National strategic planning for sustainable forests: using criteria and indicators in the United States

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The United States strives to adopt a framework based on the Montreal Process criteria and indicators in strategic planning for sustainable forestry.

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The United States Department of Agriculture (USDA) Forest Service is a pioneer in incorporating criteria and indicators into its programmes. Among its initial efforts is the adaptation of a criteria and indictors framework to national strategic plans, which are the primary instrument for setting the course to achieve the Forest Service mission of sustaining the nation's forests and grasslands for present and future generations.

This article describes the steps the Forest Service is taking to adopt a framework derived from the Montreal Process criteria and indictors in its strategic planning. It also describes challenges that the agency is encountering in adopting the framework.

STRATEGIC PLANNING BY THE FOREST SERVICE

The mission of the USDA Forest Service is "to sustain the health, diversity and productivity of the nation's forests and grasslands to meet the needs of present and future generations". The Forest Service is directly responsible for the sustainable management of 192 million acres (78 million hectares) of federal forests and grasslands in the National Forest System. The agency is also indirectly responsible for promoting the sustainable management of another 1 billion acres (405 million hectares) of publicly and privately owned forests and grasslands in the United States.

Essential to the success of the Forest Service mission are long-term strategic plans, which communicate policy and guide the agency. Federal law has required long-term planning by the Forest Service since the 1970s, but until the 1990s the plans tended to be oriented towards outputs rather than outcomes. In 1993, the Government Performance and Results Act (Public Law 103-62) was passed, mandating that each federal government agency prepare outcome-oriented five-year strategic plans, meaning that they should describe the desired results of programme activities and the means of achieving those results. Nevertheless, the Forest Service's next long-term plan, the 1997 Strategic Plan, remained primarily output-oriented and focused on management activities, as it had poorly defined indicators. Lack of baseline data also contributed to difficulty in demonstrating progress towards outcome-related objectives and overall goals. To improve the Strategic Plan, the Forest Service began linking goals and objectives to trend indicators of sustainability derived from the Montreal Process on Criteria and Indicators for the Conservation and Sustainable Management of Temperate and Boreal Forests (see Box on p. 16).

ROUNDTABLE ON SUSTAINABLE FORESTS

As part of the United States' efforts to achieve sustainable forest management, in 1994 the Forest Service organized a forum for discussion of sustainable forest management, including the development and implementation of the Montreal Process criteria and indicators. The forum, officially chartered in 1999, is known as the Roundtable on Sustainable Forests (see www.sustainableforests.net). Although the Roundtable is not a decision-making body, it contributes to better decision-making through the sharing of information and perspectives among individuals representing diverse interests and by promoting application of the criteria and indicators among the numerous agencies and stakeholders. More than 40 government and non-governmental organizations participate in the Roundtable including federal government agencies; tribal, state and local units of government; private landowners and citizens;

Arthropods as ecological indicators of disturbance in forest ecosystems

Since knowledge of forest ecology and the capacity to describe and measure functions that maintain desired forest features are limited, changes in distribution and abundance of organisms can be examined as indicators of change in ecological functioning. Such indicators make it possible to detect and thus mitigate anthropogenic perturbations that threaten "natural" systems, and also to confirm ecological recovery after ecosystem perturbation. Early efforts to use forest fauna as ecological indicators of disturbance in Canadian forest ecosystems have focused primarily on vertebrates. Yet arthropods, mainly insects, have features that make them interesting as potential indicators:

- around two-thirds of faunal species in Canadian forests are arthropods, and they have a diverse range of functions;
- it is inexpensive to gather samples reflective of populations;
- few species undertake large-scale migrations, ensuring that population changes are reliably attributed to local changes;
- their sensitivity to environment makes it feasible to identify which aspects of environmental change are responsible for faunal change.

Development of ecological indicators is a systematic process involving several essential steps, each of which offers significant challenges.

Extracted from the paper "Arthropods as ecological indicators of sustainability in Canadian forests", by David W. Langor (Natural Resources Canada, Canadian Forest Service, Edmonton, Alberta, Canada) and John R. Spence (Department of Renewable Resources, University of Alberta, Edmonton, Alberta, Canada), presented at the XII World Forestry Congress.

Indicator selection. Effective indicators must be economically and logistically viable and biologically efficacious. In Canada, the greatest challenge in the choice of taxa or assemblages for study is the difficulty of arthropod identification. Consequently, most work has focused on a few relatively well-known groups: litter-dwelling beetles (Carabidae, Staphylinidae) and spiders; saproxylic beetles associated with dead wood; moths and butterflies; and soil-dwelling mites and springtails. Other groups may offer value as ecological indicators, but investigation is often hampered by taxonomic impediments.

Data collection and interpretation. Data are required to understand the range of natural variation (RNV) in species abundance and to elucidate relationships between the indicators and selected abiotic or biotic variables. The RNV serves as a baseline against which to compare responses to anthropogenic disturbances. Recent studies have provided baseline data about RNV in relation to natural disturbances and quantified arthropod responses to human disturbances.

This step presents significant challenges. First, trapping methods and sampling protocols have inherent biases that must be recognized for correct interpretation of data. Second, seasonal variation in arthropod populations is high, so sampling over a short part of the activity season will not allow accurate assessment of the presence/absence or relative abundance of species, nor allow for meaningful comparisons over space and time as required by monitoring goals. Third, the cost of processing samples is high and may limit the scope of projects and slow the accumulation of data. These challenges usually limit arthropod studies to relatively small spatial scales.

Assessment of robustness and representativeness. The usefulness of an indicator depends on its robustness and representativeness. Robustness is a measure of how well the results of small-scale work may be scaled up additively to represent situations at larger scales. Meta-analyses of multiple data sets over increasing scales might be used to test the spatial robustness of indicators. The degree to which an indicator represents responses of other groups may now be examined, as several studies in Canada have measured the responses of multiple taxonomic groups to disturbances. Thus, individual groups can be assessed for their suitability as indicators of broader ecosystem responses. For carabid beetles in particular, sufficient data exist to permit meta-analysis of their robustness and representativeness.

Biomonitoring. Biomonitoring is the systematic assessment of a suite of proven ecological indicators over multiple spatial and temporal scales to detect incipient change in ecosystem structure, function and composition in response to natural and anthropogenic influences. To date, few terrestrial arthropod ecological indicators have been used in monitoring, and the potential for their future application rests on the outcome of the ecological indicator selection process. The indicator value of groups currently under study should be demonstrated before investment is made in the study of new groups, or in the use of arthropods in monitoring programmes.

Use in management. The cost of using arthropod indicators to guide management would be substantial. It may be more economical to focus on habitats (or other ecological surrogates) as indicators. Improving ecological knowledge of arthropod distribution and habitats could lead to much improved ecological classification systems and identification of habitats threatened by forestry activity. However, the congruence between habitat state and species state must be continually verified to ensure that the surrogacy system remains ecologically relevant.

industries and businesses; conservation and environmental groups; regional and community-based organizations; and researchers and academics.

The Roundtable meets regularly to discuss what criteria and indicators mean for forest management and conservation in the United States, how data for the indicators are collected, and who is responsible for acquiring the data. One of the biggest challenges for stakeholders has been reaching agreement on a process and guidelines for interpreting indicator trends.

Building consensus is both a great challenge and benefit of the Roundtable. Finding ways for stakeholders with varying perspectives to communicate is especially important in a country as diverse as the United States with forests that are owned and managed by many different private and public entities. To facilitate the resolution of differences, Roundtable meetings are convened by a neutral third-party organization that specializes in solving problems related to the environment.

Because Roundtable stakeholders help guide the application of the criteria and indicators by the federal government, they usually support the end results (e.g. national criteria and indicator reports by federal agencies). The Roundtable has also encouraged application of the criteria and indicators by other organizations and at multiple scales. Because of the Roundtable's success, the United States Government has established similar roundtables to discuss the sustainability of rangeland resources, minerals and water.

Two working groups carry out Roundtable activities: a Communications and Outreach Work Group and a Technical Work Group. The former has sponsored workshops to inform state, county and other government officials, forestry practitioners and the general public about sustainable forest management and the criteria and indicators. The latter has held workshops for technical experts to identify regional and national data sets and information gaps in the data available to measure the criteria and indicators at the national level. Work group members found that nine of the 28 Montreal Process biological indicators have been part of Forest Service sampling for 70 years (Maille, 2000).

An important effort initiated by the technical workshops was the production of the *National report on sustainable forests – 2003* (USDA Forest Service, 2003), which describes the current status and conditions of United States forests, including trends in their health, productivity and use, based on criteria and indicators. The report addresses an array of environmental, social and economic concerns and is a reference point for measuring national progress towards sustainable renewable resource management.

STRATEGIC PLANNING AND THE MONTREAL PROCESS

In 2000, the Forest Service published a revision of its Strategic Plan with linkages to the Montreal Process criteria and indicators framework (USDA Forest Service, 2000). The goals of the revised Strategic Plan (ecosystem health, effective public service, multiple benefits to people, scientific and technical assistance) address all three of the major categories of the Montreal Process criteria (see Box).

The connections between the Montreal Process criteria and indicators and the Strategic Plan 2000 Revision are more substantial with respect to indicators and objectives. The Montreal Process indicators provide appropriate measures of outcomes for strategic objectives focused on the agency's mission of sustainability. An example illustrates the linkages: Montreal Process Criterion 1 relates to the conservation of biological diversity. One of the indicators for this criterion is the status of forest-dependent species at risk of not maintaining viable breeding populations. Goal 1 in the Strategic Plan 2000 Revision – the promotion of ecosystem health and conservation to

Montreal Process

The Montreal Process on Criteria and Indicators for the Conservation and Sustainable Management of Temperate and Boreal Forests is an initiative among governments of non-European temperate and boreal forest countries to develop and implement agreed criteria and indicators for sustainable forest management. In 1995, the Montreal Process Working Group issued the Santiago Declaration, a non-binding agreement on criteria and indicators for sustainable forest management endorsed by 12 countries encompassing more than 90 percent of the world's temperate and boreal forests (MPWG, 1998).

The Montreal Process framework is composed of seven criteria and 67 indicators. The Montreal Process Working Group defines criteria as categories of conditions or processes by which sustainable forest management may be assessed. Indicators are measures of an aspect of a criterion. The seven criteria fall into three general categories: vital functions and attributes (biodiversity, productivity, forest health, the carbon cycle, soil and water protection); socio-economic values and benefits (timber, recreation, cultural values); and the laws and regulations that make up the forest policy framework (MPWG, 1999).

sustain the nation's forests, grasslands, and watersheds – is linked to Criterion 1. One of the objectives associated with this goal is providing ecological conditions to sustain viable populations of native and desired non-native species. The measure for this objective is the status and/or trends in populations, habitats and ecological conditions for selected species. Among the species tracked is the red-cockaded woodpecker (*Picoides borealis*) as an indicator for the longleaf and shortleaf pine (*Pinus palustris* and *Pinus echinata*) ecosystems in the southeastern United States

Despite the linkages between the criteria and indicators and the Strategic Plan 2000 Revision, insufficient data led to measurement problems. With respect to the example above, milestones set for meeting the objective were vague and data were not available for some indicator species. As another example, the watershed health objective was designed to improve and protect watershed conditions, but the Forest Service was unable to measure progress towards the objective in the absence of a comprehensive monitoring protocol and programme to assess watershed condition and function on a nationwide basis. The paucity of reliable baseline data for these and other long-term measures and milestones in the 2000 Revision left the agency unable to demonstrate accountability for many of the expected long-term results.

2003 STRATEGIC PLAN UPDATE

To redress these performance accountability problems, the Forest Service is preparing a 2003 Update of the Strategic Plan that strengthens linkages between science-based indicators derived from the Montreal Process and the agency's strategic goals and objectives. The objectives set forth in the draft 2003 Update have largely been based on existing reports using criteria and indicators to assess status and trends in forest sustainability in terms of the ecological, social and economic environment.

The draft 2003 Update has three goals: to maintain the health, productivity and diversity of the nation's forests and grasslands; to provide a sustainable flow of goods and services from the nation's forests and grasslands; and to maintain the organizational capacity to provide effective public service. These goals are parallel to the three main categories of the Montreal Process criteria (see Box).

In order to prepare objectives for the three goals, the planners sought to identify key indicators of sustainability from the full suite of 67 Montreal Process indicators. Particularly useful were the 18 core indicators adopted by the Northeast Area Association of State Foresters (NAASF), an organization that represents the directors of state forestry agencies in the northeastern United States. The 18 indicators adopted by NAASF span the seven criteria of the Montreal Process framework (USDA Forest Service, State and Private Forestry, Northeastern Area, 2002)(see Table). These indicators became the basis for drafting an initial set of measurable policy objectives that address a limited set of high-priority issues. As a result, policy objectives are linked to key social, economic and

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The main goals of the 2003 Update of the United States Forest Service's Strategic Plan – for example, the goal of maintaining the health, productivity and diversity of the nation's forests and grasslands – are parallel to the categories of the Montreal Process criteria

Epiphytic ferns as potential indicators of changes in forest microclimate

Epiphytic ferns live symbiotically on other plants (phorophytes) from which they obtain nutrients and moisture. They grow attached to the trunks and branches of trees and other plants like climbers, and some even grow on the surface of living leaves. Epiphytic ferns provide the chief and sometimes the only habitat for a rich fauna and flora and thus have an important role in the forest ecosystem. They accumulate masses of humus, which provide nesting sites for many species of arboreal ants and other invertebrates.

Epiphytic ferns are very sensitive to humidity and direct sunlight. Changes in the microclimate of closed forests resulting from changes in canopy cover due to logging or ill health of trees are likely to influence the distribution of epiphytic ferns on the tree. These ferns may therefore have potential as early indicators that could alert forest conservationists to the need to take action, for example to examine the state of tree health.

In the Amani Nature Reserve in the United Republic of Tanzania, which is a tropical rain forest, epiphytic ferns are part of the closed plant community. A study was carried out in this area to investigate factors that influence the occurrence of *Asplenium nidus* (chosen because it was the most dominant epiphytic fern in the area), its distribution on phorophytes and its potential as an indicator of forest environmental change. A total of 307 trees belonging to 47 species in more than 30 families were studied. *Asplenium nidus* occurred on many species of trees, most commonly *Myrianthus holistii*, *Cephalosphaera usambarensis* and *Pouteria cerasifera*.

It was found that the fern does not have preferences for particular host species; rather, morphological features of the host such as branching type, diameter at breast height (DBH) and canopy type were found to be influential factors in determining the host. Ferns were abundant in phorophytes with rough bark, DBH of 81 to 130 cm and acute branching angle with respect to the trunk. *Asplenium nidus* was also found to be more prevalent in trees with grooves or cuts on the trunk.

Moreover, *A. nidus* clumps were most prevalent in the subcanopy at a height of less than 20 m, and their prevalence decreased with increasing height. The preference for the subcanopy level is an adaptation to minimize water loss through evapotranspiration. To cope with the low light intensity at the subcanopy level, the fern has developed broad leaves to maximize light absorption. Where the canopy is more open, the fern develops a smaller leaf structure to reduce moisture loss on exposure to more sunlight. Epiphytic ferns may not survive as the forest becomes more open, and new clumps emerging after ferns die may have narrower leaves.

Monitoring of the ecological changes in an epiphyte community and of the fern's population dynamics could thus provide clues on ecological changes taking place in the forest ecosystem, and might have a role in tropical rain forest management.

Asplenium nidus *grows attached to a tree, from which it obtains nutrients and moisture*

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Extracted from the paper "Studies on epiphytic ferns as potential indicators of forest disturbances", by Edward Andama (Department of Zoology, Makerere University, Kampala, Uganda), Charles M. Michira (African Conservation Centre, Nairobi, Kenya) and Gebhard B. Luilo (Department of Chemistry, University of Dar es Salaam, Dar es Salaam, United Republic of Tanzania), submitted to the XII World Forestry Congress.

Base indicators adopted by the Northeast Area Association of State Foresters (NAASF) for use in state and regional forest sustainability assessments, spanning the Montreal Process criteria and subcriteria

Montreal Process criterion/subcriterion	NAASF sustainability indicator
Criterion 1: Conservation of biological diversity	
• Ecosystem diversity	Area of forest land relative to non-forest land, area of timberland and area of reserved land Extent of area by forest type and by size class, age class and successional stage Degree of forest land conversion, fragmentation and parcelling
• Species diversity	Status of species and communities of concern, with focus on forest-associated species
Criterion 2: Maintenance of productive capacity of forest ecosystems	Area of timberland Annual removal of wood products compared to net growth
Criterion 3: Maintenance of forest ecosystem health and vitality	Area and percent of forest affected by damaging agents such as insects, disease, exotic/native species, fire, storm, land clearance and domestic animals
Criterion 4: Conservation and maintenance of soil and water resources	Area and percent of forest land with significantly diminished soil organic matter, erosion, compaction and/or changes in other soil chemical or physical properties Area and percent of forest land adjacent to surface water and area of forested land by watershed Condition and vulnerability of aquatic systems by watershed
Criterion 5: Maintenance of forest contribution to global carbon cycles	Total forest ecosystem biomass and carbon pool and contribution of forest ecosystems to the total carbon budget
Criterion 6: Maintenance and enhancement of long-term multiple socio-economic benefits to meet the needs of societies	
• Production and consumption	Value and volume of wood and wood products production, consumption, imports and exports
• Recreation and tourism	Outdoor recreational activities and use, recreational facilities and use
• Investment in the forest sector	Public and private investments in forest health, management, processing, manufacturing and research
• Cultural, social and spiritual needs and values	Public, private and industrial ownership and land use (including area of specially designated land use)
• Employment and community needs	Trends in earnings and employment in forest-related sectors (e.g. wood products, recreation, forest management)
Criterion 7: Legal, institutional, and economic framework for forest conservation and sustainable management	
• Extent to which the legal framework supports the conservation and sustainable management of forests	Existence, type and monitoring of voluntary or mandatory best management practices
• Extent to which the institutional framework supports the conservation and sustainable management of forests	Existence, type and frequency of forest-related planning, assessment and policy review, including cross-sectoral planning and coordination

ecological conditions. For example, one of the indicators is "the condition and vulnerability of aquatic systems by watershed", which is aligned with a draft policy objective addressing watershed function: "increase the number of forest and rangeland watersheds in fully functional hydrologic condition". Taking a pragmatic approach, the planners made efforts to design measures to assess progress towards objectives critical to the agency's mission in order to have the capacity to demonstrate programme effectiveness.

In addition, the draft 2003 Update describes objectives in light of how Forest Service programmes are expected to influence long-term trends. Potential interactions between various outcomes are also noted. These include, for example, adverse effects on carbon sequestration through controlled burns that aim to reduce hazardous fuels and improve forest health.

CONCLUSIONS

Although the designers of the Montreal Process criteria and indicators framework warned that it should not be used as a performance yardstick to evaluate a nation's forest management programme, using the framework to support strategic planning assists the United States For-

est Service in ensuring that it addresses all the varied aspects of sustainability and improves performance accountability. Adopting a criteria and indicators framework facilitates a comprehensive analysis of progress towards sustainable forest management and also provides an efficient means of communicating condition and trend information that forms a basis for forest policy dialogue.

Despite the many challenges, the application of a criteria and indicators framework is strengthening the capacity of the Forest Service to achieve sustainable resource management in several ways:

- by providing stakeholders with widely accepted sustainability indicators which offer a common vocabulary for effective collaboration among stakeholders with varying perceptions;
- by aligning long-range goals with measurable objectives for sustainable management, thus enhancing the agency's accountability and capacity to focus scarce resources on activities that efficiently advance its mission;
- by providing the agency with tools to measure progress towards desired outcomes, i.e. trend indicators, which in conjunction with monitoring of annual performance measures enable the Forest Service to track both the near-term performance and long-term results of its programmes, and thus to demonstrate effectiveness in delivering its mission and to evaluate policies for improvement.

The United States is not alone in facing the challenge of sustainable renewable resource management. Problems such as population growth, conflicting resource uses, subdivision of open spaces and wildland fires confront most of the approximately 150 nations that are employing criteria and indicators. Using criteria and indicators to assess and monitor forest conditions can aid in addressing these problems, but further action is necessary to effectively influence policies and decisions to achieve sustainable management of renewable resources. Countries must also integrate the information derived from the use of criteria and indicators into the development and implementation of their national forest programmes. Like the United States, other countries may be able to benefit from the adaptation of criteria and indicators to strategic plans to meet the challenges of sustainable resource management. ◆

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Indicators of soil disturbances in the forests of Quebec

Activities involved in timber extraction such as road construction and the movement of heavy machinery on felling sites cause a certain disturbance of the soil. Some of these disturbances will have a low or acceptable impact in terms of the degradation risks entailed, whereas others can have a more serious effect on the productive capacity of forest soil or alter other components of the ecosystem, such as the aquatic environment.

With a view to implementing countermeasures, the Ministry of Natural Resources of Quebec, the agency responsible for forest management on public land, has been developing indicators to assess four types of physical disturbance of the soil: compaction, rutting, loss of productive land area and surface erosion. Some of these indicators are currently being implemented, while others are still under development.

Compaction. The movement of heavy machinery on felling sites exercises pressure on the ground, leading to compaction. This type of disturbance is likely to lead to reduced tree growth, because compacted soil often has poor aeration, offers more resistance to root development and has reduced water permeability, resulting in more frequent waterlogging. In most types of soil, compaction occurs the first time machinery crosses the ground. Under Quebec's regulations regarding forest intervention, skid trails are allowed to occupy a maximum of 33 percent of the area of a felling site. In support of this rule, the ministry is developing a method to measure the area occupied by skid trails together with the level of regeneration protection. The indicator will be the mean area occupied by skid trails within every cutting block on a given year for each management unit.

Rutting. On some soils, the pressure exercised by machinery can deform or displace the soil, forming ruts of various depths which can be permanent. The ministry has developed an indicator, currently in use, by which the phenomenon of rutting on all the regeneration felling sites in Quebec can be measured: the number of cutting blocks where more than 20 percent of the trail length is occupied by ruts more than 4 m long and more than 20 cm deep.

Losses of productive land area. Certain forestry operations – particularly road building – leave portions of ground unsuitable for tree growth. The ministry has developed an indicator that measures such losses: the area occupied by roads and the disturbed area alongside them (40 m on either side). This indicator, too, is being implemented.

Erosion. Roads and associated soil disturbances are the main cause of surface erosion by water in forests under management in Quebec. The ministry counters erosion problems by enforcing regulations regarding road construction aimed at minimizing erosion risks. An indicator of erosion, intended to complement the present regulations, has been under development for some years and is now being used on an experimental basis. The indicator is the number of cases of erosion per kilometre of road. Eight types of cases of erosion have been defined and are monitored; examples include lengthwise or crosswise erosion of the roadway or erosion of the road embankment.

Conclusion

Monitoring of these and other indicators allows the ministry to gain a better picture of the state of the forests with a view to achieving sustainable management. On the national level, it enables the ministry to be accountable to the various groups concerned about the management of Quebec's forests. On the international level, monitoring of these indicators may enable suppliers of timber products to demonstrate that their activities respect sustainable management principles, helping them retain access to all markets. These easily measurable indicators can be used as an adaptive management tool with which government agencies can control forest activities by focusing on achieving goals rather than on observing rules, which has been the usual approach in many jurisdictions.

Measurement of soil disturbance indicators in Quebec, Canada

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Extracted from the paper "Protecting forest soils through use of an adaptive approach" by Jean-Pierre Jetté (Ministry of Natural Resources of Quebec, Quebec, Canada), submitted to the XII World Forestry Congress, Quebec, Canada.