CAFF
Conservation of Arctic Flora and Fauna

CIRCUMPOLAR BIODIVERSITY MONITORING PROGRAM

CAFF CBMP Report No. 12
March 2008

A STRATEGY FOR DEVELOPING INDICES AND INDICATORS TO TRACK STATUS AND TRENDS IN ARCTIC BIODIVERSITY

Acknowledgements

CAFF Designated Agencies:

- Environment Canada, Ottawa, Canada
- Finnish Ministry of the Environment, Helsinki, Finland
- Ministry of the Environment and Nature, Greenland Homerule, Greenland (Kingdom of Denmark)
- Faroese Museum of Natural History, Tórshavn, Faroe Islands (Kingdom of Denmark)
- Icelandic Institute of Natural History, Reykjavik, Iceland
- Directorate for Nature Management, Trondheim, Norway
- 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

This publication should be cited as: Gill, M.J. and Zöckler, C. 2008. *A Strategy for Developing Indices and Indicators to Track Status and Trends in Arctic Biodiversity*. CAFF CBMP Report No. 12, CAFF International Secretariat, Akureyri, Iceland.

Cover photo (Carsten Egevang/ARC-PIC.COM): The glacier of Eqi, Vest Greenland, 2002. Photos of fish by Jim Reist, Fisheries and Oceans Canada. All other Photography by: Carsten Egevang/ARC-PIC.COM.

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A Strategy for Developing Indices and Indicators to Track Status and Trends in Arctic Biodiversity

A Supporting Publication to the
Circumpolar Biodiversity Monitoring Program
Framework Document

Prepared by Michael Gill and Christoph Zöckler

CAFF CBMP Report No. 12
March 2008

The authors would like to thank the following individuals for their invaluable contributions to the development of this strategy (listed in alphabetical order):

Dave Atkinson, Donald Baird, Stanislav Belikov, Reid Brewer, John Calder, Terry Callaghan, Matt Carlson, Ian Church, Dave Daum, Tony DeGange, Cindy Dickson, Bob van Dijken, Alexey Drovdoz, Joan Eamer, Craig Fleener, Rose Fosdick, Victoria Gofman, Maria Victoria Gunnarsdottir, Ivan Gutorov, Ward Hagejmeijer, David Henry, Greg Henry, Reidar Hindrum, Janet Hohn, Michelle Holm, Karin Holser, Russ Hopcroft, Thomas Hourigan, Katrin Ikens; David Irons, Bernt Johansen, Ingibjorg Jonsdottir, Naomi Kashevarof, Helmut Kruckenburg, John Kudlak, Patrick Kuss, Karen Laing, Ulla-Maija Liukko, Maarten Loonen, Igor Lysenko, Vera Kingeekuk-Metcalf, John Morton, Karen Murphy, Kaisu Mustonen, John Nick, Natalie Novik, Peggy Osterback, Aevar Petersen, Frank Pokiak, Tim Ragen, Martin Raillard, James Reist, Don Russell, Russell Shearer, Mike Simpkins, Mikhail Soloviev, Risa Smith, Steve Talbot, Ken Taylor, David Thomas, Mikhail Todyshev, Michael Usher, Tatiana Vlassova; Dag Vongraven, Skip Walker, Mike Walton, Phil Wookey, Bruce Wright, Fred Wrona, Phil Zavadil, Eduard Zdor, Maureen de Zeeuw, and Gennady Zelensky.

Your advice and guidance vastly improved the quality and comprehensiveness of the suite of biodiversity indices and indicators.

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1. Introduction

1.1 Background

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 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 initiatives such as the Arctic Monitoring and Assessment Programme (AMAP), Sustaining Arctic Observing Networks Initiative (SAON), International Polar Year (IPY), the Arctic Biodiversity Assessment (ABA) and the Convention on Biological Diversity (CBD), thereby ensuring effective coordination and integration with related Arctic and global initiatives.

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 better detect significant trends within a reasonable time frame, identify the causes driving these trends, and report on them effectively. The resulting information will be made accessible in diverse formats in order to influence policy and engage diverse audiences, such as northern communities, scientists, governments, and the global community.

1.2 The Challenge: Consolidating, Integrating, and Delivering Arctic Biodiversity Information

Information on Arctic biodiversity, human stressors, and natural changes is widely scattered among scientists, government institutions, and northern communities and available only in a piecemeal fashion. An integrated picture of the status of and trends in key species, habitats, processes, services and ecosystem integrity in the Arctic and along relevant migratory routes is not fully known. Although numerous monitoring efforts are currently underway, a lack of coordination, long-term commitment, integration, and local community

involvement has resulted in weak linkages between monitoring information and decision making and a limited ability to detect and understand change. A more effective way of communicating results so that they tie directly to the policy making process is urgently needed in order to successfully manage and conserve Arctic biodiversity and adapt to inevitable changes.

1.3 Purpose of the Biodiversity Indices and Indicators

Communicating the results of monitoring activities to target audiences ensures the longevity and maximum impact of monitoring data. However, unless the right information is reported in the right formats to the right audiences, the results of such monitoring are lost. As such, targeted and consistent reporting is a cornerstone of the CBMP and its activities.

To facilitate targeted and consistent reporting, the CBMP has chosen a suite of indices and indicators that provide a comprehensive picture of Arctic biodiversity, from species and habitats to ecosystem processes and ecological services. The suite of indices and indicators can be used to report on the current state of Arctic biodiversity at various scales and levels of detail. They reflect biodiversity components and services that are globally significant, critical to the functioning and resiliency of Arctic ecosystems, and of vital importance to the subsistence and economies of northern communities. The indices and indicators further reflect current monitoring capacity, areas of expertise, and available data – with existing and anticipated CBMP biodiversity monitoring providing the foundation.

Currently, global processes for reporting on the status and trends of biodiversity (i.e. CBD) focus mostly on temperate and tropical regions, with less emphasis on the Arctic. CAFF is well positioned to play a central role in reporting on the status of Arctic biodiversity to policy makers and the public on the global stage. The CBMP's indicators and indices will ensure that the most current information pertaining to Arctic biodiversity are highlighted in international efforts to track and communicate the status and trends surrounding global biodiversity. Most importantly, the indicators and indices will help clarify and initiate the policy and management actions that may be required to protect Arctic biodiversity.

The CBMP indicators and indices are designed to serve multiple purposes, including facilitating the reporting of the Arctic's progress towards the CBD's 2010 target to reduce the rate of loss of biodiversity. The CBMP indicators and indices will also form the foundation of the first phase of the Arctic Biodiversity Assessment (ABA) scheduled for completion in 2010. Once developed, the indicators and indices will be continually updated in order to track key trends in Arctic biodiversity.

The CBMP indicators and indices are also specifically designed to meet the information needs of decision and policy makers in local communities and regional and national government agencies. The hierarchical nature of the indices and indicators allows for users to "drill down" to specific regions, habitats, populations and sub-populations (where supporting data exists). It is anticipated that this more detailed information will be of greater assistance to local and regional decision making and the identification of significant trends that require a coordinated response.

The following strategy provides background on the approach taken in selecting the key biodiversity indicators, outlines the review process, highlights the indicators and indices chosen, and charts a course of action to develop these indicators and indices as the main reporting output of the CBMP.

2. Selecting the Indicators and Indices

One of the first steps towards implementation of the CBMP was to identify the key indicators that could provide an accurate picture of the overall status and trends around Arctic biodiversity. Four international workshops were held in 2005 and one in 2006 to discuss implementation of the CBMP. At these workshops, participants defined the process for selecting indicators and provided input with respect to potential indices and indicators.

2.1 Sources and Supporting Initiatives

Current efforts towards full implementation of the CBMP are both based and dependent upon a host of past and present initiatives to develop circumpolar and international biodiversity monitoring programs.

The origins of the CBMP predate its official endorsement by the Arctic Council Ministers in 2002. In February 2000, a workshop was held in Reykjavik, Iceland to discuss the development of a circumpolar biodiversity monitoring program. Experts from all of the circumpolar countries (Canada, Finland, Denmark/Greenland, Iceland, Norway, Russia, Sweden and the United States), as well as from the United Kingdom and the Russian Association of Indigenous Peoples of the North gathered to discuss circumpolar monitoring needs with a focus on identifying key biotic elements of Arctic environments that could serve as indicators for a full-fledged circumpolar biodiversity monitoring network. This important work has contributed to the selection of key indicators for the CBMP.

The initial selection process for the indicators and indices further drew from other relevant international initiatives such as the CBD's Global Indicators, Convention on Migratory Species, and ACIA findings. Arctic species monitoring networks (e.g., Rangifers, shorebirds, ITEX, etc.) and experts from other scientific and indigenous organizations were also consulted in the selection of the key biodiversity indicators.

2.2 Key Drivers Influencing Arctic Biodiversity

The CBMP has developed in response to widespread concern over current and future anticipated impacts of human-induced drivers (stressors) on Arctic biodiversity. Consequently, the key drivers influencing circumpolar biodiversity needed to be identified, understood, and considered in choosing indicators to track the status and trends of Arctic biodiversity. In other words, the biodiversity indicators should highlight and respond to these key drivers. At the same time, the suite of indices and indicators along with the research and monitoring programs underpinning them must be comprehensive and flexible enough to respond to emerging pressures.

The CBMP Framework Document (Petersen et al. 2004) identified the key drivers influencing the Arctic system, as follows:

1. Climate change;
2. Pollution (including contaminants);
3. Habitat fragmentation;
4. Over-harvesting of marine and terrestrial species;
5. Regional and economic development; and,
6. Invasive species.

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2.3 Selection Criteria

A discrete set of criteria was needed to ensure that the selection process for the CBMP's key indicators and indices was consistent and transparent. The criteria further needed to reflect the need to ensure that the entire suite of biodiversity indicators and indices provide comprehensive thematic, elemental and geographic coverage highlighting a range of circumpolar issues, habitats, processes, services and species.

Criteria were developed for both indicators and indices and were adapted from criteria outlined in the CBMP Framework Document (Petersen et al. 2004), and the CAFF/AMAP Workshop on a Circumpolar Biodiversity Monitoring Program (CAFF/AMAP 2000).

2.3.1 Indicator Criteria

The criteria developed for the selection of biodiversity indicators for the CBMP include the following:

- Scientifically valid (i.e., rigorous methodology and the ability to detect change);
- Easily understandable and therefore, easily communicated;
- Responsive to change (i.e., key Arctic drivers);
- Relevant to:
  - The circumpolar region;
  - CAFF's mandate;
  - Other biodiversity programs (both regional and global);
  - People within the circumpolar region;
  - People outside of the circumpolar region; and;
  - Decision and policy makers.
- Ecologically relevant;
- Subject to targets and threshold setting;
- Has long-term commitments to monitor; and;
- Practical:
  - Cost effective;
  - Relies on accessible data;
  - Technically feasible to measure; and;
  - Representative of multiple species, ecosystems and/or habitats.

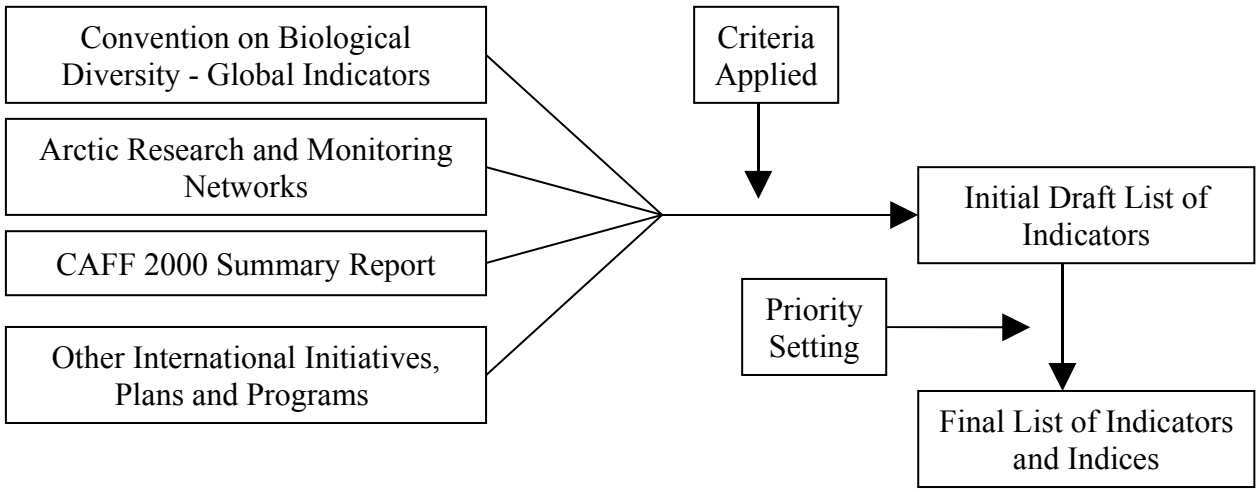

Figure 1. CBMP Biodiversity Indicators and Indices Selection Process

2.3.2 Suite Criteria

The criteria developed for the selection of suites of biodiversity indicators (or indices) for the CBMP include the following:

- Key drivers addressed;
- All components of biodiversity (genetic, species, and habitat) covered;
- Marine, coastal, freshwater and terrestrial habitats covered;
- All trophic levels covered;
- Phenological changes measured;
- Species range changes measured;
- Vulnerable species and habitats covered;
- All available knowledge systems used;
- Community-based monitoring employed;
- Remote sensing used; and;
- Human elements of Arctic systems covered.

2.4 Selection Process

A number of key sources were consulted during the initial short-listing of potential indicators, including the CBD's Global Indicators, Arctic species networks, the *CAFF/AMAP Workshop on a Circumpolar Biodiversity Monitoring Program* (CAFF/AMAP 2000), and other relevant international initiatives (e.g., Wetlands International, *Toward an Integrated Arctic Observing Network report*, etc.) Please refer to Figure 1.

A preliminary list of candidate indicators was developed from these sources through both a workshop series and expert input solicited via questionnaires. The proposed indicators were then evaluated against the suite and indicator criteria outlined in Section 2.3. Indicators that successfully met the criteria formed part of the *Initial Draft List of Indicators for the CBMP*. This list was shortened during a priority setting exercise involving various stakeholders, resulting in the *Final List of CBMP Indicators and Indices.*

This selection process was initiated at a June 2005 workshop held in Whitehorse, Yukon, Canada. Initial selection criteria were developed and indicators were organized using a modified version of the table used during the February 2005 *Tenth Meeting of the Subsidiary Body on Scientific, Technical and Technological Advice* in Bangkok, Thailand. The current CBD global indicators were reviewed and those relevant to the CAFF area were chosen for inclusion. Those deemed irrelevant were deleted and a third group of CBD indicators was modified to better reflect the Arctic.

The selection process continued at a September 2005 workshop in Cambridge, U.K. that hosted a larger group of stakeholders representing a diversity of scientific organizations, Arctic species monitoring networks, Aboriginal groups, and international non-governmental organizations. This workshop resulted in the addition of more candidate indicators along with specific biodiversity elements grouped as sub-sets with an accompanying lead organization and capacity and data quality assigned to them. A questionnaire was developed and broadly distributed to solicit further input into the initial list of candidate indicators.

Participants at a third workshop held in Whitehorse in November 2005 finalized the selection criteria and applied the two sets of criteria to the draft list of indicators from the previous workshops. Selection criteria were also assigned a priority based on their compatibility with the selection criteria. Table 1 identifies the final list of indicators and indices including information on which ones are relevant to the CBD Indicators.

The ultimate goal was to compile a relatively concise, simple, and practical set of biodiversity indicators for the CBMP to track. The first round of indicator selection was kept intentionally broad so as to avoid precluding input from the various stakeholders who were involved in the process. The CBMP's indicators and indices are in various stages of "readiness" for inclusion in the program's reporting efforts. Those indicators with existing data and methodologies supporting them will be developed first as part of Phase 1. The remaining indicators and indices currently lacking a specific methodology will become the focus of the CBMP's efforts in Phase 2.

3. CBMP Biodiversity Indicators & Indices

3.1 Indices

The list of CBMP biodiversity indices presented below is not exclusive, as it is anticipated that the CBMP´s monitoring networks will have additional reporting output not captured in the current suite of indicators and indices. Table 1 outlines the CBMP Biodiversity Indices and Indicators and highlights those with linkages to the CBD's indicators.

Arctic Species Trend Index – this index will illustrate broad trends in abundance using population data from diverse taxa across all regions of the Arctic. It will employ the methodology developed for the Living Planet Index.

Arctic Red List Index – this index will illustrate the relative rate at which species in particular groups change in overall threat status (using IUCN Red List categories).

Arctic Trophic Level Index– this index will illustrate changes in trophic level balance for freshwater, marine and possibly terrestrial systems. Methodology has been developed for the generation of a Marine Trophic Level Index utilizing existing commercial catch data.

Water Quality Index – this index will illustrate broad trends in water quality across the Arctic.

Arctic Land Cover Change Index – this index will illustrate changes in land coverage by habitats and at various scales.

Arctic Habitat Fragmentation Index– this index will measure habitat quality by tracking changes in the degree of habitat fragmentation across various regions and habitats.

Arctic Human Well-being Index– this index will track the integrity of ecosystems and their ability to provide services for local communities.

3.2 Indicators

The list of CBMP biodiversity indicators presented below is not exclusive, as it is anticipated that the CBMP´s monitoring networks will have additional reporting output not captured in the current suite of indicators and indices. Table 1 outlines the CBMP Biodiversity Indices and Indicators and highlights those with linkages to the CBD's indicators.

Trends in Abundance of Key Species– will track changes in the abundance of a number of vertebrate and invertebrate species that are of critical importance to northern communities and/or fulfill key ecosystem functions. This indicator will be developed utilizing existing Arctic monitoring capacity and data.

Trends in Other Species Parameters– a number of parameters not related to abundance (e.g., productivity) can also provide valuable insight into changes in ecosystems and identify possible drivers of change. These parameters will be developed based on the advice of member monitoring networks.

Change in Status of Threatened Species– this indicator will track relative changes in the status of reassessed species.

Trends in Total Arctic Species Listed at Risk– will track changes in the number of species listed at risk as tracked by the IUCN.

Trends in Extent of Biomes, Habitats, and Ecosystems – this suite of indicators will track changes in distribution and coverage of major ecosystems and critical habitats in the Arctic.

Trends in Patch Size Distribution of Habitats – this indicator will track the extent of ecosystem intactness by measuring changes in the patch size distribution of various Arctic and sub-Arctic habitats.

Fragmentation of River Systems – this indicator will

track changes in the degree to which rivers have been modified by dams, water transfers and/or water withdrawal.

Extent of Seafloor Disturbance - this indicator will measure changes in the extent and distribution of bottom trawling in Arctic marine waters.

Trends in Extent, Frequency, Intensity and Distribution of Natural Disturbances– this indicator will illustrate changes in the extent, frequency and distribution of natural disturbances (e.g., forest fires, insect/disease outbreaks) in various Arctic and sub-Arctic habitats.

Trends in Phenology– this set of indicators will measure changes in the timing of key ecological events in the Arctic such as first flowering dates, dates of peak primary production and arrival times for migratory species.

Trends in Decomposition Rates– this indicator will track changes in the decomposition rate in both tundra and boreal forest biomes.

Trends in Availability of Biodiversity for Traditional Food and Medicine– this indicator will measure changes in the availability of key traditional food and medicine resources for northern communities.

Trends in Use of Traditional Knowledge in Research, Monitoring and Management– this indicator will illustrate, on a regional basis, the degree to which traditional knowledge is used to influence research, monitoring and management decisions around the Arctic.

Trends in Incidence of Pathogens and Parasites in Wildlife– this indicator will measure changes in the number of incidents of pathogens and parasites reported in wildlife species where tissue sampling occurs (e.g., barren-ground caribou).

Coverage of Protected Areas– this indicator will illustrate trends in the amount and type of protected areas found within the circumpolar Arctic and the extent to which they are representative of the various ecosystems found across the North.

Table 1. Summary of CBMP Biodiversity Indices and Indicators and Relationship to Convention on Biological Diversity (CBD) Indicators and Indices

CBMP BIODIVERSITY INDICES AND INDICATORS	Linkage with CBD Indicators
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 Disturbance	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	√

4. Future Development of the Indicators and Indices

The CBMP Biodiversity Indices and Indicators will be developed concurrently with a number of other related Arctic and global initiatives. One such example is the 2010 Biodiversity Indicators Partnership (2010 BIP) which has been established to facilitate the analysis of the CBD's indicators in all regions of the planet in preparation for reporting on global progress towards the CBD's 2010 target to reduce the rate of biodiversity loss. In recognition of the CBMP's expertise in reporting on trends in Arctic biodiversity, the Program has joined the 2010 BIP with the responsibility of conducting the analyses of CBD's Arctic-related indicators.

Another complementary initiative is the three-phase Arctic Biodiversity Assessment (ABA) that CAFF is in the process of developing. The CBMP's Biodiversity Indicators and Indices will provide the foundation of the first phase of the ABA Summary Report.

The shared timelines of the 2010 BIP partnership, ABA Phase 1, and CBMP indices and indicators development provide an opportunity for cost sharing and collaboration. It is expected that the CBMP's indicators and indices will be supported by funding from CAFF countries and external parties as opportunities arise. In preparation for delivery of the CBMP indicators and indices to both Phase 1 of the ABA and the 2010 BIP, the CBMP will establish agreements with its partner monitoring networks to ensure the necessary influx of supporting data.

4.1 Timelines

The CBMP Biodiversity Indicators and Indices will be developed in two phases. The indicators and indices selected for Phase One reflect currently accessible data, network capacity, and existing methodologies. Phase Two indicators and indices are those for which methodologies have yet to be developed and/or supporting data is not currently available. Please refer to Table 3 for an overview of past and future timelines for indicator and indice development.

Phase One will take place from 2008 to 2010 and involve development of the following indices and indicators:

- Arctic Species Trend Index
- Trends in Abundance of Key Species
- Changes in Tundra Vegetation
- Arctic Red List Index
- Change in Status of Threatened Species
- Trends in Total Species Listed at Risk
- Arctic Land Cover Change Index
- Trends in Extent of Biomes, Habitats and Ecosystems
- Arctic Habitat Fragmentation Index
- Trends in Patch Size Distribution of Habitats
- Trends in Extent, Frequency, Intensity and Distribution of Natural Disturbances
- Trends in Phenology

Phase Two will take place from 2011 to 2012 and involve the development of the following indices and indicators:

- Arctic Trophic Level Index
- Water Quality Index
- Arctic Human Well-being Index
- Trends in Other Species Parameters (e.g., distribution, productivity, etc.)
- Trends in Availability of Biodiversity for Traditional Food and Medicine
- Trends in Use of Traditional Knowledge in Research, Monitoring and Management
- Trends in Incidence of Pathogens and Parasites in Wildlife
- Fragmentation of River Systems
- Extent of Seafloor Disturbance

Technical backgrounders will be developed for each indicator (similar to the CBD technical backgrounder format) to resolve issues pertaining to data availability, accessibility and power. Based on the technical backgrounders, the analysis phase will be conducted using as much data as is available at that time.

It is anticipated that subsequent to the first phase initial development of the CBMP indicators and indices, CAFF will initiate a process for identifying targets and thresholds for each indicator and index.

4.2 Proposed Budget

It is anticipated that the development of the CBMP Biodiversity Indicators and Indices will be facilitated by funding from CAFF countries (in the form of assistance to both the CBMP and ABA), and external funding and collaboration opportunities (e.g., UNEP global reporting and assessments).

The estimated budget required to fully implement the indices and indicators over the next five years is $1,080,000. Please refer to Table 2 for a more detailed breakdown.

Table 2. Proposed Budget for Development of the CBMP Biodiversity Indicators and Indices

DELIVERABLE	COST (CDN $)	COMMITTED FUNDS (CDN $)	FUNDS REQUIRED (CDN $)
PHASE 1 DEVELOPMENT			
2008	180,000	47,000 (20K from Canada; 27K from Finland)	133,000
2009	180,000	0	180,000
2010	180,000	0	180,000
SUB-TOTAL	**540,000**	**47,000**	**493,000**
PHASE 2 DEVELOPMENT			
2010	270,000	0	270,000
2011	270,000	0	270,000
SUB-TOTAL	**540,000**	**0**	**540,000**
TOTAL	**1,080,000**	**47,000**	**1,033,000**

Table 3. CBMP Biodiversity Indicators and Indices Development Timelines

TIMELINE	MILESTONE
April 2005	CBMP lead and task Teams established in Ottawa, Canada to formulate and implement CBMP action plan.
June 2005	Process for selecting key biodiversity indicators and selection of indicators begins during workshop in Whitehorse, Canada.
July 2005	Draft discussion paper outlining the indicator selection process, key indicators and review process developed and sent for initial review.
September 2005	Process for selecting key biodiversity indicators and selection of indicators begins during workshop in Whitehorse, Canada.
November 2005	Selection criteria finalized and finalize selection criteria and final selections of indicators made at third workshop in Whitehorse, Canada.
November 2006	CBMP Biodiversity Indicators and Indices presented at Anchorage, USA implementation planning workshops and CAFF Management Board meeting
December 2007	United States and Finland announced as co-leads of the ABA.
February 2008	CBMP invited to join 2010 Biodiversity Indicators Partnership
April – Sept. 2008	Technical Backgrounders for Phase 1 indicators to be developed.
Sept. 2008 – March 2009	Development of draft Phase 1 indicators and indices.
March 2009 – March 2010	Phase 1 indicators and indices finalized, contributed to ABA (Phase 1) and 2010 BIP.
April – Sept. 2010	Technical Backgrounders for Phase 2 indicators to be developed.
September 2010 – September 2011	Development of draft Phase 2 indicators and indices. Phase 1 indicators and indices incorporated into CBMP web-based data portal.
Sept. 2011-March 2012	Phase 2 indicators and indices finalized and incorporated into CBMP web-based data portal.
2012 -	Periodic reviews and refinements of indicator suite and monitoring methodologies.

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