FRAMEWORK FOR MONITORING BIODIVERSITY CHANGE (SPECIES AND SPECIES GROUPS) WITHIN THE ECOLOGICAL MONITORING AND ASSESSMENT NETWORK IN CANADA

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1. Introduction

The Ecological Monitoring and Assessment Network (EMAN) is providing a framework for setting priorities, planning and conducting research and monitoring programs with respect to just one aspect — biological diversity change at the level of species or species group. This document is directed primarily to managers of research and monitoring stations and researchers who wish to include monitoring of biodiversity change among their Ecological Science Cooperative (ESC) priorities. It is also directed to those who are interested in increasing knowledge with respect to this aspect of biodiversity monitoring through cooperative activities. The document is limited in scope, but presupposes the preparation of documents dealing with monitoring other aspects of biodiversity change. The guidelines are general; specific guidelines would vary according to ESCs and their priorities.

2. Context for Monitoring Biodiversity Change in Canada

2.1 International Context

Canada is a signatory to the United Nations Convention on Biological Diversity (UNEP, 1992). As such, it has legal obligations to develop national strategies and action plans to conserve and use sustainably the biological diversity within its jurisdiction. Article 7 of this Convention provides the legal basis for biodiversity monitoring and associated activities, such as research and data management.

The following sections of Article 7 of the Convention are particularly relevant:

Article 7(b) Monitor, through sampling and other techniques, the components of biodiversity .... paying particular attention to those requiring urgent conservation measures and those which offer the greatest potential for sustainable use.

Article 7(c) Identify processes and categories of activities which have or are likely to have significant adverse impacts on the conservation and sustainable use of biodiversity, and monitor their effects through sampling and other techniques; and

Article 7(d) Maintain and organize, by any mechanism, data derived from identification and monitoring activities pursuant to subparagraphs (b), (c) and (d) above.

2.2 Canadian Context

As required by the UN Framework Convention, the Canadian Biodiversity Strategy (Environment Canada, 1994a) has been developed. It was prepared by a federal/provincial/territorial working group in consultation with academic, industrial and NGO groups, and is Canada's formal response to the Convention.

The Strategy stresses the need for an understanding of the current status of species and their populations, population trends and the causes of population and species changes in order to develop sound biodiversity conservation and sustainable use strategies. Such an understanding can best come from coordinated and cooperative programs which encourage individual contributions, and ensure that they are consistent with an overall strategy.

Some of the strategic directions outlined in the Canadian Biodiversity Strategy are particularly relevant in this context:

- develop and implement monitoring programs to better understand the functional linkages in ecosystems, evaluate the success of conservation and sustainable use programs, and better integrate the monitoring of biotic and abiotic parameters;
- maintain and enhance bioclimate monitoring to track the effects of atmospheric changes on ecosystems, species and genetic diversity;
- investigate and implement means to enhance the collection, sharing, analysis, scope and distribution of data and information pertaining to the sustainable use of biological resources;
- develop and use biodiversity indicators that are meaningful, scientifically defensible, practical and compatible with regional, provincial, territorial, national and international programs.

2.3 Biodiversity in Canada: A Science Assessment for Environment Canada

Another response to the UN Convention was the preparation of an assessment of the state of scientific knowledge on biodiversity issues in Canada (Biodiversity Science Assessment Team, 1994). It stresses that monitoring biodiversity change involves understanding some fundamental concepts. These include scale, type, and indicators, and the relationship between stability and diversity, and habitat fragmentation, etc. The Science Assessment provides a review of what is known about the effects of major human activities on biodiversity in Canada and offers recommendations for research and policy aimed at improving the conservation of biodiversity.

A word on scale. Scale is crucial when dealing with biodiversity. Questions dealing with the measurement, monitoring, values and causes of biodiversity change may have different answers depending on the spatial and temporal scales at which the question is asked or answered. It is, therefore, important to adopt a hierarchical approach with lower levels of diversity (e.g. genetic) being aggregated to higher levels (e.g. species, populations, etc.). Actions at one level will have ramifications at both higher and lower levels. This must not be underestimated when planning, executing, and interpreting the results of longÐterm monitoring of biodiversity change, especially as it applies to the species and population levels.

What follows in this framework owes much of its form and content to the information

contained in the Science Assessment. Readers are referred to this document for more information.

2.4 Opportunities within EMAN

There are currently many programs under way in Canada which monitor variables related to biological diversity. These variables include climatic, atmospheric and weather parameters, toxics, water quality and quantity, animal and plant distribution and abundance, and landscape and land-use changes. These activities are conducted by numerous government and non-governmental agencies for many and varied purposes. For the most part, they are independent; jurisdictional or disciplinary boundaries often impede communication among those doing the monitoring.

EMAN's cooperative mode of operation and ecological framework provides an unequalled opportunity to undertake and facilitate monitoring of biodiversity change in Canada. ESCs together under the EMAN umbrella offer many advantages including:

- ongoing ecological (biotic and abiotic) research, monitoring, and experimentation on sites across Canadian terrestrial and marine ecozones;
- secure, instrumented and accessible sites;
- flexibility to arrange for interested and qualified people to undertake specific studies of interest;
- access to data, biological inventories, past research results, and synthesis on site and at distance;
- access to other disciplines and datasets, nationally and internationally;
- integration of data into the site/ESC databases.

EMAN is facilitating the development of interactive communications, data management and exchange systems across the network. It will also facilitate the integration and synthesis of information on local, ecozonal and national scales for a variety of audiences and for state of the environment reporting purposes.

2.5 Special Note on Biodiversity Indicators

There is a difference between long-term monitoring of biodiversity change and using indicators to show that change has occurred or is occurring. The State of the Environment Report "A Report on Canada's Progress Towards a National Set of Environmental Indicators" (Environment Canada, Indicators Task Force, 1991) refers to the masses of data collected by scientists and the daunting task it is for the average person to interpret. It notes that "Environmental indicators need to be selected from this information and presented ... in ways that are relevant and can be readily understood". The process it recommends for selecting national (or indeed any) indicators is complex. It has five steps:

1. identify societal goals to which the indicators relate;

2. devise a framework within which they operate;
3. identify selection criteria by which to judge potential indicators;
4. consult with data holders, experts, and potential users; and
5. verify that the indicators communicate the message effectively to the intended audiences.

EMAN does not select biodiversity indicators. Its function is to facilitate the collection of data and the synthesis of information about what is happening to Canadian biological diversity. Many of EMAN's partners, however, are intimately involved in the indicator selection process at both local and national levels and for public policy and/or sectoral purposes. The State of the Environment Directorate is currently coordinating the preparation of a national set of biodiversity indicators. These indicators require hard data and synthesized information to make them effective communication tools.

The ESCs then must be concerned with the nitty-gritty of data collection, scientific standards, methodology refinement, research enquiry, and the interpretation of results — the fundamental work necessary to provide the rationale and information for the selection of biodiversity indicators and their validation. The monitoring and research of ESCs is essential. They will provide basic information and, in light of other work, assess the efficiency and reliability of any selected indicator(s).

It is highly probable that many of the organisms monitored at ESC sites will have indicator value; information gathered as a part of regular programs could be used for more than one purpose. Such synergistic activity is part of the EMAN strategy and is compatible with the development and monitoring of biodiversity indicators.

3. Monitoring Biodiversity Change

3.1 Objectives

Within the EMAN context, the objective of monitoring biodiversity change is to gain an understanding of what is changing in the ecosystems and why. By integrating long-term information on species trends/cycles with the abiotic data and land-use change information and with the results of other ecosystem (process, attribute, etc.) research from the same area, a more complete profile of an ecosystem can be prepared, and evidence of change and/or condition documented. This integrated information should be useful for policy making with respect to natural resource management and the conservation of biodiversity in Canada.

3.2 Conceptual Guidelines

3.2.1 General: For long-term monitoring of biodiversity change, information must be comparable over time and space. EMAN recommends that the groups that are involved in monitoring activities should coordinate use of standard protocols in study design,

sampling procedures, sample and data analysis and reporting methods.

EMAN is taking a flexible approach to the gathering of useful information to encourage the broadest participation. Currently, it is compiling a list of protocols and standards for dissemination through Canada. With the help of expert working groups, it will recommend a system of common protocols for ESCs to use. These will range from simple methods that school students and the general public can use, to sophisticated methods requiring special expertise.

To make the information gathered in Canada as useful as possible nationally and internationally, EMAN is recommending the use of international and widely used Canadian protocols. Examples of the former are the protocols for forest monitoring (plot size, geo- referencing, data entry, etc.) developed by the Smithsonian Institution for the UNESCO Program on Man and the Biosphere (Dallmeier, 1992), and those for tundra developed by the International Tundra Experiment (ITEX) (Molau, 1993). Examples of Canadian methods are the breeding bird survey (Environment Canada, 1994b) and terrestrial arthropod biodiversity sampling (Biological Survey of Canada, 1994). Where common protocols do not already exist, or have not been agreed upon, EMAN will facilitate the setting up of expert working groups to recommend common methods.

An essential part of any long-term biodiversity monitoring program are relevant climatic data. While the Atmospheric Environment Service has a good general coverage for Canada, the information is not always available or relevant to the habitats of particular species.

EMAN is recommending the use of the Canadian bioclimate monitoring system for measuring climate variables underneath the plant canopy and within the soil. To this end and in cooperation with the Biodiversity Directorate, EMAN will instrument a number of the ESC sites where UNESCO/SI forest monitoring plots have been established. This is a pilot project for 1995/96.

Climate monitoring protocols for ITEX sites have been established using the same basic equipment. Work is ongoing to determine the standards for climate recording systems in aquatic and other non-forested terrestrial ecosystems.

3.2.2 Specific: Following agreement on the general protocols, each ESC should:

- define the reason(s) for undertaking biodiversity monitoring (species and species groups) in the selected location(s); (see also the Canadian Biodiversity Strategy for guidance);
- define what, where and when — these questions will be answered by ESC objectives, the specific study design, and the general and specific protocols for selected ecosystems and species;
- define how — this question will be dealt with in ESC site planning sessions, and by study design;

- ensure that methods are in place for managing collected datasets and linking them to other related datasets, and to making them available for inclusion in more extensive monitoring networks;
- ensure that the processes for analyzing, synthesizing, assessing and disseminating the results are in place.

3.3 Establishing Priorities

Each ESC, as part of its planning process and within the overall EMAN objectives, will develop its own objectives and priorities for monitoring biodiversity change and decide how they are to be implemented at each of its sites. In determining priorities, the following elements should be considered:

- the availability of expertise on site, at universities, museums or elsewhere;
- other species or species group monitoring and research activities already under way;
- other ecological research and monitoring planned or in progress (genetic, community, ecosystem or landscape levels);
- availability of representative species of the selected ecosystems. The selection should consider the different life forms (protista, fungi, vascular and non-vascular plants, invertebrates and vertebrates); very common and dominant species; exotic species; species identified by the general public as important; species that represent problems for human populations, e.g. deer, birds, carnivores, and rodents, etc; and species in ecosystems subject to intensive management/use/pressure, e.g. agriculture, ecotourism, forestry, settlement, transportation, etc.), as appropriate for the ecozone;
- availability and integration of other data (e.g. UV-B effects; major types, sources and impacts of pollutants/toxics; basic meteorological data within as well as outside the vegetation canopy; ecosystem structure and function, etc.) for use in compiling, synthesizing and interpreting the results obtained from biodiversity monitoring.

3.4 Considerations

In setting objectives and priorities, each ESC should consider:

- which species or groups to select for concentrated or specialized study;
- which relevant ecosystems to include — both unmodified and deliberately modified;
- what can be routinely accomplished by researchers and technicians working in an area;
- how to attract interested specialists to undertake special studies;
- how to involve volunteers; and
- how results will be distributed in scientific and popular media.

3.5 Guidelines for Study Design

In designing a long-term biodiversity monitoring program, ESCs should ensure that they select protocols that:

- are in broad use across Canada;
- yield useful information whether they are simple to use with little training or complex requiring specific expertise;
- are comprehensive enough to provide information about the state of an ecosystem, not only about a single species;
- measure attributes explicitly identified by managers and clients.

ESCs should also:

- ensure that information on the state of the ecosystem at one scale is related a) vertically to other scales (e.g. community, population, landscape, ecozone), and b) laterally within scales or levels;
- use or link to existing information/monitoring activities to avoid committing substantial new resources or duplicating ongoing programs;
- contain a mechanism for evaluating and reporting on the state of biological diversity in a timely and effective manner to people and organizations that require this information.

To be effective, a program developed for monitoring biodiversity change must assess and establish client needs and incorporate these needs into program design. It should also contain an independent review mechanism to ensure that client needs are being met.

4. Policy Direction

Monitoring species and species groups can produce valuable scientific data for improving our understanding of the composition, structure and functions of various elements of biodiversity. These data could be used in biodiversity assessments in Canada's ecozones. The results could be used to formulate policy with respect to sustainable resources management and the conservation of biodiversity in Canada. Agencies will be able to use this information to document existing stresses and their impacts on biodiversity, and as an early warning system for developing preventive action against new stresses.

5. Challenge

EMAN is taking action! It is issuing three challenges.

1. The challenge to **the scientific community**, and others interested in

biodiversity, is to cooperate in using ESC facilities and opportunities. Expanding information about individual species will help expand information about other aspects of ecosystems and thus increase the total knowledge about Canadian biodiversity at the ecozone level.

2. The challenge to **departments and agencies** is to extend the bioclimate monitoring system through all ecozones in Canada. This will help document the environmental changes to which species respond.
3. The challenge to **those who support research** is to find resources for those working at ESC sites in the knowledge that the work is part of a holistic study of ecosystems in Canada, with both academic and social objectives.

These challenges are issued in the expectation that all those interested in Canadian biodiversity will cooperate to make a reality of the vision stated in the Biodiversity Strategy for Canada, that Canada is a ... **"society that lives and develops as a part of nature, values the diversity of life, takes no more than can be replenished and which leaves to future generations a nurturing and dynamic world, rich in biodiversity".**

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