Technical Advisory Committee Meeting

September 23-25, 1996
Pasadena, California, USA

Memorandum

October 24, 1996

To: Members of the Montreal Process Working Group
From: Technical Advisory Committee
Re: Report of the Technical Advisory Committee

1. The eighth meeting of the Montreal Process was held between the 3-5 June, 1996 in Canberra, Australia. At that meeting, an informal Technical Advisory Committee (TAC) was created to provide technical advice to the Montreal Process Working Group, as requested under its draft terms of reference. The TAC was asked to make recommendations to the working group on issues related to the implementation of criteria and indicators, definitions of terms relating to several Montreal Process indicators, clarifying the use of forest type in assessing biodiversity and providing advice on measurement approaches for 24 of the indicators.

2. The process used by the TAC was to circulate a draft discussion paper on the subjects listed above and then, via written comments and a three day meeting, to reach consensus on recommendations to the Montreal Process Working Group. The meeting of the TAC was held September 23-25, 1996 in Pasadena, USA. Delegates from Australia, Canada, Chile, Korea, Mexico, New Zealand, the Russian Federation, the United States of America and Uruguay participated in the meeting. In addition written comments from Japan, the FAO and IUFRO were included in the final revision of the document. The final report of the TAC to the Working Group is attached.

3. The TAC was given a list of twelve terms to define. In addition, the TAC was requested to provide proposed text inclusions for the appendix, "Explanatory Notes on selected criteria and indicators" for consideration by the Working Group. This text would include an approach to gathering data to fulfill the intent of each of the indicators. Suggestions for text additions to the Explanatory Notes were developed for 24 indicators within criteria 1-6, as requested. Agreement was reached on all of the requested definitions and suggested explanatory text. The TAC realized that one term not listed in the terms of reference needed to be defined. This was the "range of historic variation" which was included in the final report.

4. The TAC also suggests that the Montreal Process Working Group may wish to give consideration to the following matters at its ninth meeting in Seoul, Korea in mid-1997:

   a. The development of definitions for additional terms used in the Montreal Process.

   b. The development of approaches to data collection for the remaining Montreal Process indicators.

   c. The extent to which definitions and approaches to data collection agreed to by the Montreal Process Working Group should be reflected in the presently published Santiago Declaration and accompanying list of criteria and indicators and explanatory notes. For example, this could be done by publishing an addendum or a new document.

d. The utility and feasibility of developing rationale statements for indicators under criteria 6 and 7.

e. The feasibility of developing a voluntary design and measurement protocol for indicators requiring field sampling or use of reference sites. This is primarily for indicators related to forest health and vitality and the conservation of soils and water (which are best assessed through the use of sampling on reference sites and extrapolation to national conditions).

f. The feasibility of endorsing an approach to modeling carbon budgets in forest ecosystems and for forest products.

5. The TAC suggests that prreliminary consideration and review of the TAC report and recommendations might be solicited at an ad hoc meeting of the MPWG on the margins of IPF4, if such a meeting could be arranged.

In conclusion, all members of the TAC appreciated the opportunity to contribute to the report. We hope the attached report is of assistance to the Montreal Process Working Group in its future work.

Draft 3.0 September 25, 1996

REPORT OF THE TECHNICAL ADVISORY COMMITTEE TO THE WORKING GROUP ON CRITERIA AND INDICATORS FOR THE CONSERVATION AND SUSTAINABLE MANAGEMENT OF TEMPERATE AND BOREAL FORESTS ("THE MONTREAL PROCESS")

1. INTRODUCTION

At the Eighth Meeting of the Working Group on Criteria and Indicators for the Conservation and Sustainable Management of Temperate and Boreal Forests ("Montreal Process"), held June 3-5, 1996 in Canberra, Australia, it was agreed to establish a Technical Advisory Committee (TAC) to provide advice on technical matters to the Montreal Process working group. The TAC was tasked with three areas of work. These areas relate to definitions of terms, an examination of the use of forest type as a means to characterize biodiversity and the development of proposals for approaches to gathering data that will fulfil certain indicators.

2. BACKGROUND

The Montreal Process is informally named after the original CSCE seminar of experts on the Sustainable Development of Temperate and Boreal Forests, held in Montreal, Canada, in September 1993. The Montreal Process has, since its inception in June 1994, worked to establish an agreed set of criteria and indicators for the conservation and sustainable management of boreal and temperate forests. The working group proposed seven criteria and 67 indicators which were endorsed via the Santiago Declaration by ten countries (Australia, Canada, Chile, China, Japan, Korea, Mexico, New Zealand, the Russian Federation and the United States of America) in February, 1995. Subsequently the Santiago Declaration was also endorsed by Argentina and Uruguay.

Following the endorsement of the Montreal Process criteria and indicators via the Santiago Declaration, countries participating at the Seventh Meeting of the Montreal Process in Auckland, New Zealand, agreed to assess the current availability of data for reporting on the indicators and to assess the difficulty of reporting on those indicators where data is currently unavailable. A summary report of the country-by-country analyses of data availability was undertaken by the liaison office and tabled at the Eighth Meeting of the Montreal Process. Also at the Eighth Meeting it was decided that the Montreal Process would collectively produce two reports, one as a progress report on implementation for distribution at the Fourth Session of the UN CSD Intergovernmental Panel on Forests in early 1997, and the second as a First Approximation Report by the Montreal Process countries, to be distributed to the Eleventh World Forestry Congress in Antalya, Turkey in October, 1997.

In assessing the needs of countries in collecting, using and reporting on data related to the 67 indicators of the Santiago Declaration, it was recognized that there remained some uncertainty of meaning of some terms and that there were shared issues among countries in choosing an appropriate approach to measuring many of the indicators. The participating countries at the Eighth Meeting of the Montreal Process determined that a technical committee, bringing together expertise from all member countries could facilitate some common progress on these definitional and measurement issues.

3. PROPOSED DEFINITIONS OF SELECTED TERMS RELATED TO THE MONTREAL PROCESS CRITERIA AND INDICATORS

The following twelve definitions are proposed related to the terms identified at the Eighth Meeting of the Montreal Process:

3.1 Forest dependent species

A forest dependent species is any species that needs forest conditions for all or part of its requirements of food, shelter or reproduction.

That is, any species that could not survive or reproduce in the absence of forest ecosystems is forest dependent. Migratory species that use the forest during migration, and forest species dependent on them will also be considered as forest dependent.

3.2 Biological Diversity

Biological diversity (or biodiversity) is the variability among living organisms from all sources including terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems (Convention on biological diversity).

With regards to forests, biodiversity incorporates three concepts:

1. Ecosystem diversity describes the variety of different ecosystems, found in a region. A categorization of the combination of animals, plants, micro-organisms and the physical environment with which they are associated is the basis for recognizing ecosystems.

2. Species diversity describes the number and variety of species in a given area.

3. Genetic diversity describes the range of genetic characteristics found within a species and among different species.

3.3 Successional stage

A successional stage is a characteristic of ecosystems that experience a change in species on a given site in relation to time since major disturbance.

Where they occur, seral stages include early successional vegetation through to later successional stages. In many cases the successional stages reflect a shift from the dominance of shade intolerant species to that of shade tolerant species.

It must be recognized that some forest types are stable in their response to disturbance.

3.4 Age class

Age class is a category into which the average age or age range of trees or other vegetation is divided for classification or use.

Age class is usually used in reference to even-aged stands of trees. It represents the dominant age of the main body of trees in a stand. In mixed-aged stands, age class can be used to describe the average age of specific cohorts of trees.

3.5 Direct and Indirect employment

Direct employment is the number of jobs created by firms in the process of producing a good or service. However, in the process of producing the good or service, the primary firm also generates secondary economic activity in other sectors of the economy. The jobs created by this secondary economic activity are referred to as indirect employment. Indirect employment is the result of two types of economic transaction. First, jobs are created in secondary firms that provide materials, supplies, goods and services to the primary firm. Second, employees of primary firms spend their wages and salaries in the local economy which generates activities in the local retail and service sectors.

3.6 Forest dependent communities

Forest dependent human communities are defined as communities dependent upon forests for their survival. Such communities include municipalities, indigenous communities and family groups.

There is some difficulty in making general statements about what constitutes a forest dependent human community, because a wide range of factors may affect the future viability of a community. Forest dependent human communities are defined as communities with more than a significant level of the base income earned or proportion of employment coming from forest products or forest use.

In many cases, especially in rural communities, the economy develops around a single resource-based activity. The viability of such communities may be threatened or impacted by the loss of that industry, goods or services.

In the case of subsistence dependency, a different concept would apply. Where the residents of communities hunt, gather, collect, or grow, in forests, goods equal to a significant proportion of their total needs, they can be viewed as forest dependent.

3.7 Subsistence

Harvesting or growing products directly for personal or family livelihood.

Subsistence needs generally include foodstuffs, fuelwood, clothing and shelter. Subsistence goods can be considered any good which is a substitute for a market good.

3.8 Merchantable tree species

A merchantable tree species is one that has known commercial wood uses.

Merchantability is usually judged with respect to the suitability of a species for pulp, paper, lumber or specialty wood products. Both native and exotic tree species can be considered merchantable tree species.

3.9 Exotic species

An exotic species is any species growing or living outside its natural range of occurrence.

Normally this refers to species purposely or accidentally introduced into countries or regions where they are not historically occurring naturally.

3.10 Diminished biological components

A reduction in the diversity of biological species that may affect the resilience of the whole ecosystem.

An ecosystem is considered to have both biotic and abiotic elements. Many species of microflora or insects are very important to soil building, plant reproduction, or nutrient cycling. The biotic elements are dynamic in occurrence and will change in response to natural vegetation succession or artificially induced changes. The concept of diminished biological components reflects reductions or shifts in biological processes in a given forest relative to what might be expected based on an undisturbed, similar reference site.

3.11 Forest ecosystem vitality

The ability of an ecosystem to perpetuate itself.

The degree of vitality may be reduced by chronic factors such as pollution, nutrient imbalance, foraging stress or change in the historic disturbance frequency or intensity. The loss or replacement of key biological components such as decomposers, pollinators, or food chain relationships can also reduce the degree of vitality.

3.12 Range of historic variation

Interpretation of indicator data or trends may require a benchmark or reference. Experience has shown that seeking to describe "natural conditions" as a reference is difficult. Describing the historic conditions or ecological history prior to the changes brought about by industrial development can be accomplished. This time period can be set based on the context of national conditions.

Forest ecosystems or their biotic elements cannot be described as a static condition at any one place or time. It is difficult to define all the interrelationships and needs of species or processes within an ecosystem. Recognition of historic disturbance regimes and habitat conditions, however, provides a broad understanding for interpreting the implications of current conditions on species and overall ecosystem health and integrity. Disturbance regimes or habitat conditions are a function of the size, frequency and intensity of recurring natural processes, e.g., fire, volcanic eruptions, insect outbreaks, storms or watershed conditions. The species characteristic of an ecosystem are partially products of their adaption to these conditions or disturbances cycles and continue to be dependent on them.

4. THE USE OF FOREST TYPE AS A MEANS TO EFFECTIVELY CHARACTERIZE BIODIVERSITY

Under Criterion 1 of the Montreal Process, "Conservation of Biological Diversity", reference is made to the use of measures of change in the extent of forest types as an indication of changes in ecosystem diversity. Forest type is a term with a hierarchical set of meanings depending on the scale of the landscape being addressed. At a national level countries must first distinguish forest ecosystems from non-forest ecosystems. Within forest, then, forest ecosystems can be categorized at varying scales. Within areas defined as forested, aggregated forest types can be used to broadly categorize vegetation, for example as broadleaved vs mixed vs evergreen, hardwood vs softwood or rainforest vs wet schlerophyll vs dry schlerophyll. In most countries forest type refers to the categorization of forest into tree species types such as hinoki, spruce-fir, or flooded gum.

The elements of a forest type category will vary from country to country. For example forest type can include the percentiles of major forest canopy tree species, the age of the forest since last major disturbance, the quality of the site in terms of productivity, the canopy closure or tree stocking, understory vegetation, the total or merchantable timber volume, etc. The boundaries of a forest type are usually defined by forest inventory specialists who quantify or judge the variation and determine when one forest type has changed to another. Forest types or groups of forest types can be as small as less than one ha or up to thousands of ha depending on the nature of the forest and the variability of landform and terrain.

Many forest type classification systems were initially established as part of a timber inventory mapping process. The types were often used as the basis for forest inventory, monitoring and projection of timber growth and yield. However, recent increases in public interest in non-timber values in forests has led to a broadening of the concept of forest type and a broadening of the uses and interpretations placed on forest types. At an optimum, forest type can be expanded beyond tree species groupings to a concept forest ecosystem mapping. This type of change would be expected to take many years to unfold because of the magnitude and cost of full vegetation mapping processes. At the point at which ecosystems are mapped, the forest type mapping becomes a highly effective tracking of the distribution and abundance of ecosystems and hence, their diversity. Changes in the diversity of ecosystems allows some ability to estimate the potential changes in availability of habitat for species and hence to estimate potential changes in species diversity. Where there has been large scale habitat modification, or land use changes, for example, to agriculture there is also the ability to recognize the risk or magnitude of reduced genetic diversity.

A total mapping of forest ecosystems has been done in some countries. However, at present, most countries could use forest type as a surrogate measure of forest ecosystems. As forest type is generally a mapped feature, it does provide a continuing record of the distribution and abundance of tree species cover and other associated features, such as habitat. It is in this regard that forest type can be used to monitor potential changes in ecosystem diversity. Systematic changes in the proportions of forest types, such as late successional versus seral, or broadleaved versus conifer, can indicate changes in the nature of the biodiversity of a country or region. While tracking ecosystem diversity via forest type can overlook slight changes in vegetation communities and biota, it will signal changes that likely correlate with shifts in the pattern and character of biodiversity.

Using forest type as a surrogate for ecosystem diversity, then, relies on the ability to track or predict changes in the nature, extent and distribution of aggregated forest types at the national or, in the case of larger countries, regional scale. Some benchmark record or historical record of forest type must be used against which to measure the degree of change and repeated measures over time can then indicate expansion, contraction, loss and creation of forest types. Where specific forest types are shown to be critical to the survival or well-being of certain species, proportional changes in forest type can provide insight into potential changes in dependant flora and fauna. Where there has been loss of forest types at the edge of climatic or geographic ranges of species, there is likelihood that genetic diversity of species or populations may be compromised. It must also be recognized, however, that many locally adapted populations (e.g. resistant to drought or salinity) are not found solely at the edge of overall species ranges.

In summary, forest types (or groups of forest types) are defined and used differently in different countries. Forest type is presently considered to be the best available surrogate for the measurement of forest ecosystem biodiversity. The effectiveness of this approach, however, will be dependant on the degree of correlation actually found between forest types and inter- and intra-specific diversity, the quality of the data, the amount of information used in the forest type label, and the ability to assess trends in forest type changes. Finally, the interpretation of changes in the distribution and abundance of forest types can potentially be used cautiously as a signal that changes may be occurring in species and genetic diversity of forests.

5. APPROACHES TO DATA GATHERING FOR SPECIFIC INDICATORS

The Montreal Process group requested specific advice on potential approaches to gathering data for the following 24 indicators. The following recommendations are applicable to all tenures of forest land, including production forests, protected forest areas and privately owned forest lands.

5.1 Fragmentation of forest types

Fragmentation is a break in the continuous distribution of an ecosystem or a successional stage.

Fragmentation is a phenomenon that occurs naturally due to fire, windstorms, insect epidemics or other disturbances. Human disturbance such as harvesting, roadbuilding, or recreational site development also causes fragmentation of forest cover. More significant is the fragmentation of forest cover by land use changes, for example from forest cover to agriculture, where fragmentation is permanent or semi-permanent.

At a national scale, fragmentation of forest types is primarily an issue of species migration and genetic flow and interchange among neighbouring populations. However, judging the impact of fragmentation will depend on a number of factors including the size, shape and location of the fragment, the land use in surrounding areas and the breeding system of species living in the fragment. Systematic fragmentation of forest cover, due to large scale harvesting of specific forest types, clearing of lowland vegetation for agriculture, isolation of higher elevation forest types or clear breaks in continuous belts of forest are the key national scale phenomena that should be monitored.

Given the issues involved, the most effective tool for mapping forest fragmentation would be a combination of aerial photography and satellite imagery. Simple mapping and identification of connectedness or fragmentation of broad forest cover would serve to address this indicator at a national scale.

5.2 Number of forest dependant species that occupy a small proportion of their former range

Forest dependent species are those requiring forest conditions for all or part of their requirements of food, shelter or reproduction.

The range of species is constantly fluctuating in response to geological time scale phenomena such as glaciation, vegetation migration, climatic fluctuation, predation and interspecific competition. Human induced changes in forest landscapes have often accelerated the changes in species ranges or destabilised the competitive relationship among species. For example, the white-tailed deer has migrated far north of its former range in North America due to forest clearing, while the southern extremity of the range of moose has been shifted northwards. Most forest dependent species that are now occupying small portions of their former range would be dependant on forest types that have been significantly cleared for other purposes.

These species are likely often the core of endangered species lists. Other, more ubiquitous species may also have a reduced range, while not being under endangered status as a species. Development of a list of such species should be based on historical records of past and current distribution. The setting of a specific level for species occupying a small portion of their former range should be undertaken in the national context and with reference to the organisms concerned. Given that countries may not have specific data on this aspect, it may be worthwhile to present a specific case study or example species.

Consideration should also be given to identifying species with significant increases in their ranges.

5.3 Population levels of representative species from diverse habitats monitored across their range

It is often difficult to identify early warnings of changes in conditions that may impact negatively on biodiversity. It is difficult to diagnose natural population variations that may result from climatic fluctuation or predator-prey cycles. Monitoring a set of key species may help distinguish natural variation from changes related to habitat loss, fragmentation, exotic species predation or competition, or other factors. Design of such a monitoring system should focus on species with very different critical habitat requirements, i.e. cavity nesting birds, seral stage dependant birds and mammals, browsing ungulates, migratory species, carnivores, insectivorous birds or species of other taxa known to be sensitive indicators of ecosystem health such as lichens.

Monitoring approaches cover a range of techniques including systematic measurement of core habitat, direct ground survey techniques, bird counts using volunteers, bird call recorders, aerial counts, and trapping. The choice of technique and design of sampling should be guided by conventional statistical design texts.

5.4 Annual removal of non-timber forest products, compared to the level determined to be sustainable

There are a wide range of non-timber forest products including game animals, fur-bearers, nuts and seeds, berries, mushrooms, oils, foliage, medicinal plants, peat and fuelwood, forage, etc. Non-timber forest products in this context do not include services provided by forests such as water regulation, biodiversity conservation, recreational or spiritual values or carbon release offsets.

Many non-timber forest products are subject to limited regulation, either because they are highly localised activities, their harvest rate does not appear to approach a level judged to be threatening to the sustainability of the resource, or because there has not been a recognition of the economic importance or potential impacts of the activity. Activities such as hunting, fur-trapping, commercial seed or berry collecting are usually regulated under a permit system. Individual subsistence or recreational harvesting of products is less often regulated via permits.

This indicator could potentially be initially developed via a matrix that shows the currently known non-timber forest products being actively harvested, the periodicity of harvest and the regulation method used if any. Then, for those products regulated, an estimate of the sustainable yield, approved harvest, and actual harvest could be presented in tabular format if available. In cases where there is no regulation of non-timber forest products, it may be feasible to use a qualitative assessment of the range of products harvested, the kinds of ecosystems they are derived from, the status of those ecosystems and the ease of renewability of the products.

5.5 Area and percent of forest affected by processes or agents beyond the range of historic variation.

This indicator requires three questions to be addressed. The first is whether in fact certain factors are operating outside a range considered to be normal in some historic context, second is for those that are, to what degree are they negatively affecting the forest, and third is the rate at which the change is occurring. The first question requires an analysis to be done, potentially of the forces listed in the original wording of the indicator (insects, disease, competition from exotic species, fire, storm, land clearance, permanent flooding, salinisation and domestic animals).

When growth, reproduction or mortality of a particular species or the diversity of an ecosystem is altered more than is known to have occurred in historic cycles or against some benchmark, the condition would be noted. Those processes or agents considered within a benchmark level or the historic range of variation based on an initial analysis could be identified as not applicable. Areas where processes caused by human activity or where changes are the secondary result of altering the frequency of natural disturbance agents could be presented in terms of the causal agent and area impacted if historic variation or the benchmark were exceeded.

In recent years, more attention is being given to biological surveys and forest health surveys in plantations. These surveys can indicate systematic changes in processes or agents with impact on plantation forests that may be adequately monitored. Land clearance is a process of forest alteration that may be adequately monitored in criterion 1.

5.6 Area and percent of forest land subjected to levels of specific air pollutants or UV-B radiation

This indicator is designed to address the measurement of a threatening process to ecosystem health. Many countries, usually via their Environment Ministry undertake monitoring of contamination, deposition or concentration of airborne pollutants. In most cases the results of these monitoring programs are maps showing isolines of deposition rates for sulphates or nitrates or their elemental equivalents. Similarly isolines have been used to depict average ozone concentration in the air. Ultraviolet radiation varies seasonally, but also can be depicted via isoline maps, possibly for the summer period when the sun is strongest.

In countries without monitoring systems for these pollutants or UV-B, it may be a result of insignificant pollutants or lack of the perception of a problem, or the lack of appropriate technology. In these cases it may be worthwhile establishing a limited number of benchmark sample sites to confirm that there are low levels of pollutants influencing forests.

5.7 Area and percent of land with diminished biological components

The direct monitoring of ecological processes and biota over time is a challenging task. Yet, this indicator provides an early diagnosis of changes in ecosystem processes, such as soil nutrient cycling, seed dispersion or pollination. In some countries plot-based ecological monitoring systems have been implemented, often in response to concerns over forest decline related to air pollution. These sample plots are usually fixed plots where measurements are taken on tree condition, nutrient concentrations in soil and foliage, understory vegetation, and elements of the biota. The data generated by these plots will need to be linked with models to allow extrapolation or prediction of national-level phenomena.

While these systems are operating in North America, Europe and Japan, some Montreal Process member countries do not at present undertake this type of systematic ecosystem monitoring. Ecosystem health monitoring may be one area of future opportunity for cooperative action within the Montreal Process group, as it would provide a common tool for early diagnosis of common challenges in maintaining forest ecosystem health and vitality.

A high proportion of biodiversity consists of invertebrates and micro flora, such as fungi. They also make up the greatest mass of the biological world. While the monitoring of these microorganisms is in its infancy, it is recognized that their short regeneration times,high reproduction and high association with specific ecological processes, e.g., nutrient cycling, make them useful early warning mechanisms.

5.8 Soil Erosion

Soils are a basic determinant of the type and quality of forests that exist on them. The quality of soil is difficult to define, but processes like erosion and compaction known to diminish soil quality can be measured. Soil erosion is usually a result of the loss of vegetative cover and a breakdown in the integrity of root systems. Localised soil erosion can also occur in response to the construction of roads on steep hillsides or as a result of harvesting trees on sites with fragile or erodible soils. In most countries erosion is monitored as part of the forest management process, but data are not generally assembled at a national level.

To undertake national estimates of soil erosion from forested lands would require a sampling system, either using multi-stage sampling (satellite/air photography to delineate areas under pressure, followed by sampling of a sub-set of those areas) or via systematic sampling of areas disturbed (harvest, fire, roading, etc.). Aggregate estimates of soil erosion would have little meaning because of natural variability in soil erosion. National indicators would report the percent of area judged to be beyond local standards for erosion given management disturbance. Some measurement protocols already exist. Sheet and rill erosion are, however, difficult to measure extensively and aerial survey techniques have limitations in quantifying erosion under forest cover.

5.9 Area and percent of forest land managed primarily for protective functions

In many countries areas of forest are zoned or put under special regulation for non-timber functions such as watershed protection, riparian zone protection, floodplain protection or avalanche protection. In other countries these functions are recognised as part of the forest management regulatory or stewardship responsibility and it could be said that all forest lands are therefore managed for these protective functions.

It would be useful in the first approximation report for each to country to clearly lay out in tabular form the regulatory approach to managing the protective functions of forests on government owned and privately owned forests, whether via land tenure and zoning or via regulatory approaches. Where possible this table could include actual area and percentage figures for areas zoned or categorised specifically for protection functions.

5.10 Percent of stream kilometres in forested catchments in which stream flow and timing has significantly deviated from historic ranges

Few countries maintain comprehensive monitoring systems related to water flow specifically from forested catchments. The net water flow from a forested catchment is based on the balance between precipitation and evaporation, transpiration, surface and sub-surface flow. Forest management can impact on water flow by affecting any of these components of the hydrological cycle.

The water flow is usually measured using a gauging weir or flume that uses an automatic recorder to monitor the height of the water and from that, interpolate to flow volume per unit time. Systematic introduction of monitoring for water flow would logically be combined with monitoring of water quality, turbidity temperature or other factors. The location of sample monitoring points must be designed to be able to distinguish between forested and non-forested portions of catchments, as agricultural land, for example has very different water relations from forest land.

5.11 Area and percent of forest land with significantly diminished soil organic matter and/or changes in other soil chemical properties

Soil organic matter changes, like erosion, are a matter which has largely been monitored at a local or site specific scale. Changes in organic matter and chemical composition of soils would be expected to indicate chronic or long term impacts of forest management regimes such as short rotation cropping, biomass harvesting or extreme forms of site preparation for plantation or natural forest regeneration.

Sampling of soil chemical properties should be focussed on representative sites where forestry operations are occurring.

5.12 Area and percent of forest land with significant compaction or change in soil physical properties resulting from human activities

Changes to soil bulk density or infiltration capacity are symptomatic of the use of heavy equipment, excessive localised grazing pressures by hoofed animals or even high levels of recreational foot traffic on land. While forest soils are dynamic and the actions of root growth and soil fauna will often reverse soil compaction over time, it is important to monitor the results of forest operations on soil physical properties.

Like earlier indicators within Criterion 4, soil physical properties are not conventionally monitored in a way that facilitates national reporting. Measurements of soil bulk density changes on different soil types in response to different harvesting or other pressures are usually made on a site specific basis. A national approach would require either standardisation of local measurements or a sampling system. A national sampling system could be designed in combination with other soil sampling work on a limited number of representative sites.

5.13 Percent of water bodies in forest areas with significant variance of biological diversity from the historic range of variability

Changes in aquatic flora and fauna can be viewed as potential integrating indicators of stress caused by chemical or physical impacts on watercourses and waterbodies. Similarly to the earlier indicator on diminished biological components within forest ecosystems, aquatic monitoring would require an ongoing sampling program and should be able to distinguish between forested and non-forested portions of catchments. Design of these sampling programs should also be able to discriminate between changes related to forestry operations and those occurring due to other causes.

Such a sample monitoring program, on a limited number of representative sites, could include identification of algal blooms, fish species, benthic fauna, and water plants. Some sampling might be undertaken for pesticide residues in plants and fish where this is considered a potential issue.

5.14 Percent of water bodies in forest areas with significant variation from the historic range of variability in pH, dissolved oxygen, level of chemicals, sedimentation or temperature

This indicator is aimed at monitoring a wide range of potential chronic or periodic influences on stream and water body health. The specific factors indicated would address changes due to leaching, erosion, algal blooms, changes in riparian buffers, and contamination by chemicals. Design of these sampling programs should also be able to discriminate between changes related to forestry operations and those occurring due to other causes.

Like the previous indicator on biological diversity in water, this indicator would require an ongoing sampling and monitoring program on a limited number of representative sites and should be able to distinguish between forested and non-forested portions of catchments. The two indicators could be monitored concurrently at specific sample points.

5.15 Area and percent of forest land experiencing an accumulation of persistent toxic substances

Specific point sources or widespread contamination events may require specific mapping and sampling distinct from statistically designed sampling programs. A narrative approach indicating location, toxic substance, source, and remedial action if any, would be a useful way to report. In areas where contamination by industrial chemicals, nuclear waste, pesticides, sewage sludge and wastewater or other toxic substances has occurred these areas could be mapped and summarised in tabular form. Toxic substances should be defined in the national context.

5.16 Total forest ecosystem biomass and carbon pool, by forest type, age class and successional stages

The carbon pool in forest ecosystems includes living biomass in trees, other plants, dead trees and branches, organic matter in peatlands, on the forest floor and in the soil. The biomass of trees is usually estimated using allometric relations with mensurational measures such as stem volume or diameter and height. Non-tree vegetation and soil organic matter are usually measured using field sampling points. The carbon fraction of the biomass is usually estimated using a scientifically-based conversion factor.

Estimation of the carbon pools by forest type, age class and successional stages, where possible, is a useful way to stratify sampling programs and increase the efficiency of sample design. These variables may be correlated with changes in the carbon pool and lead to the ability to model the carbon budget and its response to changes in forest management or natural disturbances.

5.17 Contribution of forest ecosystems to the total global carbon budget, including absorption and release of carbon

This indicator requires the development of a carbon budget model at a national level. Recent international work on this topic has been undertaken by the NATO Science Symposium Series, the Intergovernmental Panel on Climate Change, and International Institute for Applied Systems Analysis (IIASA).

Recent scientific work by National Aeronautical and Space Administration (NASA) and others have developed effective ways of estimating net carbon uptake by forests using a variety of satellite sensors. Soil carbon uptake or emission, however, still require modelling of the dynamics of litterfall and decomposition. The Montreal Process countries may wish to review, then endorse, a forest carbon budget approach based on existing work.

5.18 Contribution of forest products to the global carbon cycle

The forest products sector, including timber products, paper, and composite products is also considered part of the global carbon cycle. Forest products are removed from the carbon pool in ecosystems, but do not go through a conventional decomposition process. They have residence times in use and in waste dumps that require modelling and estimation. Again, studies have been undertaken in this area, and the Montreal Process may wish to review and then adopt a specific protocol already in international use.

5.19 Supply and consumption / use of non-wood forest products

Non-timber forest products, as mentioned earlier, may include game animals, fur-bearers, nuts and seeds, berries, mushrooms, oils, foliage, medicinal plants, peat and fuel, forage, etc. This indicator is very closely related to the indicator (e) under criterion 2. It is designed to monitor the consumption of non-wood forest products in parallel with other indicators that monitor the consumption or production of wood products.

In many countries not all non-wood forest products are regulated and therefore there may be difficulties providing accurate statistics on the production or consumption of non-wood forest products. It may be necessary to list the major non-wood forest products known, and where possible, place estimates on the annual supply, production or consumption rates of those products.

5.20 Number and type of facilities available for general recreation and tourism, in relation to population and forest area

This indicator is designed to provide a measure of the availability of recreational opportunities in the country's forests. The type of recreational facilities that might be included would be picnic and barbecue sites (#), camp sites (#), interpretation and visitor centres (#), large developments such as sports and outdoor recreation centres (#), hiking trails (km), and road access (km) or other facilities as judged appropriate in a national context. These facilities could be measured on a per ha basis or per 100,000 population.

It also must be recognized that there are differences among countries in the interpretation of whether certain recreational facilities contribute to or detract from the quality of recreation and tourism.

5.21 Number of visitors attributed to recreation and tourism, in relation to population and forest area

This indicator measures recreation demand in a forest setting in terms of actual participation and in terms of the recreational pressure on forest land. Visitors are often not easily monitored, especially in large dispersed areas with hiking trails or picnic sites. In many cases it is necessary to undertake specific monitoring programs, for example monitoring the number of users of a hiking trail, picnic site or recreation area and then extrapolating to estimate national totals and trends over time. A second option is to use a national public survey to obtain estimates of activity levels by various types of recreation activities. In reporting on this indicator it is suggested that use may be defined in visitor days and that direct counts be kept distinct from estimates.

5.22 Non-consumptive use forest values

Non-consumptive 'goods' are those that do not lead to the physical taking of products from the forest. They would include recreation, photography, birdwatching, education, and contemplation or meditation. The indicator is phrased to focus on the direct uses of forests for non-consumptive benefits, rather than indirect benefits such as existence values, bequeath values, etc.

In most cases, these values can be estimated via public surveys, questionnaires, or via indirect indicators such as memberships in hiking clubs, bird watching clubs or forest conservation organisations. Countries may wish to evaluate the relative importance of these values.

5.23 Viability and adaptability to changing economic conditions, of forest dependent human communities, including indigenous communities

While there is growing recognition of viability and adaptability of communities regarding their sustainable forest management, measurement approaches and tools are largely unavailable at this time. Development and evaluation of suitable methods are needed.

Forest dependent communities are those that, in either subsistence or economic terms, derive a significant proportion of their livelihood from products derived from the forest. Community viability is a subjective term, as it is as much an attitude as a measurable feature. In some cases viability can be judged based on the unemployment rate, changes in employment base, degree of welfare or social assistance dependency or population growth rates or out-migration rates.

The adaptability of communities to change is usually a function of the diversity of the local economy and the adaptability of the workforce. Diversity can be measured economically based on the number of firms and their relative contribution to the local economy. For example, a town where a single large pulp and paper facility is the major employer, would potentially have a low level of adaptability if the mill were to close.

In the case of indigenous communities, particularly where subsistence activities are a large part of the support for human life, communities may be highly adaptable to natural cycles, but completely unprepared to adapt to restrictions or changes to their traditional uses of the forest. Viability and adaptability of indigenous communities, therefore, must be reflected in the security of their tenure with respect to their traditional lands and land uses.

The interpretation of measures of viability and adaptability of communities must be done carefully and in the context of the wider socio-economic conditions of the country concerned.

5.24 Area and percent of forest land used for subsistence purposes

Subsistence uses of the forest are often associated with indigenous peoples. There are, however, also significant subsistence uses of forest lands by non-indigenous peoples, for example mushroom picking, hunting of wild game and collection of wild fruits and berries, and fuelwood.

In the case of indigenous peoples, there are often reserves or legal boundaries on areas where subsistence use of forest products is guaranteed by law. On other lands there is often the opportunity for a wide range of subsistence or traditional activities with or without legal or regulatory control. Often as well, rights to traditional subsistence uses of forest lands overlap with other tenures, such as those controlling timber harvesting. Therefore it will be necessary for each country to explain and categorise the regulatory and legal approaches to providing for subsistence needs and to assess the extent of those areas over the entire forest land area.