

# Scaling National Criteria and Indicators to the Local Level

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Working Group on Criteria and Indicators for the Conservation and  
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# The Issue of Scale in the Aggregation of Data on Indicators of Sustainable Forest Management from Subnational to National Levels<sup>1</sup>

## Why Scale Is Important

The countries of the Montréal Process on Criteria and Indicators for the Conservation and Sustainable Management of Temperate and Boreal Forests have agreed to report on the condition of their forests, which cover areas from millions to hundreds of millions of hectares. This involves collecting, synthesizing, and reporting data on indicators of sustainable forest management at subnational (that is, local and landscape levels where forest management occurs) and national levels and determining the relationship between these levels. Some criteria and indicators (C&I) are intended to measure elements of national or regional progress toward a resource condition, and others, the progress toward sustainability as adaptive forest management occurs. The data used for measurement range from statistics on forest environment and products to information on employment and working conditions. The countries of the Montréal Process are federal or unitary states that encompass different levels of government and/or private business with responsibility for resource management. A variety of reporting histories and structures also exists among the countries. The interrelationships of data reported at the subnational and national levels raise the issue of scale.

The Montréal Process C&I require nationally relevant reporting; however, forest management activities are site-specific. The issue of scale of data must be addressed if managers are to minimize errors when data collected at one organizational level are used to estimate parameters at another. Finding an appropriate means of aggregating data is fundamental to solving the problem of scale, and as scale is a technical problem, it is amenable to a technical solution. Gross National

Product and greenhouse gas emissions are examples of indicators for which data are collected and reported on at a national level. Indicators of soil and water quality or forest health are commonly based on data collected and reported on at local or subnational levels.

Management activities at each level should be concerned with sustainability. For example, to describe an annual water balance for a region, data on soil water content should be applied at particular points in time and space. Once the kind of data at each decision level has been defined (scaling), the appropriate statistical methods can be applied to the design of the data to be collected. Without the appropriate design, many subnational data cannot be aggregated to provide national level information. This limits the ability of countries to report on some indicators, for instance, soil and water quality. The aggregation and disaggregation of data are possible, but the issue of scale must be considered in the design of how data are collected to allow this.

For ecologically diverse countries, reporting on sustainable forest management may involve using data collected at the subnational level but reported nationally. How data can be aggregated or disaggregated up and down an organized hierarchy is part of the analysis and synthesis that is essential to the proper application of C&I. The indicator for soil erosion, for instance, is based on data collected and applicable at the local level, such as tonnes of soil lost, but these data would be meaningless at the national level as an average of widely diverse conditions. This results in problems in analysis and synthesis. These indicators are essential to assess sustainable forest management. Countries need to ensure that the issue of scale is considered in the design, analysis, and reporting of indicators.

This paper discusses the following issues concerning scale:

- What are the issues of scale regarding the collection and aggregation of data at the subnational and national levels?
- What is the effect of scale on the interpretation of data?

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<sup>1</sup> The following paper was prepared by the Working Group on Criteria and Indicators for the Conservation and Sustainable Management of Temperate and Boreal Forests (Montréal Process) Technical Advisory Committee to assist member countries and promote the sharing of experiences on criteria and indicators. It is considered a working technical aid and not an official document of the Montréal Process Working Group. The paper is made available so that other countries may also

- What are the implications of the periodicity of nationally collected data on subnational application of C&I?

## The Concept of Scale

Scale is defined as a hierarchical arrangement or classification (for example, land area, organizational level) with uniform reduction or enlargement, consisting of elements or information that are proportional to actual ones. The synthesis and reporting of data usually begin at a particular and well-understood level and the data are aggregated into progressively generalized levels. National data are also disaggregated to subnational levels. Certain indicators are most appropriately applied at particular levels, and some indicators have little meaning at other levels. Scale is an essential consideration in the reporting of data for large areas, and over long time periods, because all indicators regarding scale have both spatial and temporal components. Thus, it is important to understand the relationship of data among different levels to ensure the proper use of the information at different levels of reporting.

Ways of synthesizing and reporting environmental data that are appropriate at the subnational level may not be applicable at national and international levels. For instance, indicators of sustainability at the subnational level can consist of data on soil loss or toxic levels in water or soil or pollution emissions, whereas at the national level the comparable indicators might be the percentage of forest land that meets local soil-loss criteria.

The concept of scale also applies to economic and social data collected for indicators listed under Montréal Process Criteria 6 and 7. At the subnational level, social data reflect specific concerns from farmers, fishermen, local planners, or industrial managers, such as the number of jobs and revenues. At the national level, social data define generalized issues for the public, politicians, national decision-makers, and world environmental organizations, such as the percentage of communities that have diverse economies.

Indicators can also be aggregated to assess forest management practices and to support an adaptive approach to forest management. In this way, the integration of science and policy can be used to assist in the development of environmental, economic, or social decision-making policies. Indicators should be environmentally, socially, and economically relevant, statistically valid, measurable, and cost-effective in order to

support the process. In addition, the methods and protocols by which indicators are measured must be retained at the different levels of scale.

The effective description of conditions at the subnational level must reflect the biological and abiotic elements at that level. At the national level, data cover areas of several subnational units and are then generalized into a broad context for reporting on sustainable forest management. At national levels indicator information can be used to change policies and influence international obligations and treaties.

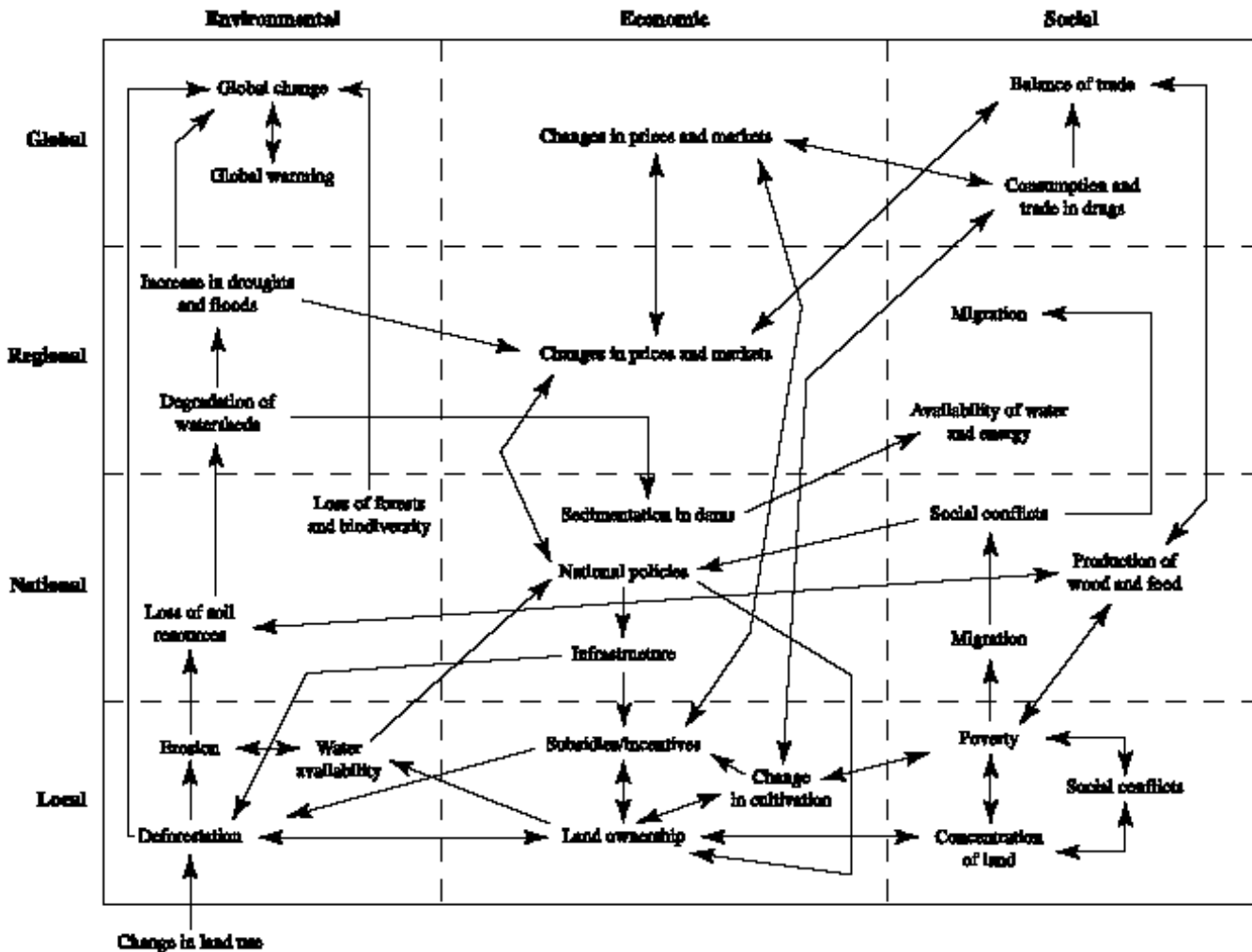
Because national data are obtained from a variety of subnational organizations, the issue of scale is relevant to units at the same organizational level. Such units should have comparable data in order for countries to integrate the data into single national frameworks. This becomes increasingly important as governments seek to gather and report on data that have been accumulated by a variety of sources.

## Environmental, Economic, and Social Data

The linkages from local to global scales for environmental, economic, and social data are shown in Figure 1. The figure illustrates the effects of a change in one component of environmental data at a subnational level on environmental and social data at subnational and national levels. These linkages demonstrate the effects of scale on the data collected for the C&I of sustainable forest management.

**Environmental Data (Criteria 1–5)**—Environmental data are used to report on forest type, wood volumes, forest health, atmospheric change impact, water quality and quantity, and so on. Both spatial and temporal data are used to report on indicators. These data are needed at national levels for international commitments and at the stand level for decisions on adaptive forest management.

Spatial data are needed to show the extent of forest area affected, for instance, to show changes in forest type or the volume of wood available for harvest. Temporal data allow determination of these changes over time and monitoring of the response to adaptive forest management policies. For many environmental indicators, assessment involves considerable costs in sampling because the areas are large and the time periods often long. New techniques such as remote sensing and geographic information systems are increasingly implemented to permit the use of subnational data at national levels. This reinforces the need for



consistent methods. Figure 1 shows some of the linkages among environmental indicators at different levels.

**Economic Data (Criteria 6 and 7)**—Economic data are collected to enable governments to assess and monitor policies for employment, trade, taxes, manufacturing, and products. In many countries, both the national and subnational governments may have responsibility for labor codes, workplace safety, resource management, and associated activities. Methods have been developed over several decades for the collection and interpretation of social and economic data at subnational and national levels. These data are often collected more frequently than are data for environmental indicators; in addition, much of the data comes from nongovernmental organizations operating at subnational and/or national levels. Subnational economic statistics convey important information for determining policy at subnational levels that affect forest

management policies. With economic data, scales have been previously defined to reflect fiscal and monetary considerations that do not vary among subnational units. Therefore, economic data are often easier to aggregate at the national level than are environmental data. Figure 1 shows how the links among changes in land ownership or subsidies at the subnational level affect the infrastructure and subsequently price changes at the national level.

**Social Data (Criteria 6 and 7)**—The indicators in Criteria 6 and 7 are primarily social. The issue of scale is as important here as for environmental and economic data. The heterogeneous environment typical of subnational-level monitoring data is clearly demonstrated when applied to the human and sociological aspects of land use and land patterns. Assessment of the condition of subnational units reflects the condition of these environmental, economic, and social elements. Figure 1

shows how changes in land ownership at the local level that result from environmental and economic pressures have consequences at national levels.

### Data Collection and Reporting

Two forest management activities used to collect and synthesize data that are widely used by Montréal Process countries are subnational data collection networks and national forest inventories. Subnational or regional data collection networks are usually focused on particular data for a portion of forested lands. National data inventories contain data on the condition of all forested and nonforested land. Both types of systems, maintained over time, are necessary to produce the data needed to assess sustainable forest management.

**Subnational Data Collection Networks**—Subnational data collection systems are commonly used to assess forests for limited objectives—evidence of disturbance or stress or some particular use of the forest such as removal of nonwood products. Such networks were in place before the development of the current C&I and had objectives that may now have to be adjusted to reflect C&I requirements.

Subnational networks report over time on a portion of the indicators rather than on a broad range of indicators, which should be available from national inventories. However, subnational information also contributes to national assessments, and data may be aggregated on the basis of political and/or ecological boundaries. The design of subnational networks must therefore allow both for the aggregation of data to national levels and for the provision of information at the forest stand level. Temporal aspects are addressed when monitoring systems are based on permanent sample plots and measurements continue over time. Data reported on a spatial basis allow reporting of ecological and/or political units. Subnational and national systems may be integrated if design methods are compatible; scale is one of the primary considerations.

**National Forest Inventories**—National data collection systems clearly demonstrate the value and feasibility of aggregating data from the subnational to the national level. Because stand-level data have to be presented at national levels, subnational data sets need to be compatible with national ones. Many national inventories, however, are not yet capable of incorporating

stand-level data, which limits the use and value of the data at a national level.

Increasingly, countries are being asked to provide a broader range of higher quality information on traditional and new indicators from their inventories. Such information is required for the C&I, the Framework Convention on Climate Change, the Convention on Biological Diversity, and similar national and international needs. At the same time, the traditional forest management needs of the countries remain important. An estimated one third of the indicators designed to report on sustainable forest management can be addressed by using traditional national forest inventories.

The intention of Montréal Process countries is that proposed inventories should have the capacity to be nationally consistent, describe all classes of ownership, provide changes and trend estimates, be statistically sound and defensible, be compatible with ecological classification, and allow multiple attributes to be reported.

With a system of permanent sample plots established across all ecological and jurisdictional boundaries under a statistically valid method, the collection and subsequent interpretation of spatial and temporal data is possible. Such a system allows scaling up and down from subnational to national levels. Attributes such as forest cover and disturbance, for example, can be monitored and assessed using remote sensing techniques. Estimations of species diversity, wood volumes, and other detailed data can be done using ground-based sub-samples. National reporting, as well as subnational reporting, can benefit from the inventory, and there are opportunities to develop partnerships among other organizations to share costs and results. Countries have to address the issue of the added resources needed to collect data for new indicators and for more data on traditional indicators.

## Conclusions

An analysis of the issue of scale leads to the following conclusions:

1. Data can be reported at a variety of levels depending on national requirements, but collecting and reporting methods must be designed so that they can be linked from subnational to national reporting frameworks. The design of the system must allow aggregation and disaggregation of environmental, economic, and social data. Countries are considering adopting national and subnational data collection



systems for reporting on indicators of sustained forest management.

2. Measurement of indicators based on statistically valid sampling methods and assessed over extended periods will enable assessments of trends and responses to policy changes.

3. The scale issue must be resolved when data collecting systems are being designed and when reporting frameworks are being developed by a variety of organizations.

4. Countries may find it useful to evaluate each indicator and determine the appropriate scales at which indicators should be reported because methods to aggregate or disaggregate data will be unique nationally.

## Appendix. Examples of Data Aggregation at Subnational and National Levels

### Air Quality Data

At national levels, air quality concerns relate to global warming and long range transport of pollutants, whereas at subnational levels concerns are primarily about deposition and impacts on local forests. Relating measurements to data obtained at different levels is therefore important. Monitoring impacts may have limited value as an indicator of ecosystem change because deposition levels are primarily a function of local topography. However, a monitoring network of such sites covering a range of areas can detect trends that indicate ecosystem change. The indicators describing air quality respond to public concerns of health and can be expected to generate wide support.

Carbon dioxide emissions, controls on organochlorines, and nuclear testing are environmental issues that have developed as science issues; they have the greatest impact at national levels, where the information directly affects national and international policies. Research is also needed in applying national level information to subnational conditions in the case of biological indicators of sustainable forest management.

### Economic and Statistical Data

National level C&I reporting should enable policy-makers and international observers to decide how to achieve sustainable forest management. The Gross National Product has been used by most countries as a statistic of economic growth because it meets the requirements for indicators at subnational and national

levels. Few corresponding national environmental indicators exist that allow decision-makers or the public to evaluate environmental trends. That a national level indicator exists that can describe the state of the economy while also showing the relationship between environmental factors and economic development is appropriate—this is the essence of sustainability. Concurrently, the importance of errors associated with scaling questions depends on the use of the data. Economic data are also appropriate at global monitoring levels, where the information is used to set goals and affect international obligations and treaties, and at local to regional levels, where decisions are made by subnational governments on economic policy. These data are frequently collected by several organizations; thus the issue of scale must be considered when the frameworks for reporting are developed. Effective lateral communication is essential.

### Traditional Forest Knowledge

The issue of scale applies to the use of traditional forest knowledge, where information and data are collected by methods less conventional than for environmental or socioeconomic data. This knowledge has been accumulated over generations by forest-dwelling societies. It is a challenge for the science community to integrate this knowledge into the C&I framework. Many governments have, to varying degrees, incorporated this knowledge into assessment frameworks. Public consultation (in Criterion 7) is another area where this and associated knowledge is important. Data collected at subnational levels are easily aggregated to higher levels, usually with few scale problems in the process. Questions of scale regarding standards for collecting, analyzing, and reporting still need to be considered.

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## Possible Application of Montréal Process

### National Criteria and Indicators at the Subnational Level<sup>1</sup>

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## Introduction

The relationship of the national level Montréal Process Criteria and Indicators (C&I of sustainable forest management of temperate and boreal forests) to the subnational level, which includes the forest management unit level, is of growing interest. Managers at the subnational level are asking how the C&I are relevant at their level of work. National managers are asking how data generated to guide management decisions at subnational levels can be used to monitor resource, social, and economic trends at the national level. The relationship between national and subnational level C&I must be made clear to provide the rationale for their use and ensure the efficiency of actions designed to implement them.

National level C&I can shape the development of C&I at the subnational level. National level C&I are a set of important elements that national policy-makers and stakeholders have agreed to use to assess progress towards sustainable forest management (SFM). As such, the Montréal Process C&I can serve as a higher level context or framework for assembling and interpreting regional resource, economic, social, and institutional assessments at the subnational level. Because resource management at the subnational level cumulatively results in the trends observed at the national level, application of national C&I at the subnational level is of interest to national managers in interpreting these national trends.

Information generated by both national and subnational C&I can provide a scientific basis for the improvement of policy, guidelines, best management practices, performance measures, and in turn, improvements to the C&I themselves at the national and subnational levels. These are tools used to achieve sustainable forest management. However, it is important to understand the distinctions between national and subnational C&I. Whereas C&I at the national level can be used for describing, assessing, and evaluating a nation's progress towards sustainable forest management, subnational level C&I can be the source of data aggregated to the national level. Subnational C&I can provide information on local conditions and trends. They can also be used to monitor the compliance of local managers with best management practices and, therefore, provide a scientific basis to modify local practices to affect locally and nationally observed trends.

National assessments of social, environmental, and economic progress toward sustainable forest management and local C&I can, therefore, complement

each other. Together they provide the critical elements of an adaptive management system. National trends provide information on the cumulative impact, or effectiveness, of subnational management activities or codes of sustainable practice. Local C&I test conformance with best management practices, or resource and social conditions, at the local level and provide a means to change national trends.

The following discussion of the possible application of Montréal Process national C&I at the subnational level responds to questions identified by the Montréal Process Working Group.

## Discussion

What is the basis for current country interpretations of what constitutes subnational levels for the application of national level C&I?

Political, land ownership, and management boundaries provide the basis for current country interpretations of what constitutes subnational levels. Some countries have, however, defined subnational units based on biophysical/environmental factors. Subnational management units vary widely in size and complexity and are inclusive of forest management units. These units can be a complex array of ownership, management, and political boundaries. They are the areas for which goals and objectives are established, where people work, and where accountability rests.

Each country will continue to make its own decisions on what constitutes a subnational level or unit.

Practices at the subnational level, in aggregate, influence the national level trends measured by indicators. This relationship emphasizes the importance of the linkages between subnational activities and national outcomes related to sustainable forest management.

The Montréal Process C&I were designed for application at the national level. Before their use at the subnational level, national level C&I will generally need to be assessed. The size of the subnational unit and/or the sustainable forest management objectives at the subnational level will influence how subnational managers find national C&I useful for their applications.

Concepts of sustainability will vary between the national and subnational level. In its "Introduction," "Criteria and Indicators for the Conservation and Sustainable Management of Temperate and Boreal Forests" (Canadian Forest Service 1995, par. 1.3) states,

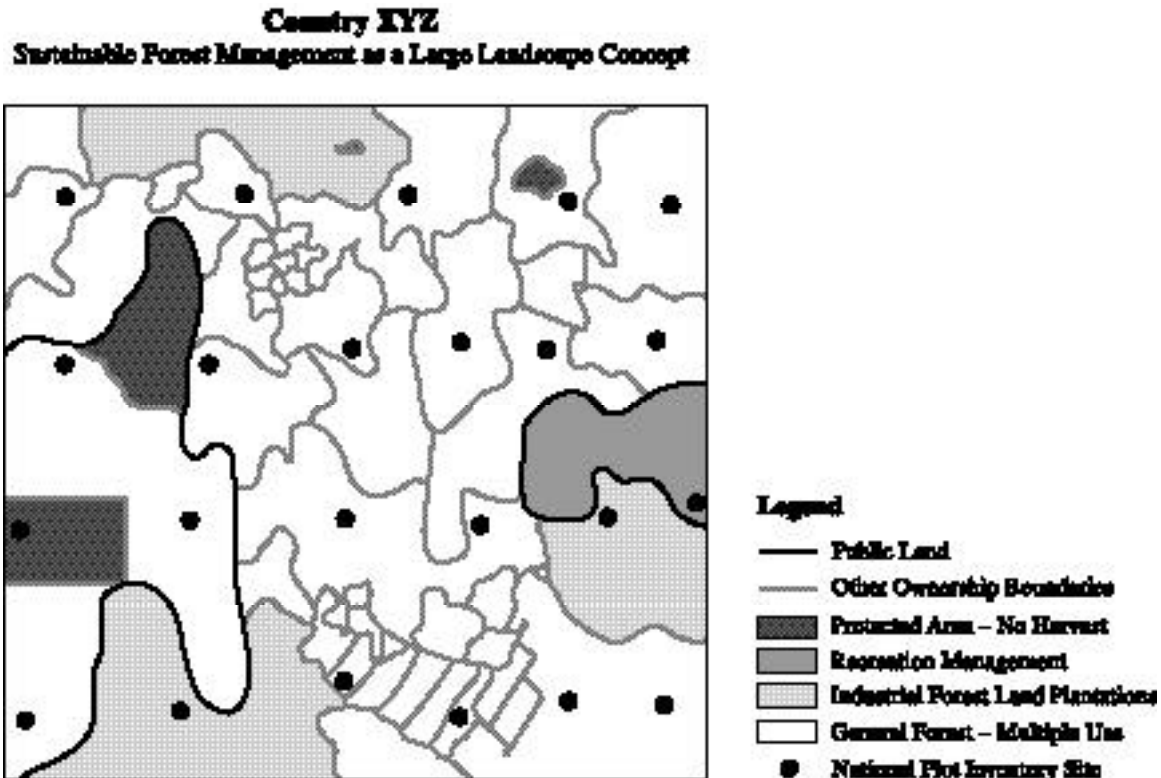


Figure 1. Sustainable management is the collective result of actions on all lands within a country as measured by 67 indicators. Any particular management regime's sustainability is best judged by the quality of management versus how it responds to all 67 indicators.

"Taken together, the set of criteria and indicators suggests an implicit definition of the conservation and sustainable management of forest ecosystems..." It recognizes that "no single criterion or indicator is alone an indication of sustainability." Paragraph 1.7, in addition, states that the indicators should be assessed as trends or with an historical perspective to established trends. This makes it clear that the conservation and sustainable management of forest ecosystems at the national level must account for all the criteria of sustainability. Multiple criteria are to be used at the national level because the Montréal Process countries recognized that nations require a multiple set of conditions and benefits related to forests if, in the long run, they are to be maintained. At any one time, an unacceptable trend in an indicator in one country may be temporally acceptable in another. The trend observed for one indicator might affect how to interpret the trends of other indicators.

At the subnational level, the relative importance of a criterion or indicator may vary depending on the sustainable forest management objectives of each management unit. This recognizes that the sustainable management of forests can be viewed as the aggregate

of individual actions in a large landscape. It also recognizes the need and right of private landowners and local managers to manage their particular tracts of land to accomplish their respective objectives.

The size of the subnational level unit may also influence the relevance of a national level indicator at that level. For example, the effect of a single small timber harvest on global climate change or the collection of data for such an indicator may have little meaning to a subnational manager who is responsible for only a few thousand hectares of forest. Current management strategies for global climate change issues have focused on modeling forest biomass trends in large landscapes.

Because subnational managers may manage their lands for specific objectives, it is reasonable to assume they will collect data relevant to their management objectives. The ability to aggregate data for national use may depend on the ability of managers at the national level to convince subnational managers to collect data for their use that is comparable or at least compatible with other subnational data sets. It may also make evident the need to encourage subnational managers

to collect more than minimal data. An inability to accomplish this may result in the need for a national inventory.

The application of national level C&I to the subnational levels is valuable because:

- they provide a single consistent framework for assessing SFM;
- they identify areas requiring improved management practices;
- they can be useful for the improvement of policies;
- they increase the efficiency of data gathering by minimizing duplication; and
- they can improve the effective use of subnational data by providing a framework that will encourage comparable and compatible data from different ownerships.

Managers at the subnational level are generally concerned with the accomplishment and the quality of implementation of management activities. Although the unit manager may be interested in global and/or national resource condition trends, it is more likely that the primary concern will be in meeting local forest management goals and complying with best management codes of practice. The focus of unit level managers is generally more on project level activities (output targets), complying with certain specific quality objectives or process standards, or assuring the maintenance or enhancement of a particular resource condition. Examples include complying with particular road construction standards, assuring that a particular production target is accomplished, or protecting an eagle's nest from harm. In both the national and subnational level examples, managers are working toward sustainability.

How do forest lands with various management objectives at the subnational level contribute to the overall reporting of indicators at the national level?

The measurement of comparable and compatible criteria at the subnational level can be useful in assessing SFM at the national level. Some of the national level indicators are applicable or comparable to those used currently at the subnational level. Information in the First Approximation Reports in some countries was derived from such indicators.

National data collection strategies should address the use of comparable and compatible data gathered across forest lands comprised of multiple ownerships and management objectives. These data will greatly increase

the efficiency and effectiveness of SFM assessments nationally. Subnational managers will find it useful in planning and collaboration to have comparable measures across the forested landscapes of multiple ownerships in which they operate. In response, some countries are developing integrated frameworks for assessing SFM at a variety of levels and across a range of management units.

Currently, different agencies that have land management responsibilities for adjacent lands commonly make isolated decisions because of the inability to share data. In the United States, federal, state, and private agencies at national and subnational levels now collectively spend hundreds of millions of dollars for data that cannot be effectively aggregated. While many subnational managers are trying to practice ecosystem management, they are commonly frustrated by the lack of comparable data on adjacent lands. Collaborative efforts between subnational managers will continue to be frustrated by lack of comparable data for analysis of common resource management issues.

Efforts to make C&I data at the subnational level comparable and compatible should recognize the varying contributions of forest lands with different management objectives (Figure 1). It must be fully expected that managers will collect data relevant to their management objectives. If they collect data for management issues beyond their primary management objectives, the use of that data will differ from one manager to another. For example, bio-diversity and wood production indicators would be used differently in intensively managed plantations than in conservation forests. The same would be true in private versus public forests managed for timber production. If data on the subnational units are not comparable, compatible, or complete, national managers must acquire the data with systems such as national plot inventories.

How can national level C&I be used to assess conditions at the subnational level?

Forest managers at various levels are interested in how their programs contribute to SFM. National level C&I provide context for assessments of SFM at the subnational level. National level indicators were not intended to directly assess sustainability at the forest management unit level (Santiago Declaration, par. 1.2). National level C&I, however, can be used in the development of subnational C&I. It is recognized that unique subnational situations exist that may require the

alteration, removal, or addition to the Montréal Process indicators. For example, in an area where drought is common, perhaps an indicator of natural seed production would be appropriate as an indicator of probable forest regeneration following harvest. In addition, subnational units with specific management objectives may not collect all of the data relevant to the national level. National C&I provide a clear framework for reporting against national expectations. In other words, everyone will be aware of the national data that will be used in debate relative to sustainable management of the nation's forests. By providing a single C&I framework, these national level C&I help subnational managers develop management plans and outcomes for SFM that are both consistent with national goals relevant to SFM at the local level, and more consistent among themselves. This national C&I framework also facilitates the prioritization of resources for research, increasing institutional and administrative capabilities, and educating and working with the public.

The achievement of healthy ecosystems and sustainable economies cannot be done in a vacuum. It requires a high level of collaboration between neighboring managers and stakeholders that share responsibility for, or are affected by, resource management activities adjacent to them. Collaborative management is an approach dependent on willing partners, respect for each other's roles and responsibilities, access to common information, and trust. The use of agreed to C&I to measure national trends in resource condition and the development of comparable and compatible data at the subnational level will greatly enhance collaboration.

Effect of scale on assessment, data collection, forest planning, monitoring, and related technical topics as it might affect the application of national level C&I at the subnational levels

The question of scale is addressed in the preceding paper in this publication.

## Summary

National level assessments provide context and useful linkages to subnational assessments.  
National C&I provide a basis for comparable and compatible data between subnational levels.

The Montréal Process C&I provide a useful framework for subnational data collection, reporting and planning, assessments, and decision making.

It is desirable to aggregate data up to higher levels of use. This ability/capacity depends on the availability of comparable or at least compatible data across subnational units.

The complementary use of national and subnational C&I is a key part of an adaptive management system for national resources.

The linkages between the national and subnational C&I measurements should be made clear. These linkages will be somewhat different for each nation.

## Recommendations

The Technical Advisory Committee recommends that the Montréal Process Working Group consider:

- identifying mechanisms to assist participating countries to implement C&I for SFM at subnational levels;
- developing and identifying subnational C&I that are linked to the Montréal Process C&I; and
- publication of national experiences in subnational implementation of C&I.

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<sup>1</sup> The following paper was prepared by the Working Group on Criteria and Indicators for the Conservation and Sustainable Management of Temperate and Boreal Forests (Montréal Process) Technical Advisory Committee to assist member countries and promote the sharing of experiences on criteria and indicators. It is considered a working technical aid and not an official document of the Montréal Process Working Group. The paper is made available so that other countries

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<sup>2</sup> Australia, Canada, Chile, China, Japan, Mexico, New Zealand, the Republic of Korea, the Russian Federation, and the United States; since 1995, Argentina and Uruguay have joined the Montréal Process. These 12 nations represent nearly 60% of the world's forests. European forests are

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<sup>3</sup> Australia has historically used the phrase “ecologically sustainable forest management” where other countries have used “sustainable forest management”. The meaning and uses



## Examples of Mechanisms for the Development, Identification, and Implementation of Subnational Indicators of Sustainable Forest Management That Can Be Linked to National Level Indicators<sup>1</sup>

### Abstract

The Montréal Process is an ad hoc intergovernmental process organized to assess national progress toward the goal of sustainable forest management using a common international framework. Some countries are also developing indicators for sustainable forest management for reporting at various sub-national levels. Examples of the development of subnational indicators from four Montréal Process nations (Australia, Canada, China, and the United States) illustrate the progress that some countries have made as well as some common and unique challenges in developing subnational indicators.

Although not all countries need subnational indicators, those that do base them generally on the national-level indicators, modified or supplemented as necessary. The processes used involve extensive consultation in various forms, and often local test areas. In some countries, reporting on subnational indicators has started before all indicators have been finalized, in an attempt to implement them as soon as possible.

### Introduction

Sustainable development, a concept developed in *Our Common Future* (World Commission on Environment and Development 1987) and subsequent discussions, is seen increasingly as a necessary and desirable objective. Sustainable forest management is the forest sector's contribution to sustainable development. While the Montréal Process characterizes sustainable forest management for the national level, some countries need to identify and implement indicators that could be used to evaluate progress toward sustainability at the subnational level.

The Montréal Process began in 1994 and brings together 12 temperate and boreal forest nations<sup>2</sup> to assess progress toward sustainable forest management at a national level. To achieve this goal, the Montréal Process has developed a set of 7 criteria of sustainable forest management with 67 indicators. Some of the Montréal Process countries, however, have recognized a need for a finer level of assessment and are in various stages of developing subnational indicators and refining national criteria for subnational use. These subnational C&I are generally intended for the use of subnational administrators in assessing their progress or contribution toward sustainable forest management. Because of administrative structure or

size, some countries do not need to develop subnational indicators.

Processes of developing and implementing subnational indicators are difficult and present many common and unique challenges for each country, region, or forest management unit engaged in them. This paper presents examples of mechanisms used to develop subnational indicators for sustainable forest management from four Montréal Process nations (Australia, Canada, China, and the United States). The focus here is not on the C&I themselves, but rather on the mechanisms for their identification, development, and implementation. The specific questions asked are:

- (1) How was the need for subnational C&I identified?
- (2) What mechanisms were used to develop the subnational indicators? and
- (3) How were the subnational indicators implemented?

## Australia

### Identifying the Need for Subnational Indicators

In 1992, Australia developed a National Forest Policy Statement, which led to the development of bilateral Regional Forest Agreements between the national and some state governments for some regions. Australia adopted the Montréal Process C&I of conservation and sustainable management of forests. Reporting on the condition of the forest resources was to be an integral component of management for the full range of forest values. The diversity of biological, social, and economic conditions across the breadth of the forested parts of the continent of Australia clearly required the development of subnational indicators.

The councils of national, state, and territory government ministers responsible for forestry and conservation made a policy decision requiring the public agencies to ensure that the systems of reporting were compatible between subnational and national levels. The subnational systems were based on the Montréal Process.

### Developing the Subnational Indicators

The process of identifying the subnational indicators was to call on scientists, policy-makers, and representatives of industry, conservation groups, Indigenous people, unions, and community groups to contribute to development of subnational indicators

using the Montréal Process C&I. That exercise involved the examination of the national level Montréal Process C&I for applicability at the subnational level.

Specialist workshops were held to explore in detail some of the conceptually or pragmatically difficult indicators, for example, ecosystem health, soils, and biodiversity. At two stages in the process, input was sought from large, national, stakeholder meetings. Research priorities were identified and a phased implementation approach was developed.

The subnational framework of indicators coming out of these procedures was then sent for approval by the Ministerial Council on Forestry and the equivalent Council for Environment and Conservation. The final document, entitled *A Framework of Regional (Subnational) Level Criteria and Indicators of Sustainable Forest Management in Australia*, was released in 1998 by the Commonwealth of Australia (ISBN 0-642-32052-7).

As a result of this process, 30 of the national level indicators unchanged for use at the subnational level were adopted, 10 were not applicable, 25 were reworded to more accurately reflect subnational issues, and 2 indicators were amalgamated with related indicators. Twelve new or interim indicators were developed for use at the subnational level. The Australian subnational indicators are compared with the Montréal Process indicators in Appendix A.

### Implementing the Subnational Indicators

The process of developing the subnational set of indicators also classified each indicator according to three categories:

- Category A—the indicator could be reported on immediately (that is, the information was currently available or with little effort could be made so for at least a significant proportion of forested land);
- Category B—up to 5 years of research was required;
- or
- Category C—more than 5 years of research was needed.

The implementation process is applicable to all forests in Australia on a voluntary basis. Implementation of reporting on subnational indicators is continuing to evolve. In Tasmania, for example, all category A

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<sup>4</sup> “Cash plantations” in China are plantations that are established to produce an economic and social outcome in the short term (3–5 years), thus providing an early income for local farmers without the need to cut the trees. Examples of cash

indicators, and any others for which information is available for that state, have been listed and reviewed by government agencies in the state and national governments, plus by the general public and industry. The National Forest Inventory will produce the first report on Category A indicators for Australia by early 2001.

Example: New South Wales—The need for subnational indicators in New South Wales was identified as a major requirement of the implementation of sustainable forest management<sup>3</sup> in the forests being reviewed under the national Regional Forest Agreement process.

A mechanism for implementing C&I was developed by a group (composed of representatives of state and national government agencies, the timber industry, trade unions, conservation groups, and indigenous peoples) convened to address requirements of sustainable forest management. A comprehensive project specification was developed by the group based on the framework of subnational C&I developed for all Australia. This was endorsed by state and Commonwealth governments and included the following steps:

1. A review of each of the subnational indicators was done to determine applicability to each of four regions within New South Wales. Regions varied in size from about 800 000 ha to 10 000 000 ha. Data availability, reliability, and access were used to determine sets of indicators that could be reported on immediately;

2. A consultancy report by an expert group of independent scientists was commissioned by the group to draw together resource material on current and international trends, and the state of information on the use of C&I; advice was provided on the development of indicators requiring further research before being implemented;

3. Stakeholder workshops were held to inform local stakeholders and experts of the process, and to receive their feedback on regional issues affecting the development of indicators;

4. Specialist expert workshops were held to provide scientific and technical advice on regional indicator sets and to further develop and refine specific indicators;

5. Indicators were developed for each region by the group using the input from the various workshops, meetings, the expert report, and the advice provided by specialist workshops;

6. Reports were prepared on "Criteria, Indicators, Targets and Monitoring Processes of Ecologically Sustainable Management" for specific regions to provide

a basis for monitoring and reporting by responsible state agencies on the environmental, social, and economic performance of forest management in each region (available at <http://www.rfa.gov.au/rfa/nsw/eden/esfm.html>).

Implementation in New South Wales is an ongoing process in which reports and five-year reviews assist stakeholder groups in implementing the C&I.

## Canada

### Identifying the Need for Subnational Indicators

Forests in Canada are 94% under federal, provincial, or territorial ownership. In 1995, the Canadian Council of Forest Ministers (CCFM), which includes federal, provincial, and territorial ministers responsible for forests, agreed to a set of national C&I for sustainable forest management. These national C&I were developed in consultation with governments, academics, industry, Aboriginals, and other interest groups, at the same time as the Montréal Process C&I. The two sets of national C&I are very similar and are viewed as complementary.

At the various meetings involved in developing the national C&I, it became clear that no single set of C&I could satisfy the needs of all regions and all scales. Local and provincial managers, increasingly interested in C&I for their potential application to certification, began to seek mechanisms for developing subnational indicators.

### Developing the Subnational Indicators

One of the major mechanisms for developing subnational indicators in Canada has been Canada's 11 model forests, established in representative forest regions of the country for developing sustainable forest management practices. Each model forest represents a partnership consisting of a broad range of interests which may include educational institutions, industry, Aboriginal groups, governments at all levels, community and public interest groups, environmental organizations, recreation associations, and others. One of the model forests is specifically designed to explore the effectiveness of a framework where Aboriginals have the leadership role and are not just another partner. To assess their progress toward sustainable forest management, each model forest board is testing and developing indicators for use within its region.

In keeping with the participatory concept of the model forests, a series of stakeholder meetings was held in each model forest to develop local sets of subnational indicators. The Model Forest Network, which links all the sites, regularly exchanged notes and experiences in order that each model forest might benefit from the progress made in the others. In most cases, the national indicators were used as a starting point and adjusted to suit local needs and conditions. Although this has led to indicator sets that are well-tailored to the needs of each region and are linked to the national set, this decentralized process has also meant that the resulting subnational indicator sets differ from each other in several respects.

At another subnational level, several of Canada's provinces have also engaged in defining C&I, generally starting with the national C&I. Quebec, Ontario, Saskatchewan, and Newfoundland are in various stages of developing provincial indicators; in some cases, reporting on these indicators is expected to be required by law.

As an example of the mechanism used, in the province of Quebec, a workgroup in the provincial government was established to develop subnational indicators for the province. This group started with the national indicators, largely because many of the group members had been part of the team that developed the CCFM C&I. The national criteria were adopted, and individual indicators were adapted, replaced, and added as needed to reflect provincial requirements. This process involves extensive consultation with partners in industry, academia, Aboriginal groups, and other interested parties. A draft document was widely circulated to stakeholders for comment, appropriate revisions made, and the new draft circulated again. This process is ongoing.

#### Implementing the Subnational Indicators

Within the model forests, reporting on the various local-level indicators has started with those for which data are most readily available. Because the model forests have strong research components, the capacity to report on most indicators is not expected to require a great deal of additional research, and much of the reporting is being done in the form of scientific or technical publications in the normal course of research activities. The model forest indicators are being used outside the model forests themselves. For example, the government of Newfoundland and Labrador, a partner in the Western Newfoundland Model Forest,

has worked closely with that model forest in developing indicators (Appendix B) and a guide to C&I used by the province in all its forest management offices ("Sustainable Forest Management: A Practical Guide to Using Criteria and Indicators" is available at < <http://www.wnmf.com/guidetoc.htm>>).

Although Quebec's provincial C&I are not all finalized, implementation has begun. As the Quebec government already holds large computerized databases, collected for other purposes, several indicators can already be reported on. The intent is that any data relevant to reporting on provincial C&I will eventually be accessible through the Internet, as a tool set for evaluation of progress toward sustainable forest management in Quebec.

## China

#### Identifying the Need for Subnational Indicators

The national Framework of Criteria and Indicators for Sustainable Forest Management in China was drafted by the Sustainable Forestry Research Centre of the Chinese Academy of Forestry, based on the Montréal Process C&I. Comments were supplied by various divisions of the State Forestry Administration and the final document was then approved by the State Forestry Administration of China.

Among the main challenges facing sustainable forest management in China are the shortage of forest resources, population pressure, economic pressure, and lack of public awareness. Subnational indicators in China are required to increase public awareness of sustainable forest management, to use indicators as the basis for forestry planning, to monitor and produce forest inventory, and to provide a framework for decision making by local government.

#### Developing the Subnational Indicators

The process of developing subnational indicators in China has involved several activities coordinated by the Sustainable Forestry Research Centre of the Chinese Academy of Forestry, for example, the assessment of the national level Montréal Process indicators for their immediate relevance to China. Some indicators were added, while others were deleted to reflect national issues. The resulting list, showing all changes, is included in the Year 2000 Progress Report and can be

seen on the Montréal Process web site ([www.mpci.org](http://www.mpci.org)).

Subnational indicators have been under development and testing since 1997 in three representative forest zones supported by the United Nations Development Program (UNDP). The subnational C&I were developed partly through consultation and partly through the establishment of eight sustainable forest management experiment and demonstration areas in selected areas across the ecozones of China. Further testing of the indicators is planned through model forests developed in cooperation with the Canadian Forest Service. The subnational indicators are based on the national C&I with appropriate deletions or additions to reflect the local or regional situation.

The national indicators were presented to several local workshops to determine what was useful, where data could be found, and who would find it useful. Comments on the subnational set were sought from national and international consultants. The subnational set was then presented to a national workshop, attended by experts and forest officials from different regions of China and from the Chinese Academy of Forestry. Another workshop was organized at which Chinese representatives came from the eight Demonstration Experimental Areas, as well as from Provincial Forestry Institutes. This workshop included experts from the Center for International Forestry Research (CIFOR) and Australia invited to assist in the evaluation. The subnational indicators are being tested in the field at four sites (Fenyi, Zhangye, and two at Yichun). These tests were expected to be completed by the end of 2000.

In the Fenyi region of Southeast China, 60 indicators have been developed (Appendix C), with several indicators designed specifically to take into account issues regarding forest ownership, timber plantations, and "cash plantations".<sup>4</sup> In the Zhangye region of Northeast China, 68 indicators have been developed with an emphasis on environmental and social issues, including water resource conservation, shelterbelts, and cash plantations. In the Yichun region of the Northeast, 77 indicators were developed, several of which emphasize maintaining forest productivity.

#### Implementing the Subnational Indicators

China is currently identifying which subnational indicators require more research or data and which can be reported on with existing information, with a view to completion by the end of 2000. A feasibility study for a

selected set of indicators has been carried out at the forest management unit level. Testing the local capacity to report on subnational indicators is currently under way for the Zhangye, Yichun, and Fenyi regions.

### United States

There are currently many activities under way developing C&I in the United States. These are linked in a variety of ways and degrees to the Montréal Process C&I. Examples of these activities follow.

#### Identifying the Need for Subnational Indicators

In the United States, forested areas are overlain by diverse and largely decentralized, jurisdictional, ownership, and organizational patterns. The need for subnational indicators is driven by the management requirements of the various agencies and organizations responsible for different aspects of land and resource management. For example, the six million private landowners who own and manage 58% of US commercial forest lands must meet state environmental standards designed to safeguard the environment. Within the private sector, certification initiatives such as the Green Tag Program sponsored by the National Woodland Owners Association, an association of nonindustrial woodland owners, feature certain C&I. The National Woodland Owners Association participates in national interagency efforts to implement the Montréal Process C&I nationwide.

The timber industry, which owns and manages 14% of US commercial forest lands, is also required to meet state regulations and is also interested in demonstrating sustainable management practices to satisfy public demand for products from lands that are properly managed. The American Forest & Products Association has a sustainable forest initiative with C&I to improve and demonstrate sustainable forest management activities on industrial lands. Concurrent with their development of subnational C&I for sustainable forest management, they participated in international efforts to identify the Montréal Process C&I.

Similarly, on federal US Forest Service lands, by law the agency must complete Forest Plans that entail collaborative assessment, planning, and decision-making processes. Forest Plans lay out the constraints, probable impacts, goals and objectives, desired future condition, and land-based performance measures to gauge progress. Thus, information needed for planning and decision-making processes, the need to demonstrate that

environmental laws and regulations are being met, and public demand for responsible management all drive the need to collect specific C&I measurements at both subnational and national scales.

### Developing the Subnational Indicators

Example: US Forest Service—As a first step in the development of subnational indicators, the federal US Forest Service hosted a CIFOR–North American test in Boise, Idaho. Many subnational indicators developed by a variety of organizations were examined, and a report on the initial selection and testing of appropriate measures of sustainability was produced (available at <http://www.fs.fed.us/institute/lucid/>). The federal US Forest Service has adopted the Montréal Process criteria as a framework. To strengthen the linkages between subnational indicators and the national Montréal Process C&I framework, the Forest Service is undertaking the Local Unit Criteria and Indicators Development project, or LUCID. This project will further refine the C&I selected during the CIFOR–North American Boise test, reconfiguring the indicators under the seven Montréal Process criteria. Organizing the CIFOR–North American indicators (Appendix D) under the Montréal Process C&I framework suggests a strong relationship between indicators. The LUCID project will strengthen these linkages. It has established six test forest areas to identify the areas that are necessary to sustain ecological, economic, and social systems and the C&I necessary to assess how forest management is influencing sustainability.

### Implementing the Subnational Indicators

Currently hundreds of millions of dollars of measurements of various indicators are collected annually by the plethora of forest management entities. Current initiatives adapting existing Forest Stewardship Council C&I will identify key C&I and help focus scarce resources on collecting measurements most useful in gauging sustainable forest management. Certification efforts by the forest industry are gaining momentum. In some sectors, increasing public demand for products generated from sustainable forest management is fueling certification efforts in the private sector. The National Association of State Foresters has endorsed the Montréal Process C&I, and several multiple state initiatives are under way using the Montréal Process C&I to assess sustainable forest management. The LUCID project is still under development. Thus efforts to implement C&I

for sustainable forest management at both the national and subnational scales within government, industrial, and private sectors are ongoing and increasing in momentum.

## Conclusions

- The Montréal Process C&I have provided a good basis for developing a subnational monitoring system of indicators to evaluate or assess subnational contributions to a country's progress toward sustainable forest management.

- In some countries, the implementation of the Montréal Process C&I has highlighted the need to develop subnational indicators. National circumstances, such as the size of the country, political infrastructure, and ecological diversity, strongly influence the requirement for subnational indicators. Consequently, some countries are developing subnational indicators based on the Montréal Process framework (or closely related sets of C&I), whereas other countries do not perceive a need for such indicators.

- The processes used to develop subnational indicators vary. Extensive consultation, frequently through a workshop with a diverse range of stakeholders, has been an integral part of the process. There is, however, no single mechanism for developing subnational indicators.

- Some countries have developed demonstration areas and test sites to assess subnational indicators. While these areas may fulfill multiple goals, they are proving useful for the development and evaluation of subnational indicators.

- Implementation of subnational indicators need not wait for the entire indicator set to be defined or for data to be available for all indicators.

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Appendix A. Comparison between Montréal Process (MP) indicators and the Australian (Au) sub-national indicators. Significant differences are highlighted with bold type.

MP #	Montreal Process text	Au #	Australian text
1.1.a	Extent of area by forest type relative to total forest area	1.1.a	Extent of area by forest type and tenure
1.1.b	Extent of area by forest type and by age class or successional stage	1.1.b	Area of forest by type and growth stage and distribution by tenure
1.1.c	Extent of forest type in protected area categories as defined by IUCN or other classification systems		see 1.1.a
1.1.d	Extent of areas by forest type in protected areas defined by age class or successional stage		see 1.1.b
1.1.e		1.1.c	Same
1.2.a	Fragmentation of forest types	1.2.a	Same
1.2.b	The number of forest dependent species  The status (threatened, rare, vulnerable, endangered, or extinct) of forest dependent species at risk of not maintaining viable breeding populations, as determined by legislation or scientific assessment	1.2.b	Same
1.3.a		1.3.a	Amount of genetic variation within and between populations of representative forest dwelling species
1.3.b	Number of forest dependent species that occupy a small portion of their former range	1.2.c	Same
	Population levels of representative species from diverse habitats monitored across their range	1.3.c	Extent of native forest and plantations of indigenous species which have genetic resource conservation plans prepared and implemented
2.a		2.a	Same
2.b	Area of forest land and net area of forest land available for timber production	2.b	Total growing stock of both merchantable and non-merchantable tree species on native forest land available for timber production
2.c	Total growing stock of both merchantable and non-merchantable tree species on forest land available for timber production	2.c	The area, age class and future yields of plantations of native and exotic species
2.d	The area and growing stock of plantations of native and exotic species	2.d	Same
2.e	Annual removal of wood products compared to the volume determined to be sustainable	2.e	Same
	Annual removal of non-timber forest products (e.g. fur bearers, berries, mushrooms, game)	2.f	

MP #	Montreal Process text	Au #	Australian text
	compared to the level determined to be sustainable	2.g	Area and per cent of plantation established meeting effective stocking one year after planting
		2.h	Area and per cent of harvested area of native forest effectively regenerated
3.a		3.a	<del>Extent of exotic plantations managed according to documented procedures or management plans to maintain genetic resources</del>
3.b	<del>Area and percent of forest affected by processes or agents beyond the range of historic variation, e.g. by insects, disease, competition from exotic species, fire, storm, land clearance, permanent flooding, salinisation, and domestic animals</del>	3.b	Area and percent of forest affected by processes or agents that may change ecosystem health and vitality
3.c	Area and percent of forest land subjected to levels of specific air pollutants (e.g. sulfates, nitrate, ozone) or ultraviolet B that may cause negative impacts on the forest ecosystem	3.c	Same
4.a	<del>Area and percent of forest land with diminished biological components indicative of changes in fundamental ecological processes (e.g. soil nutrient cycling, seed dispersion, pollination) and/or ecological continuity (monitoring of functionally important species such as fungi, arboreal epiphytes, nematodes, beetles, wasps, etc.)</del>	4.a	Area and percent of forest land with diminished or improved biological, physical and chemical components indicative of changes in fundamental ecological processes
4.b	Area and percent of forest land with significant soil erosion	4.b	Same; Interim indicator: Area and per cent of forest land systematically assessed for soil erosion hazard, and for which site-varying scientifically-based measures to protect soil and water values are implemented
4.c		4.c	Same
4.d	<del>Area and percent of forest land managed primarily for protective functions, e.g. watersheds, flood protection, avalanche protection, riparian zones</del>	4.d	Same
4.e	Percent of stream kilometres in forested catchments in which stream flow and timing has significantly deviated from the historic range of variation	4.e	Same; Interim indicator: The total quantity of organic carbon in the forest floor (<25 mm diameter components) and the surface 30 cm of soil
4.f	Area and percent of forest land with significantly diminished soil organic matter and/or changes in other soil chemical properties	4.f	Same; Interim indicator: Proportion of harvested forest area with significant change in



MP #	Montreal Process text	Au #	Australian text
4.g	Area and percent of forest land with significant compaction or change in soil physical properties resulting from human activities  Percent of water bodies in forest areas (e.g. stream kilometres, lake hectares) with significant variance of biological diversity from the historic range of variability	4.g	bulk density of any soil horizon of the surface (0-30 cm) soil  Same
4.h		4.h	Same
5.a	Percent of water bodies in forest areas (e.g. stream kilometres, lake hectares) with significant deviation from the historic range of variability in pH, dissolved oxygen, levels of chemicals (electrical conductivity), sedimentation or temperature change	5.a	Same
5.b	Area and percent of forest land experiencing an accumulation of persistent toxic substances	5.b	Same
5.c	Total forest ecosystem biomass and carbon pool, and if appropriate, by forest type, age class, and successional stages	5.c	Same
6.1.a	Contribution of forest ecosystems to the total global carbon budget, including absorption and release of carbon (standing biomass, coarse woody debris, peat and soil carbon)	6.1.a	Same
6.1.b	Contribution of forest products to the global carbon budget	6.1.b	Same
6.1.c	Value and volume of wood and wood products production, including value added through downstream processing	6.1.c	Same
6.1.d		6.1.d	Same
6.1.e		6.1.e	Same
6.1.f	Value and quantities of production of non-wood forest products	6.1.f	Deemed not to be useful at a sub-national level
6.2.a	Supply and consumption of wood and wood products, including consumption per capita	6.2.a	Value of wood and non-wood products production as percentage of regional value of production
6.2.b	Value of wood and non-wood products production as percentage of GDP	6.2.b	Deemed not to be useful at a sub-national level
6.2.c	Degree of recycling of forest products	6.2.c	Same
6.2.c	Supply and consumption/use of non-wood products	6.2.c	Area and percent of forest land available for general recreation and tourism
		6.2.d	

MP #	Montreal Process text	Au #	Australian text
6.3.a	Area and percent of forest land managed for general recreation and tourism, in relation to the total area of forest land	6.3.a	Number, range and use of recreation/tourism activities available in a given region
6.3.b	Number and type of facilities available for general recreation and tourism, in relation to population and forest area	6.3.b	Number of visits per annum
6.3.c	<del>Number of visitor days attributed to recreation and tourism, in relation to population and forest area</del>	6.3.c	<del>Proportion of forest sites available for recreation and tourism which are impacted unacceptably by visitors</del>
6.3.d	<del>Number of visitor days attributed to recreation and tourism, in relation to population and forest area</del>	6.3.d	<del>Proportion of forest sites available for recreation and tourism which are impacted unacceptably by visitors</del>
6.4.a	<del>Value of investment, including investment in forest growing, forest health and management, planted forests, wood processing, recreation and tourism</del>	6.4.a.i	Same  Deemed not to be useful at a sub-national level
	<del>Level of expenditure on research and development, and education</del>	6.4.a.ii	Same  Same
6.4.b	<del>Extension and use of new and improved technologies</del>	6.4.b	<del>Area and per cent of forest land in defined tenures, management regimes and zonings which are formally managed in a manner which protects Indigenous peoples' cultural, social, religious and spiritual values, including non-consumptive appreciation of country</del>
6.5.a	Rates of return on investment	6.5.a	Area and per cent of forest land in defined tenures, management regimes and zonings which are formally managed in a manner which protects Indigenous peoples' cultural, social, religious and spiritual values, including non-consumptive appreciation of country
6.5.b	Area and percent of forest land managed in relation to the total area of forest land to protect the range of cultural, social and spiritual needs and values	6.5.b	Proportion of places of non-Indigenous cultural value in forests formally managed to protect those values
6.5.c		6.5.c	Same
6.5.d		6.5.d	Same  Same
	Non-consumptive use forest values	6.6.a	Same (not specifically including Indigenous communities)
	Direct and indirect employment in the forest sector and forest sector employment as a proportion of total employment		
7.1.a	Average wage rates and injury rates in major employment categories within the forest sector  Viability and adaptability to changing economic conditions, of forest dependent communities, including indigenous communities	7.1.a	Area of land available and accessible for Indigenous people to exercise their inherent rights to meet subsistence or individual and family cultural and spiritual needs

MP #	Montreal Process text	Au #	Australian text
7.1.b	Area and percent of forest land used for subsistence purposes	7.1.b	Extent to which the management framework maintains and enhances Indigenous values including customary, traditional and native title use by Indigenous peoples and for Indigenous participation in forest management
7.1.c		7.1.c	Extent to which the legal framework provides mechanisms to clarify property rights and establish appropriate land tenure arrangements that recognize traditional management practices and self-management as well as the existence of native title and the customary and traditional rights of Indigenous peoples
7.1.d	Extent to which the legal framework clarifies property rights, provides for appropriate land tenure arrangements, recognizes customary traditional rights of indigenous people, and provides means of resolving property disputes by due process	7.1.d	Same
7.1.e	Extent to which the legal framework provides for periodic forest-related planning, assessment, and policy review that recognizes the range of forest values, including coordination with relevant sectors	7.1.e	Same
7.2.a	Extent to which the legal framework provides opportunities for public participation in public policy and decision-making related to forests and public access to information	7.2.a	Extent to which the legal framework encourages the development and application of best practices codes for forest management
7.2.b	Extent to which the legal framework encourages best practices codes for forest management	7.2.b	Extent to which the legal framework provides for the management of environmental, cultural, social and/or scientific values in forests and ensures the participation of Indigenous peoples in all aspects of forest planning and management processes
7.2.c	Extent to which the legal framework provides for the management of forests to conserve special environmental, cultural, social and/or scientific values	7.2.c	Same
7.2.d		7.2.d	Same
7.2.e		7.2.e	Same
7.3.a	Extent to which the institutional framework supports the capacity to provide for public involvement activities and public education, awareness and extension programs, and make available forest-related information	7.3.a	Same
	Extent to which the institutional framework supports the capacity to undertake and implement periodic forest-related planning, assessment, and		Deemed not to be useful at a sub-national level

MP #	Montreal Process text	Au #	Australian text
7.3.b	policy review including cross-sectoral planning and coordination	7.3.b	Same
7.4.a	Extent to which the institutional framework supports the capacity to develop and maintain human resource skills across relevant disciplines	7.4.a	Deemed not to be useful at a sub-national level
7.4.b	Extent to which the institutional framework supports the capacity to develop and maintain efficient physical infrastructure to facilitate the supply of forest products and services and support forest management	7.4.b	
7.4.c		7.4.c	
7.5.a	Extent to which the institutional framework supports the capacity to enforce laws, regulations and guidelines	7.5.a	Deemed not to be useful at a sub-national level
7.5.b	Extent to which the economic framework supports investment and taxation policies and a regulatory environment which recognizes the long-term nature of investments and permit the flow of capital in and out of the forest sector in response to market signals, non-market economic valuations, and public policy decision in order to meet long-term demands for forest products and services	7.5.b	Same
7.5.c	Extent to which the economic framework supports non-discriminatory trade policies for forest products	7.5.c	Deemed not to be useful at a sub-national level
7.5.d	Availability and extent of up-to-date data, statistics and other information important to measuring or describing indicators associated with criteria 1-7	7.5.d	Deemed not to be useful at a sub-national level
7.5.e	Scope, frequency and statistical reliability of forest inventories, assessments, monitoring and other relevant information	7.5.e	
		7.5.f	Deemed not to be useful at a sub-national level

Appendix B. Sub-national indicators from Canada's Western Newfoundland Model Forest organized under Values (in italics) which are in turn organized under Criteria (in bold); an indication of geographic scale of applicability is given in parentheses after each indicator.

### Conservation of Biological Diversity

#### Representative Landscapes

- Proportion of each eco-region that is in a protected status (District/Provincial)
- Proportion of each eco-region that is barren, bog, forest and water (District/Provincial)
- Proportion of each protected area that is barren, bog, forest and water (District/Provincial)

#### Special Places

- Proportion of unique features identified in the Natural Areas System Plan that are protected or subject to special management provisions (Provincial)

#### Wildlife Habitat

- Area of each forest type by age class (District/Provincial)
- Area of suitable habitat for selected species (District/Provincial)

#### Native and Valued Species

- Known forest-dependent species classified as extinct, extirpated, endangered, threatened and vulnerable on national, provincial and local lists, including change in risk status of species and change in numbers of individuals for each species at risk (District/Provincial)
- Change in population level or ranges of selected species (District/Provincial)
- Genetic information about selected species (Provincial)
- Reproductive success or fecundity of selected species (Provincial)

### Healthy Forests

#### Natural Processes

- Area and severity of insect, fire and disease disturbance, and succession pattern afterwards (District/Provincial)
- Area and severity of human-caused disturbances and succession pattern afterwards (District/Provincial)
- Frequency, abundance and distribution of selected indicator species relative to natural cycles (District/Provincial)

#### Natural Productive Capacity

- Mean annual increment (District/Provincial)
- Reproductive success or fecundity of selected species (Provincial)
- Land use changes, changes to total area of forest cover (District/Provincial)

#### Long-term Ecosystem Health

- Information about provincial strategies to respond to the management challenges posed by global climate change (Provincial)

### Soil and Water

#### Water

- Percentage of forest managed primarily for water protection (District/Provincial)
- Hydrometric data compared with stream-specific historical values in selected watercourses (Stand/District)
- Number and severity of extraordinary flood events (Stand/District)
- Reported cases of giardia ("beaver fever") (Local/Provincial)
- Changes to streams (positive and negative) that affect salmonid habitat (Stand/District)



### Soil

Percentage of harvested area having significant soil compaction, displacement, erosion, puddling, loss of organic matter, etc. (District/Provincial)

Information about nutrient cycling, such as nutrient availability, nutrient uptake, and evidence of nutrient loss (Stand/District)

### Good Forest Policy Enforcement

Percentage of the forest lands that are part of a current Five-Year Management Plan that has been registered under Environmental Assessment and released (District/Provincial)

Number of forest-related infractions (District/Provincial)

## Global Impacts

### Stable Climate

Percentage of wood harvested that is used for energy, paper and lumber (District/Provincial)

Logging utilization rate (District/Provincial)

Information about forest wood product life cycles (Provincial)

Percentage of recycled fibre used in newsprint manufacturing (Provincial)

Forest sector CO<sub>2</sub> emissions (Provincial)

Surface area of fresh water (District/Provincial)

### Forests as Carbon Sinks

Tree biomass volumes (District/Provincial)

Vegetation (non-tree) biomass estimates (District/Provincial)

Percentage of canopy cover (District/Provincial)

Percentage of biomass volume by general forest type (District/Provincial)

Soil carbon pools (District/Provincial)

Soil carbon pool decay rates (District/Provincial)

Area of permanent forest depletion (District/Provincial)

Area of forest lands that are not sufficiently restocked (District/Provincial)

## Benefits to Society

### Commercial Timber

Volume or mean annual increment (District/Provincial)

Area treated to encourage the growth of timber for sawlog production (District/Provincial)

Area and percentage of the forested land base available for commercial timber production (District/Provincial)

Volume of merchantable wood left on site after harvest (District)

Percentage of Annual Allowable Cut used for lumber (District/Provincial)

Volume of wood exchanged between pulp mills and sawmills (Provincial)

Volume of lesser-used species used in forest product manufacturing (District/Provincial)

Total value of value-added forest product manufacturing (District/Provincial)

### Employment

Number of people employed in forest-based activities, broken down by category (Local/District/Provincial)

Number of people employed, in full-time equivalents, by category (Local/District/Provincial)

Average annual income, by category (Provincial)

Workers' Compensation costs, by category (Provincial)

Forest-related employment (in person-hours) per unit (Provincial)

Investment in training to promote best practices related to sustainable forest management (Provincial)

### Non-timber Forest Products and Services

- Number of lodges and businesses (District/Provincial)
- Number of out-of-province licenses issued (District/Provincial)
- Total revenue generated by the outfitting industry (Provincial)
- Number of licensed trappers (District/Provincial)
- Total revenue from fur sales (Provincial)
- Volume of berries shipped (District/Provincial)
- Total revenue from commercial berry sales (Provincial)

#### Recreation

- Number of domestic hunting and fishing licenses (District/Provincial)
- Membership in forest-based recreation clubs (Local/District/Provincial)
- Participation rate in forest-based recreation activities (Local/District/Provincial)
- Resource base available for selected recreation activities (District/Provincial)
- Satisfaction levels (Local/District/Provincial)

#### Forest Products for Personal Use

- Estimated volume of harvest for personal use (Local/District/Provincial)
- Equivalent dollar value (Local District/Provincial)

#### Heritage

- Number of sites, trails or facilities that provide public interpretation of some aspect of or information about forests (Local/District)
- Proportion of each ecoregion in a protected area (District/Provincial)
- Historic or archaeological sites that have been inventoried, and percentage that have adequate protection (District/Provincial)

#### Spiritual Values

- “Litter index” based on ground surveys (Local/District)
- Percentage of each watershed or valued viewscape that has been cut in the previous 10 years (District/Provincial)

#### Public Involvement and Commitment

##### Forest Contribution to Community Sustainability

- Percentage of households that have some forest-based employment (Local/Provincial)
- Number of households that supplement their income through the collection or sale of forest products, and approximate value as a percentage of total household income (Local/Provincial)
- Value of forest-based goods and services, in dollars or dollar equivalents and as a percent of Gross Domestic Product (Provincial)

##### Fair Decision Making

- Number and variety of different stakeholders represented on forest management planning or monitoring committees (District)
- Degree of consensus on the part of all stakeholders who have been involved in the planning process (District)

##### Informed and Responsible Decision Making

- Investments in forest-related communications and awareness-raising (Local/District/Provincial)
- Investments in forest-related education and training (Local/Provincial)
- Investments in forest-related research and technology transfer (Provincial)
- Violations or infractions (District/Provincial)



Aboriginal Perspectives and Involvement

Number of Aboriginal groups/communities involved in the forest management planning process  
(District/Provincial)

Area of Aboriginal forest lands under integrated management plans (District/Provincial)

Appendix C. Sub-national indicators developed for the Fenxi Region of China, compared to China's national indicators. Major differences are marked in bold type.

national indicator	regional indicator	regional	FMU
national indicator	regional indicator	regional	FMU
1.1.1	ecosystem diversity	Yes	Yes
1.1.2	species diversity	Yes	Yes
1.1.3	genetic diversity	Yes	?
2.1	area and net area forest land available for timber production	Yes	Part
2.2	area and total growing stock	Yes	Yes
2.3	ratio of different productivity classes/ types of forest land	Yes	Yes
2.4	total growing stock of forests for timber	Yes	Yes
2.5	area and growing stock of plantation	Yes	Yes
2.6	distribution of area and stock of forest for wood by age-class	Yes	Yes
2.7	annual cutting of forests for timber should not exceed	Yes	Yes
2.8	annual removal of non-timber forest products	Yes	Yes
3	Maintenance of forest ecosystem health and vitality		
3.1	area and percent of forest affected by processes or agents beyond the range of historic variation	Yes	Yes
3.2	area and percent of air polluted	Yes	Yes
3.3	area and percent of land with diminished biological components	Yes	Yes
4.1	area and percent of land with serious soil erosion	Yes	Yes
4.2	area and percent of cultivated land on slope over 25 degrees which has been turned back into forest land	Yes	Yes
4.3	area and percent of forest for soil and water conservation	Yes	Yes
4.4	percent of stream km in forested catchments	Yes	Yes
4.5	range of changes in physical and chemical properties	Yes	Yes
4.6	controlled area and control percentage of areas with soil and water losses - middle (rehabilitation)	Yes	Yes
4.7	controlled area and control percentage of areas with soil and water losses - light (rehabilitation)	Combine with 4.6	
4.8	area and percent of cultivated (agricultural) land on slope on which maintenance and conservation	Yes	Yes
4.9	area and percent of man-made forest which has a serious degrading index	Yes	Yes
4.10	area and percent of broad leaved forest in man-made forest	Yes	Yes
4.11	area and percent of different tree species	Yes	Yes
4.12	area and percent of replanted man-made forest	Yes	Yes
4.13	area and percent of land on slope on which maintenance and conservation of soil and water	Yes	Yes
4.14	Intensity, area and percent of protection of forest ground vegetation	Yes	Yes
5.1	area of forests	Yes	Yes
5.2	total forest ecosystem biomass	No	No
5.3	area and consumption of forests for energy resources and its contribution	Yes	No
5.4	production and consumption of forest products and its contribution	No	No
5.5	area of forest cutting and its contributions	No	No
5.6	absorption of carbon by forest	No	No
5.7	carbon emission by soil	No	No
5.8	release of CO <sub>2</sub> and CH <sub>4</sub> by peat	No	No
6.1	demand and supply of forest products	Yes	No
6.2	investment in forestry	Yes	Yes

national indicator	regional indicator	regional	FMU
6.3	forest recreation and tourism	Yes	Part
6.4	demands and assessment of culture	Yes	Yes
6.5	employment and social community requirements	Yes	Yes
7.1	Legislation		
7.1.1	forest resource ownership in China	No	No
7.1.2	institution for management of forest resources in China	Yes	No
7.1.3	forest management system should be established	Yes	No
7.1.4	adopt data management system for managing forest resources	Yes	Yes
7.1.5	strengthen administrative regulation in forest, management (forest management act)		
No	No		
7.2	Policy		
7.2.1	policy for social participation in forestry	Yes	No
7.2.2	policy for training of forestry human resources	Yes	No
7.2.3	policy for adjusting the structure of forestry industry	Yes	No
7.2.4	policy for construction of forestry infrastructure	Yes	No
7.3	investment policy		
7.3.1	favourable policy on forestry	Yes	No
7.3.2	adopt policy collecting silviculture expenditure (tax)	No	No
7.3.3	establish forest ecology compensation system	Yes	No
7.3.4	strengthen institution of forestry funds	Yes	Yes
7.3.5	expand fund channel for forestry construction	Yes	Yes
7.3.6	absorb and exploit overseas funds to speed up major project construction in forestry	dropped	
7.3.7	speed up construction of institution for modern forestry enterprise	Yes	No
7.3.8	establish fair trading of forest products	Yes	No
8.1	measuring and monitoring		
8.1.1	the scope and rationale for choice of criteria on relevant data	dropped	
8.1.2	the scope within which data in different monitoring network are available	Yes	Yes
8.1.3	selection of common internationally used measurement methods and the..	No	No
8.2	research and development		
8.2.1	classified characteristics	Yes	No
8.2.2	the accounting system and techniques	No	No
8.2.3	evaluation of the contribution of science and technology	No	No
8.2.4	evaluation of effects of anthropogenic disturbance to forests	Yes	Yes
8.2.5	evaluation of possible effects of climate on forests	Yes	No
	Forest Management Unit Types in SE China	Avg. size	
	State owned forest farm	2000	
	Township	200	
	a) Collective forest farm		
	b) village		
	Contracted forest	2	
	Other (National reserve & forest park)	1000	

Montreal Process National C&I	CIFOR–NA sub-national C&I
<p>1. Conservation of biological diversity</p> <ul style="list-style-type: none"> <li>1.1 Ecosystem diversity</li> <li>1.2 Species diversity</li> <li>1.3 Genetic diversity</li> </ul>	<p>7.4 Capacity to measure and monitor changes in the conservation and sustainable management of forests</p> <p>7.5 Capacity to conduct and apply research and development aimed at improving forest management and delivery of forest goods and services</p>
<p>2. Maintenance of productive capacity of forest ecosystems</p>	
<p><del>3. Maintenance of forest ecosystem health and vitality</del></p>	
<p><del>4. Conservation and maintenance of soil and water resources</del></p>	
<p><del>5. Maintenance of forest contribution to global carbon cycles</del></p>	
<p>6. Maintenance and enhancement of long-term multiple socioeconomic benefits to meet the needs of societies</p> <ul style="list-style-type: none"> <li>6.1 Production and consumption</li> <li>6.2 Recreation and tourism</li> <li>6.3 Investment in the forest sector</li> <li>6.4 Cultural, social and spiritual needs and values</li> <li>6.5 Employment and community needs</li> </ul>	
<p>7. Legal, institutional and economic framework for forest conservation and sustainable management</p> <ul style="list-style-type: none"> <li>7.1 Legal framework</li> <li>7.2 Institutional framework</li> <li>7.3 Economic framework</li> </ul>	
Montreal Process National C&I	CIFOR–NA sub-national C&I

