain the most from the CBMP. They will not only have access to the most relevant biodiversity information but also receive this information in a format tailored to their needs, which will be identified through consultation. The Web-based Arctic Portal will meet many of these needs by providing interactive maps and reports, however, it is also recognized that many communities will find printed products more helpful. Ultimately, the CBMP aims to reach a global audience. Changes in the Arctic are of growing international concern and are being watched as closely by educators and schools, as by members of the general public.

Reporting

The frequent release of products tailored to specific audiences will be a trademark of the CBMP. The CBMP will use the internet as a data management and reporting tool to the greatest extent technology will allow. Interactive mapping has already begun and will continue to be enhanced as data comes in from the networks. From the documentation of protocol details, to newsletters for non-technical audiences, the Program intends to ensure highly visible reporting on both progress toward implementation and program results. Reports will range from the timely release of indicators designed for local decision-making, to the provision of information for less frequent

reporting initiatives, such as national and circumpolar reports. An early client is anticipated to be the 2010 Arctic Biodiversity Assessment.

Anticipated Costs

While Arctic countries are already spending substantial amounts on biodiversity monitoring, very little is currently being invested in coordinating this monitoring and providing regular, integrated reporting. As a result, much of the collected information never reaches decision makers or the interested public and important links between data sets are never made. However, as Table 1 outlines, an additional investment of just 1.2 Million dollars annually could greatly increase the value of the data collected by addressing these gaps.

TABLE 1: CBMP KEY MILESTONES, DELIVERABLES AND RESOURCES (in thousands US $)

Milestone	Description of Activities and Deliverables	Start date	Completion date	Current Investment	Additional annual investment needed from CAFF countries
1. Fully staffed program **secretariat** coordinates monitoring networks	a. Hire **secretariat staff** and develop office infrastructure (2006/2007) b. Host **annual workshop** with all collaborating partners to integrate monitoring programs	2006	On-going	**Canada**: 2.5 Person Years + 200 K operational funds **US:** 27 K **WCMC**: 10 K	**2 additional staff** = 150 K - data management specialist -communications specialist: **Annual workshop** = 50K **Total required: 200 K**
2. Establishment of **Expert Monitoring Groups** (EMGs)	a. Establish Marine, Coastal, Freshwater, Terrestrial Vegetation and Terrestrial Fauna Groups (2007) b. Identify lead country for each group (2007) c. Workshops to develop integrated circumpolar monitoring plans (2007 to 2009) d. Implement integrated monitoring program	2007	2009	**Canada** – 50 K **U.S**. – 75 K **Iceland:** 9.5 K **Norway:** 9.5 K **Finland:** 9.5 K	**Each expert group requires lead country** and operational funds for workshops and coordination: **Total** from CAFF = 50 K per expert group x 5 = **250 K**

3. Establishment of **Data Management** system and web-based portal	a. Complete **data management strategy** b. **Pilot** projects c. Development of **web-based data portal** d. Operation and management of web-based data portal	2006 2006 2007 2009	2007 2009 2009 Ongoing	**UNEP WCMC**: 10K **Canada**: 10K **Microsoft Research Cambridge**: 25K	a. Data Mgmt. Strategy: 20 K b Pilot projects: 30 K c.Web portal: 50 K per year for 3 years d. 20 K per year ongoing **Total: 120 K per year**
4. **Gap analysis** of Current Monitoring Efforts and develop Arctic Biodiversity Monitoring Strategy	a. Conduct **inventory** of current, available Arctic biodiversity information and monitoring programs (2007) b. Establish **two post-doctoral positions (**one to investigate current elemental and geographic coverage of Arctic biodiversity monitoring; one to address sampling design issues) (2008) c. Conduct **strategic gap analysis** (2008 to 2009) d. Develop **comprehensive Arctic biodiversity monitoring strategy** to address gaps e. Address key monitoring gaps through pilot projects and additional monitoring	2007	2010	None	a. Contract for each country: 10K x 8 = 80K b. Two post-docs: 100K c. Strategic analysis: 60K d. Develop monitoring strategy: 60 K e. Pilot projects and additional monitoring (through external funds, not from CAFF countries): estimated at 1.5 Million dollars per year. **Total** 300 K over 3 years = **100 K per year**

5. Include data from **existing in-country monitoring programs** in CBMP information system		2008	On-going		Covered under Milestones 1, 3 and 5.
6. Establishment of **Community-based Monitoring Program**	a. Develop a Community-based Monitoring **Strategy** for the CBMP (2007) b. Add Community-based monitoring **modules** for expert monitoring workshops (2008)	2007	2008	Community Monitoring Workshop in 2006: 40 K	a. CBM Strategy: Contract 30 K b. Add modules: no cost **Total: 30 K**
7. Establishment of **statistical baselines**, using historic data, so current trends can be interpreted.	a. Utilize existing data to generate statistical baseline: Determine if an observed trend is significant or just part of normal variability? b. Contribute these assessments to the 2010 Arctic Biodiversity Assessment	2008	2009	None	Research historical baseline data: **Total: 80 K (10 k per country)**
8. **Outreach and Education**	a. Develop Website b. High profile News releases on eye catching stories c. Provide decision makers with key biodiversity information d. Quarterly newsletter production	2006 2007 2008 2007	2007 Ongoing Ongoing Ongoing	Canada: currently invests 10 K into a contract to develop strategy	a. c. and d: Hire Communications staff: (covered under milestone 1) b. Create public awareness through high

	and other regular, plain language communications products in a number of languages (2007 begin; ongoing) e. Interim Status and Trends reports – based on currently available analysis (2008)	2008	Ongoing		profile news releases and assessments: 1 per year @ 30K e. Interim report costs: 50K **Total: 80 K**
Totals:				**685.5 K**	Total funds required to coordinate all monitoring, communicate results and maximize efficiency: **1.2 Million US $ annually** External funds (not from CAFF countries) to address key monitoring gaps: 1.5 Million US $ annually.

TABLE 2: Arctic Biodiversity Indices and Indicators

The following tables outline the Arctic Biodiversity Indices and Indicators, the monitoring networks (both existing and in development) that underlie them and our current ability to report on them. This list is not exclusive as it is expected that the CBMP will be reporting on information, derived from the integrated monitoring plans, not captured in the current indicators and indices.

Table 2a: Summary of CBMP Indices and Indicators and relationship to Convention on Biological Diversity (CBD) Indicators and Indices

CBMP Indices and Indicators	Linkage with CBD Indicators (yes/no)
Species Composition	
Arctic Species Trend Index	√
Trends in Abundance of Key Species + Trends in other species parameters (e.g. distribution, productivity, survival, body condition, etc.)	√
Arctic Red List Index	√
Change in Status of Threatened Species *	√
Trends in Total Species Listed at Risk *	X
Ecosystem Structure	
Arctic Trophic Level Index	√
Water Quality Index	√

Habitat extent and change in quality	
Arctic Land Cover Change Index	X
Trends in Extent of Biomes, Habitats and Ecosystems	√
Arctic Habitat Fragmentation Index	X
Trends in Patch size distribution of Habitats	X
Fragmentation of River Systems	√
Extent of Seafloor Destruction	X
Ecosystem Functions & Services	
Trends in Extent, Frequency, Intensity and Distribution of Natural Disturbances	X
Trends in Phenology	X
Trends in Decomposition Rates	X
Human Health & Well-being	
Arctic Human Well-being Index	X
Trends in availability of biodiversity for traditional food and medicine	√
Trends in use of Traditional Knowledge in research, monitoring and management	X
Trends in incidence of pathogens and parasites in wildlife	X
Policy Responses	
Coverage of Protected Areas	√

Table 2b: Detailed chart on CBMP indices and indicators

***= indices closely related to the Convention on Biological Diversity indicators or a subset of the global indicator**
****= index suggested for inclusion in the Millenium Development Goals**

THEME	INDEX	INDICATOR	ELEMENTS	SUB-ELEMENTS	NETWORK LEADS	CURRENT MONITORING AND REPORTING CAPACITY
Species Composition	Arctic Species Trend Index*	Trends in Abundance of Key Species + Trends in other species parameters (e.g. distribution, productivity, survival, body condition, etc.)	Terrestrial Fauna	Wild *Rangifer (Caribou/Reindeer)*	CARMA	Yes
				Invasive Species	NatureServe International	Partial (incomplete geographic coverage)
				Invertebrates	None	No
				Landbirds	US Fish and Wildlife Service, Canadian Wildlife Service, etc.	Partial (incomplete geographic coverage and statistical deficiencies)
				Predators (e.g. foxes, wolves, lynx, snowy owls, eagles, etc.)	Russian Wildlife Census Service and other national and regional census organizations	Partial (incomplete geographic coverage and statistical deficiencies)
				Brown Bears	Northern Forum Brown Bear Network	Partial (incomplete geographic coverage)

THEME	INDEX	INDICATOR	ELEMENTS	SUB-ELEMENTS	NETWORK LEADS	CURRENT MONITORING AND REPORTING CAPACITY
				Lemmings	Moscow State University; University of Helsinki	Partial (incomplete geographic coverage)
			Societal	Human Populations	National Census Organizations	Yes
			Marine	Commercial Species (e.g. Cod, flatfish, Pollock, salmon)	ICES, FAO, NOAA, University of British Columbia	Partial (incomplete geographic coverage)
				Invertebrates (e.g. benthos, phytoplankton, zooplankton)	Census of Marine Life	Partial (incomplete geographic coverage and statistical deficiencies)
				Polar Bears	IUCN Polar Bear Specialist Group	Partial (incomplete geographic coverage)
				Ringed Seals	US Marine Mammal Commission	Partial (incomplete geographic coverage)
				Whales	US Marine Mammal Commission	Partial (incomplete geographic coverage and statistical deficiencies)

THEME	INDEX	INDICATOR	ELEMENTS	SUB-ELEMENTS	NETWORK LEADS	CURRENT MONITORING AND REPORTING CAPACITY
			Coastal	Seabirds	Circumpolar Seabird Group	Yes
				Invasives	Census of Marine Life	Partial (incomplete geographic coverage and design deficiencies)
			Aquatic = Freshwater Overlap with terrestrial	Waterbirds	Wetlands International and IUCN Goose Specialist Group	Yes
				Arctic Char	Char Network	In Development
				Invertebrates	Freshwater Biodiversity Network	In Development
				Invasives	NatureServe International	Partial (incomplete geographic coverage and design deficiencies)
	Arctic Red List Index**	Change in Status of Threatened Species	Biomes (Marine, Terrestrial, Aquatic)		IUCN in collaboration with EMGs	Yes
			Species Groupings (e.g. mammals, birds, etc.)		Marine Mammal Commission, BirdLife International	Yes

THEME	INDEX	INDICATOR	ELEMENTS	SUB-ELEMENTS	NETWORK LEADS	CURRENT MONITORING AND REPORTING CAPACITY
		Trends in Total Species Listed at Risk	Biomes (Marine, Terrestrial, Aquatic)		IUCN	Yes
			Species Groupings (eg.mammals birds, etc.)		IUCN	Yes
Ecosystem Structure	Arctic Trophic Level Index*		Biomes (Marine, Terrestrial, Aquatic)		University of British Columbia, UNEP – WCMC	Partial (Marine – incomplete geographic coverage; Aquatic and Terrestrial – No current capacity)
	Water Quality Index*		Aquatic		UNEP GEMS Water, Canada	Yes
Habitat Extent	Arctic Land Cover Change Index	Trends in Extent of Biomes, Habitats and Ecosystems	Terrestrial	Tundra, Forest, Glaciers, Shrubs, Snow Cover	CAFF Flora Group, FAO	Partial (incomplete coverage of sub-elements)
			Aquatic		University of Alaska Fairbanks	Partial (incomplete coverage (Siberia and Alaska only)
			Marine	Sea Ice, Plankton Distribution, Corals	Various Universities and National Ice Services	Yes

THEME	INDEX	INDICATOR	ELEMENTS	SUB-ELEMENTS	NETWORK LEADS	CURRENT MONITORING AND REPORTING CAPACITY
Habitat Quality	Arctic Habitat Fragmentation Index	Trends in Patch size distribution of Habitats	Terrestrial		GLOBIO and Universities	Partial (incomplete coverage)
				Human Footprint (Urban, Agriculture, Roads, Seismic, other)	UNEP GRIDA (GLOBIO)	Partial (incomplete coverage)
		Fragmentation of River Systems	Aquatic		CAFF countries	Yes
		Extent of Seafloor Destruction	Marine			No
Ecosystem Function & Services		Trends in Extent, Frequency, Intensity and Distribution of Natural and Human induced Disturbances	Terrestrial Flora/Veg.	Forest and Tundra Fires	CAFF countries	Yes
				Forest Insect Outbreaks	CAFF countries	Yes
				Vegetation Disease Outbreaks	CAFF countries	Yes
		Trends in Phenology	Terrestrial Flora/Veg.	Plants	ITEX, GLORIA	Yes
			All Biomes	Migration Timing	Various	Partial (incomplete coverage)
		Trends in Decomposition Rates	Terrestrial Flora/Veg.	Tundra	ITEX, GLORIA	Yes
				Forest		
Human Health& Well-being	Arctic Human Well-being Index	Trends in availability of biodiversity for traditional food and medicine	Societal		SLICA?	Partial (incomplete coverage)
		Trends in use of Traditional Knowledge in research, monitoring and management				No
		Trends in incidence of pathogens and parasites in wildlife			CARMA, CHAR	In development

THEME	INDEX	INDICATOR	ELEMENTS	SUB-ELEMENTS	NETWORK LEADS	CURRENT MONITORING AND REPORTING CAPACITY
		Change in Status of Threatened Species	Biomes (Marine, Terrestrial, Aquatic)		IUCN in collaboration with EMGs	Yes
Policy Responses	Arctic Red List Index**	Coverage of Protected Areas	Societal	Coverage according to IUCN categories	UNEP-WCMC	Yes
				Overlays with areas of key importance (biodiversity hotspots)	UNEP-WCMC	No
			Biomes (marine, terrestrial, aquatic)		UNEP-WCMC	No
					UNEP-WCMC	Yes
		Change in Status of Threatened Species	Biomes (Marine, Terrestrial, Aquatic)		IUCN in collaboration with EMGs	Yes

Appendix 1: ACIA Follow-up:

Arctic Climate Impact Assessment Key Findings and Recommendations Addressed, Fully or in Part, by the CBMP

ACIA 10 Key Findings:

Finding 1:
Arctic climate is now warming rapidly and much larger changes are projected

Finding 2:
Arctic warming and its consequences have worldwide implications

Finding 3:
Arctic vegetation zones are very likely to shift, causing wide-ranging impacts

Finding 4:
Animal species' diversity, ranges, and distribution will change

Finding 5:
Many coastal communities and facilities face increasing exposure to storms

Finding 6:
Reduced sea ice is very likely to increase marine transport and access to resources

Finding 7:
Thawing ground will disrupt transportation, buildings, and other infrastructure

Finding 8:
Indigenous communities are facing major economic and cultural impacts

Finding 9:
Elevated ultraviolet radiation levels will affect people, plants, and animals

Finding 10:
Multiple influences interact to cause impacts to people and ecosystems

Chapter by Chapter Analysis

Although the CBMP is clearly focused on tracking the status and trends of Arctic biodiversity, it will, to a large extent, be accounting for and tracking impacts to biodiversity derived from climate change, thereby fulfilling, fully or in part, some of the recommendations made by the Arctic Climate Impact Assessment. The following lists the ACIA recommendations partially or fully relevant to the CBMP and provides a short explanation as to how the CBMP might address them.

Chapter 2

ACIA Recommendation: As the Arctic is a region of large natural variability and regional differences, more uniform coverage must be obtained to clarify past changes. In order for the quantitative detection of change to be more specific in the future, it is essential that steps be taken now to fill in observational gaps across the Arctic, including the oceans, land, ice and atmosphere.

CBMP's Role: The CBMP is mandated with improving the coverage and frequency of long-term biodiversity monitoring across the Arctic, in all biomes. It will also compile and synthesize existing information involving not only biodiversity variables, but also physical variables such as sea-ice extent.

Chapter 3

ACIA Recommendation: For some areas, such as the central and eastern Russian Arctic, few or no current records of indigenous observations are available. To detect and interpret climate change, and to determine appropriate response strategies, more research is clearly needed.

CBMP's Role: Community-based monitoring techniques will be employed by the CBMP to track the status and trends of Arctic biodiversity and understand the mechanisms driving this change, such as those from human-induced climate change. The CBMP's approach will likely be through several regional partnership programs, new or existing, that utilize indigenous observations on changes, specific to Arctic biodiversity.

ACIA Recommendation: In Eurasia and Greenland, little systematic work on indigenous knowledge has been done, and research in these regions is clearly needed. Indigenous observation networks have been set up in Chukotka, Russia, and some projects have taken place in Alaska, but little systematic work has been done to set up, maintain, and make use of the results from such efforts.

CBMP's Role: Systematic long-term community-based biodiversity monitoring programs that involve indigenous observations are expected to developed in different parts of the Arctic such as in parts of Eurasia, where feasible.

ACIA Recommendation: Problems to be tackled: determining how indigenous knowledge can best be incorporated into scientific systems of knowledge acquisition and interpretation; and; finding ways to involve indigenous communities in scientific research and to communicate scientific findings to indigenous communities.

CBMP's Role: Through the CBMP's development of pilot community-based biodiversity monitoring programs, the program will be exploring ways for involving, utilizing and synthesizing information regarding that the status and trends of Arctic biodiversity derived from scientific, indigenous and citizen science based approaches.

Chapter 6

ACIA Recommendation: A climatology of the spatial distribution of snow-water-equivalent in each month is a critical need for model validation and hydrological simiulations; this is especially urgent in high latitudes.

CBMP's Role: The CBMP has applied for funding through IPY Canada to collect, ground-truth, and interpret snow-water-equivalent data derived from satellite observations for parts of Northern Canada.

Chapter 7

ACIA Recommendation: There is also a need to identify and monitor currently widespread species that are likely to decline under climate change, and to redefine conservation and protection in the context of climate and UV radiation change.

CBMP's Role: The CBMP will be monitoring a number of Arctic species, some of which are likely to decline under climate change.

ACIA Recommendation: The dominant response of current Arctic species to climate change is very likely to be relocation rather than adaptation. Relocation possibilities are very likely to vary according to region and geographic barriers. Some changes are already occurring. However, knowledge of rates of relocation, impact of geographic barriers, and current changes is poor. There is a need to measure and project rates of species migration by combining paleo-ecological information with observations from indigenous knowledge, environmental and biodiversity monitoring, and experimental manipulations of environment and species.

CBMP's Role: The CBMP will be monitoring, over time, the distribution of a number of biodiversity elements, such as the distribution and extent of Arctic species and biomes.

ACIA Recommendation: Long-term environmental and biological monitoring are becoming increasingly necessary to detect change, to validate model projections and results from experiments, and to substantiate measurements made from remote sensing. Present monitoring programs and initiatives are too scarce and are scattered randomly. Data from the Arctic are often not based on organized monitoring schemes, are

geographically biased, and are not long-term enough to detect changes in species ranges, natural habitats, animal population cycles, vegetation distribution, and carbon balance. More networks of standardized, long-term monitoring sites are required to better represent environmental and ecosystem variability in the Arctic and particularly sensitive habitats. Because there are interactions among many co-varying environmental variables, monitoring programs should be integrated. Observatories should have the ability to facilitate campaigns to validate output from models or ground-truth observations from remote sensing. There should be collaboration with indigenous and other local peoples' monitoring networks where relevant. It would be advantageous to create a decentralized and distributed, ideally web-based, meta-database from the monitoring and campaign results, including relevant indigenous knowledge.

CBMP's role: The CBMP will be integrating and standardizing information from current monitoring programs using a decentralized, distributed web-based data portal and will be filling gaps in geographic, temporal and elemental biodiversity monitoring coverage as resources become available. The approach taken will utilize both remote sensing information as well as community-based monitoring techniques involving indigenous observations.

ACIA Recommendation: Monitoring requires institutions, not necessarily sited in the Arctic, to process remotely sensed data. Much information from satellite and aerial photographs exists already on vegetation change, such as treeline displacement, and on disturbances such as reindeer/caribou overgrazing and insect outbreaks. However, relatively little of this information has been extracted and analyzed.

CBMP's Role: With a circumpolar perspective, the CBMP will be implementing some remote sensing pilot projects that utilize remotely sensed data to determine the status and trends in the distribution of various Arctic biomes as well as the extent of human impact on these biomes.

Chapter 8

ACIA Recommendation: Integrated circumpolar monitoring of freshwaters – key scientific gaps: the limited records of long-term changes in physical, chemical and biological attributes throughout the Arctic; differences in the circumpolar availability of biophysical and ecological data (e.g., extremely limited information about habitat requirements of Arctic species); a lack of circumpolar integration of existing data from various countries and disparate programs; a general lack of integrated, comprehensive monitoring and research programs, at regional, national, and especially circumpolar scales; a lack of standardized and networked international approaches for monitoring and research.

CBMP's Role: The CBMP's mandate includes Arctic freshwater systems where they pertain to the monitoring of biodiversity. Through partnerships with existing monitoring programs, the CBMP will assist in building capacity and coverage for long-term

monitoring of Arctic freshwater biodiversity and will assist in the standardization, compilation, analysis, synthesis and reporting of status and trends information.

Chapter 9

ACIA Recommendation: The existing monitoring programs should be continued and expanded (high priority), both spatially and in breadth of measurement. New monitoring activities should be established in areas where they are presently lacking and these should be designed to address the effects of climate change. Issues to be addressed include the timing and amount of primary and secondary production, larval fish community composition, and reproductive success in marine mammals and seabirds. Key ecosystem components, including non-commercial species, must be included.

CBMP's Role: The CBMP is working with its marine biodiversity monitoring partners to develop monitoring strategies and build capacity and coverage of current monitoring and assist with standardization, compilation, analysis, synthesis and reporting of marine biodiversity status and trends information.

ACIA Recommendation: An Arctic database should be established that contains all available physical and biological data.

CBMP's Role: The CBMP is currently developing a web-based data portal that will access distributed databases, including ones containing marine biodiversity monitoring data, for the compilation, analysis and synthesis of biological information to determine status and trends.

ACIA Recommendation: Past physical and biological data from the Arctic should be recovered. There are many data that are not presently available but could be recovered.

CBMP's Role: If resources became available, the CBMP could assist with the recovery of archived biodiversity monitoring data that is not currently accessible.

Chapter 10

ACIA Recommendation: There are many areas of Arctic taxonomy that require exploration and research; it is vital to the conservation of the Arctic's biodiversity that these taxonomic subjects are addressed.

CBMP's Role: Many of the CBMP's partner species networks are putting resources towards taxonomic classification of Arctic species.

ACIA Recommendation: Monitoring is important for understanding how the Arctic's biodiversity is changing and whether actions to conserve biodiversity are being successful; monitoring needs to occur at both the system level and the species level.

CBMP's Role: The CBMP's mandate is to coordinate monitoring of Arctic biodiversity including the tracking of the effectiveness of conservation efforts and the monitoring of species and systems.

ACIA Recommendation: There needs to be a supply of trained ecologists who can devise appropriate circum-Arctic classifications of habitats and then survey them so as to measure their extent and quality and to establish their dynamics.

CBMP's Role: Through collaborations with its partner monitoring networks, the CBMP will be developing a Circumpolar Boreal Vegetation Map, involving standardized habitat classifications and acting as a baseline for future monitoring of the trends in extent and quality of these habitats.

ACIA Recommendation: Inventories need to be generated for the Arctic's biodiversity (both species and habitats), indicating for each entry in the inventory where it occurs and either the size of the overall species population or the extent of the habitat. Such inventories need to be on a circum-Arctic basis rather than on a national basis as nations with Arctic territory also have territory south of the Arctic.

CBMP's Role: While the CBMP is not directly developing inventories, its partners will, in many cases, be the holders of information such as species populations and extent of habitats that will be accessible, in most instances, through the CBMP's web-based data portal.

ACIA Recommendation: The genetic diversity of many of the Arctic's species is presently poorly known or unknown. Much research is needed to explore this aspect of the Arctic's biodiversity and conservation management will need to ensure that genetic diversity is not lost.

CBMP's Role: Through its partner monitoring networks, many aspects of genetic diversity of Arctic species are being researched (e.g. Arctic Char).

ACIA Recommendation: Models need to be further developed to explore changes in biodiversity under the various scenarios of climate change. These models will need to explore biodiversity change in the sea, in freshwater, and on land.

CBMP's Role: Biodiversity monitoring information managed by the CBMP will contribute to model development through the comparisons of regional differences in climate change impacts and the response of biodiversity to these impacts.

ACIA Recommendation: Circum-Arctic monitoring networks need to be fully implemented throughout the Arctic. Data on the state of the Arctic's biodiversity, on the drivers of change in that biodiversity, and on the effectiveness of responses to those changes, need to be collected, analyzed, and used in the development of future Arctic biodiversity policy.

CBMP's Role: The CBMP will directly address all of these recommendations.

ACIA Recommendation: Attention needs to be given to establishing the kinds of subsidiary aspects of monitoring, such as integrated monitoring and monitoring of phenology, genetic diversity, and invertebrate fauna. These are vital if a holistic view is to be taken of the Arctic's biodiversity, its conservation in the face of a changing climate, and the management of the biodiversity resource for future generations of people to use and enjoy.

CBMP's Role: The CBMP's biodiversity indicators include phenology and the monitoring of some invertebrate fauna.

ACIA Recommendation: A suite of indicators needs to be devised and agreed, monitoring for them undertaken, and the results made publicly available in a format (or formats) so as to inform public opinion, educators, decision-makers, and policy-makers.

CBMP's Role: The CBMP has a draft list of biodiversity indicators for circumpolar monitoring. The resulting status and trends information from these indicators will be reported on regularly in a diversity of formats to reach the wider public as well as decision and policy makers.

ACIA Recommendation: Best practice guidelines need to be prepared for managing all aspects of the Arctic's biodiversity. These need to be prepared on a circumpolar basis and with the involvement of all interested parties.

CBMP's Role: While not directly focusing on best management practices, the CBMP's biodiversity information will aid industry and governments in the development of best practices as the CBMP will not only track changes in biodiversity but investigate the causal mechanisms driving those changes, thereby informing best management practices.

ACIA Recommendation: Integrated forms of management, incorporating the requirement for biodiversity conservation, need to be explored for all uses of the land, freshwater, and sea in the Arctic.

CBMP's Role: The CBMP will produce policy recommendations based upon the status and trends it produces, especially where information regarding the mechanisms driving biodiversity change is available. This information could be used to develop integrated management approaches for the conservation of biodiversity.

ACIA Recommendation: Biodiversity conservation needs to be incorporated into all policy development, whether regional, national, or circumpolar.

CBMP's Role: The CBMP will produce policy recommendations for biodiversity conservation based upon the results produced through its circumpolar monitoring.

ACIA Recommendation: All nations with Arctic territory should be working toward full implementation of the Convention on Biological Diversity, coordinating their work on a circumpolar basis, and reporting both individually and jointly to the regular Conferences of the Parties.

CBMP's Role: The CBMP has adopted many of the CBD biodiversity indicators, when relevant to the Arctic. These indicators will allow the entire Arctic region to be able to report on progress made towards the 2010 CBD target.

Chapter 11

ACIA Recommendation: Achieving effective conservation and management of wildlife in a changing Arctic will require a team-building approach among governments at all levels that relate to the environment and human well-being, and with all other groups with an interest in the Arctic. This effort should include the indigenous peoples and other residents of the Arctic, and scientists undertaking research in the Arctic, representatives of industry and business seeking development of Arctic resources or other economic opportunities in the Arctic, those who travel to the Arctic for recreation or tourism, and the non-governmental organizations seeking to protect or sustain environmental, aesthetic, and other less tangible values of the Arctic in the broader interest of society. The successful management and conservation of Arctic wildlife requires that these groups be represented in the management process and that adequate information is available for equitable consideration of the diverse interests that relate to Arctic wildlife. The role of international, non-governmental environmental organizations is particularly important in maintaining focus of the public on the broad spectrum of environmental values existing in the Arctic when proposals for large-scale industry- or government-sponsored projects become politicized at the regional or national levels.

CBMP's Role: The CBMP represents a multiple partner (governments, NGO's, indigenous people's, northern communities, industry, etc.), holistic approach to the monitoring and conservation of Arctic biodiversity. It strives to bring together diverse partners towards the common goal of conserving Arctic biodiversity in order to ensure human well-being both inside and outside the Arctic.

Chapter 13

ACIA Recommendation: Present monitoring of the physical and biological marine environment must be continued and in many cases increased. Basic research is a prerequisite for understanding biological processes. Modern technology enables the automation of many of the time-consuming tasks previously conducted from expensive research vessels, e.g., buoys can now be deployed in strategic locations on land and at sea for continuous measurement of many variables required in marine biological studies. The monitoring of commercial stocks must also continue, applying new technologies as these become available. There is a general shortage of ship time for sea-based work. Administrators or governments are often unaware of this, also that despite computers

enabling more extensive and deeper analyses of existing datasets, people are still required to operate and program the computers.

CBMP's Role: The CBMP will be working with its marine biodiversity monitoring partners towards the goal of continuing and increasing the effectiveness of current Arctic marine biodiversity monitoring efforts.

Chapter 14

ACIA Recommendation: Forest advance into tundra has the potential to generate a large positive temperature feedback. Unfortunately, the understanding of change at this crucial ecological boundary comes from a small number of widely separated studies undertaken to achieve many different objectives. A coordinated, circumpolar treeline study and monitoring initiative will be necessary to address definitively the question of how and why this boundary is changing at the scale required to address its potential global importance.

CBMP's Role: The CBMP, while not planning on directly monitoring treeline position, will be monitoring the distribution and extent of various terrestrial Arctic biomes. This information may be able to contribute, over time, to a greater understanding of the impacts of an advancing treeline on climate, but it may not be at an appropriate temporal scale for climate modelling.

Chapter 15

ACIA Recommendation: There is a need for a carefully planned strategy, at the community and regional level, to monitor and document environmental change. Arctic Council members and program workgroups should provide technical assistance regarding monitoring strategies, climate impact mitigation and pilot studies, data analysis, and evaluation.

CBMP's role: The CBMP is developing a biodiversity monitoring strategy based on a set of indicators and including community-based and regional approaches.

ACIA Recommendation: There are few data on climate change impact on regional biota. A critical need exists for the monitoring of wildlife diseases, and human–wildlife disease interaction. There are few data on climate-induced changes in the diet of subsistence species, which affects their nutritional value in traditional diets. Arctic Council programs have the expertise to design effective regional and international monitoring programs in cooperation with communities. This critical activity should be given a high priority.

CBMP's Role: The CBMP, in collaboration with its partner species monitoring networks, is developing a set of biodiversity indicators for long-term monitoring, that includes monitoring the presence and distribution of such impacts on wildlife as disease.

Chapter 18

ACIA Recommendation: Regional impacts: The ACIA mostly addressed impacts at the large-scale circumpolar level. The attempt to differentiate between impacts within the four ACIA regions was exploratory and did not cover these regions in depth. There is a need to focus future assessments on smaller regions (perhaps at the landscape level) where an assessment of impacts of climate change has the greatest relevance and use for residents in the region and their activities.

CBMP's Role: The CBMP, in some cases, may be able to shed light on the impacts of climate change on biodiversity at the regional level, where regionally specific programs are implemented and data rigour allows for such an analysis.

ACIA Recommendation: Observations and process studies: To improve future climate impact assessments, many Arctic processes require further study, both through scientific investigations and more detailed systematic documentation of indigenous knowledge. Priorities include collection of data ranging from satellite, surface, and paleo data on the climate and physical environment, to rates and ranges of change in Arctic biota, and to the health status of Arctic people.

CBMP's Role: The CBMP's biodiversity indicators include the distribution and extent of Arctic biota.