Bridging boundaries among disciplines and institutions for effective implementation of criteria and indicators

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The development of a coherent system of criteria and indicators (C&I) requires collaboration and communication among scientists, government, the public, certifying organizations, and the forest industry. It also demands the integration of knowledge from many fields of study, which is foreign to the disciplinary nature of most forestry research. There needs to be greater effort to link groups of indicators and to favour those that are assimilative in nature. Modelling tools adapted to a multi-disciplinary approach and collaborative development will help to integrate knowledge from various fields and institutions. Specific challenges for implementation of C&I have been identified, including: leadership and vision in the evolution towards sustainable forest management (SFM); linking of grass-roots and higher level C&I initiatives; streamlining and co-ordinating different certification initiatives and agencies; technology transfer; and collaboration among disciplines.

Keywords: criteria, indicators, sustainability, forest management, integration

L'élaboration du système cohérent de critères et d'indicateurs (C&I) nécessite la collaboration et la communication entre les chercheurs, le gouvernement, le public, les organisations qui certifient et l'industrie forestière. Cela exige également l'intégration des connaissances en provenance de plusieurs champs d'étude ce qui est étranger au concept de discipline de la majeure partie de la recherche en foresterie. Il est nécessaire d'accentuer les efforts pour relier les groupes d'indicateurs et de favoriser ceux qui sont assimilables de part leur nature. Les outils de modélisation adaptés à l'approche multidisciplinaire et au développement en collaboration permettront d'aider à intégrer les connaissances des différents domaines et institutions. Les défis spécifiques de l'implantation des C&I ont été identifiés, et comprennent le leadership et la vision de l'évolution vers l'aménagement forestier durable (AFD), les liens entre les initiatives en matière de C&I issues de la base et des niveaux plus élevés, la rationalisation et la coordination des différentes initiatives de certification et des agences impliquées ainsi que la collaboration inter-disciplinaire.

Mots-clés: critères, indicateurs, durabilité, aménagement forestier, intégration

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Introduction

Initiatives at the national and international level have prompted Canadian forestry researchers to contribute to frameworks for the development and implementation of criteria and indicators (C&I) (Riley 1995). The importance of achieving sustainability in forestry has led to a number of different approaches and systems of C&I (CSA 1996, FSC 1996, McLaren *et al.* 1998, MRNQ 2000, Kneeshaw *et al.* 2000a, Lautenschlager *et al*. 2000, CMFN 2002). Within any of these, communication among researchers, the forest industry, and the public is necessary to create a coherent and effective approach and to ensure evolution toward sustainable forest management (SFM). In order to understand the complexities of interactions among humans and ecosystems, a multidisciplinary perspective integrating knowledge from all fields relevant to forestry is required (Chapin and Whiteman 1998, Côté *et al.* 2001). Achieving a truly multidisciplinary approach to SFM research is difficult, however, due to the disciplinary nature of most research and training.

The principle objective of this paper is to encourage collaboration and co-ordination among industry, government, and bio-

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physical and socio-economic researchers, to support effective integration and implementation of C&I. In this paper, we discuss: (i) the integration of biophysical and socio-economic knowledge, (ii) modelling tools as integrators of knowledge, (iii) the linking-up of indicator frameworks to their social contexts, and (iv) challenges that face those seeking to develop and implement indicators of SFM.

Linking Biophysical, Social, and Economic Indicators

The development of a comprehensive set of indicators of sustainability for forested ecosystems presents new challenges for scientists, forest managers, and society as a whole. Indicators must be based on the best and most current knowledge and, at the same time, must be simple enough to be integrated into existing management systems. A wide breadth of knowledge—from biodiversity to soil productivity, community well-being and ancestral values—is needed to address sustainability. While there is a need for knowledge from specific fields to support and validate the indicators, the development of a coherent, informative, and thorough suite of indicators requires the integration of knowledge from many disciplines. By developing indicators discipline by discipline, synergistic and antagonistic effects that affect eventual outcomes may not be properly identified. This is indeed a problem with most indicator sets. Thus, a broader perspective, which integrates across disciplines, is necessary to ensure that the suite is not simply a collection of narrowly focused indicators.

Integration of indicators

The integration of knowledge within and among all fields related to forestry will be needed to ensure that society and its environment evolve together towards sustainability. Collaboration among forestry planners and biophysical and social scientists will be necessary to incorporate and link-up indicators of biophysical and socio-economic sustainability into management systems.

Within the biophysical sciences, environmental factors (e.g., biodiversity and soil fertility) as measured by indicators are more strongly linked than our current approaches would suggest. While indicators may be developed in a disciplinary manner, they all refer back to the forest ecosystem, which is composed of inextricably linked components. Some indicators are themselves more integrative than others are, and this property should be applied as a criterion for identifying particularly useful indicators. The following may help to develop more integrated biophysical indicators: 1) more explicit linkages between terrestrial and aquatic indicators; 2) linking ecosystem productivity to soil indicators; 3) the development of linkages between indicators of ecosystem function and biodiversity (most often treated separately) (Kneeshaw *et al.* 2000b, Fyles 2001). The grouping of indicators into a smaller number of indices (i.e., multi-metrics) is an approach that should be more widely investigated and applied (e.g., Burger and Kelting 1999).

In order to verify that the benefits of a given management strategy outweigh the actual costs, socio-economic indicators must be made to reflect projected and observed environmental change. Indicators must be developed to measure the maintenance of the value of the natural capital of landscapes, including timber and non-timber goods (e.g., berries, traditional use and recreation). For this to happen, collaboration among social and biophysical scientists will be required, in order to develop linkages among ecological and social values.

Indicators should evolve with the acquisition of new knowledge

As our understanding of forested ecosystems evolves and objectives and strategies for forest management change, indicators should evolve and change as well. Continuous consolidation of new knowledge, its integration into management, and the development of new practices and monitoring approaches will mean that indicators will need to be adjusted over time in order to continue to inform stakeholders on the state of the forest. This process of feedback will require a flexible framework (Messier and Kneeshaw 1999), *i.e.*, provincial institutions that are responsive rather than rigid, and mechanisms that will facilitate the process of adaptive management. By building stable relationships between provincial inventory agencies and certifying organizations, i.e., the development of provincial monitoring protocols and systems, the effectiveness of monitoring could be enhanced.

Modelling Tools and The Integration of Knowledge

Ecological knowledge must be integrated in order to evaluate synergistic and antagonistic effects among components of an ecosystem for different management strategies. This integration is often difficult, as most human experience is limited to one or a few disciplines. Computer modelling of forested ecosystems, however, offers a powerful tool to explore potential changes in many indicators simultaneously and a platform with which scientists and decision-makers from different backgrounds can meet and exchange ideas. These tools will help to communicate the implications of various scenarios to those involved (such as the public, regulatory and policy agencies, and other researchers). While the use of models in integrating research has perhaps been under-exploited in the past, there are a growing number of examples. For example, Fall *et al.* (submitted) use a landscape-level model to assess the impact of different strategies on age-class structure. The Biodiversity Assessment Project (BAP) (Doyon and Duinker 2001) has also developed many ideas related to the use of modelling tools to balance forestry and biodiversity values.

The forest is not a static entity and the effect of management scenarios on indicators of SFM must be explored across different temporal and spatial scales. The use of computer simulation tools in sustainable forest management permits us to ask questions about indicators, to determine what indicators may be most informative over the management time-horizon. The state of forests is dynamic over different temporal and spatial scales. Thus, planning for an indicator at only one scale or at the wrong scale may lead to unsustainable practices. For example, it has been suggested that planning for moose habitat in forest management at only one scale can lead to an over-simplification of the landscape (Rempel 2001). Models can also help us investigate changes in indicators (such as biodiversity or habitat) that would be difficult to evaluate through field trials, and to adjust management plans so that values such as biodiversity are maintained.

Linking Indicator Frameworks to Their Social Context

Gaining a better understanding of the social and economic processes that surround forestry and forest-dependant communities will greatly benefit the development and maintenance of systems for SFM. There are many examples of sustainable development initiatives that have failed because those implementing the management system did not take into account the social context (Hoff 1998). By contributing to the refinement of public participation processes, by clarifying the social relevance of indicators, and by facilitating the establishment of thresholds, the social sciences can contribute to the development and implementation of indicators that will be more likely to lead to SFM.

Roles of stakeholders in the adoption and implementation of indicators

Many agencies, both governmental and non-governmental, have promoted the involvement of stakeholders in forest management (Canadian Council of Forest Ministers (CCFM), Ministère des Ressources naturelles du Québec (MRNQ), the Forest Stewardship Council (FSC), and the Canadian Standards Association (CSA)). While the exact role for these stakeholders is often not clear, many expect that public participation will lead to a more effective resolution of conflict and to management systems that are better adapted to local contexts. The resolution of conflicting wants and true stewardship of the forest can only result from commitment to the process. In order to commit to the process of sustainable development, it is becoming clear that stakeholders must first understand and be involved in the identification of problems (Bélanger and Lapierre 2001). Having identified problems, stakeholders can proceed to adopt indicators reflecting universally, locally, and traditionally important values. As stakeholders, committed scientists and other experts can play a key role in demonstrating the importance of biodiversity and other less tangible forest values and the relevance of related indicators.

C&I for the real world

While indicators may be developed by scientists, their primary function remains a social one. Indicators of SFM, as described in most processes of SFM (CCFM, CSA, FSC), serve to inform people—stakeholders, forest managers, and policy makers—on the actual and potential condition of the forest. It is crucial for researchers to realize this when developing indicators.

There are certain characteristics that will allow indicator sets to better function within systems of forest management. First, there is a limit on the number of indicators that can be applied within a given management system (Kneeshaw *et al.* 2000a, Williams 2001). If indicators are meant to be used during the planning phase as part of model simulations, to describe the actual and potential state of the forest, the indicators must be defined in terms of forest conditions (Erdle and Sullivan 1998). When indicators refer to forest conditions, they may be more relevant to management; i.e., an indicator measures something that is directly affected by management practices. In this way, forest managers can work with objectives in terms of elements over which they have some amount of control. Also, when an indicator is intended for this purpose, data must be available for the entire management area. In order to verify the result of practices on the ground, field measurements of response indicators will be required. In this case, the data should be simple and quick to obtain. The challenge will be to translate complex information and solid science into simple indices that will not require excessive effort to integrate into an environmental monitoring system.

Establishing "acceptable" thresholds

The establishment of thresholds will be crucial for the implementation of indicators. Natural forest conditions and disturbance regimes are often characterized for this purpose. The range of natural variation is used to set thresholds, to understand the "natural" limits of an ecosystem. However, there is still a need to define, on a regional basis, what is an acceptable amount of change from the natural reference condition (McKenney *et al.* 1994, Galindo-Leal and Bunnell 1995, Bergeron *et al.* 1999, Fyles 2001). This will require both sound science and open discussion, bringing value judgements to the table along with the science. In some situations, we may set specific operational goals for emulating natural disturbance, and in others we may be restoring ecosystems towards the reference condition. These objectives will be specific to the local context. Bélanger and Lapierre (2001) proposed that public participation forums, in which participants identify the specific regional issues that need to be addressed to attain SFM, could facilitate the definition of common regional objectives and thresholds. When both the public and the industries involved "buy in" to these issues and the pertinent indicators, it is more likely that a monitoring framework will function and endure over time.

Challenges for Institutions and The Implementation of C&I

Reform of social, political, and forest management systems is needed to allow for the development of sustainable forestry practices. The principal role for leadership in sustainability lies in providing a vision for the future; governments must move beyond their current regulatory role and develop a vision of forests of the future. Meanwhile, political will originating from a grass-roots level could ensure that momentum develops in the movement towards sustainability. To maintain this grass-roots support, action must take place once commitments are made. Reform should involve the development of institutions through which commitments are translated into action and results, as well as mechanisms of accountability.

The development of leadership and vision in matters of SFM

Currently, ninety-six percent of commercial forests in Canada are public (Weetman 2001). Since provinces are responsible for the long-term sustainable management of forests, provincial governments must play a leadership role in the evolution of forestry towards sustainability (Côté and Bouthillier 1999). Governments must play a key role in developing a vision of SFM. Without such a vision, plans for sustainability will lack the coherence necessary to direct the initiatives and actions of industry, scientists, and other stakeholders.

Linking top-down initiatives with bottom-up movements

An entirely top-down approach, where objectives and constraints originate solely from international, national, or provincial institutions, will result in weaker local support, from both

forestry workers and communities. It will be individuals acting or not acting in the field that will lead to the successful implementation of SFM. If forestry workers and other community members are not convinced of the value of new practices and procedures, the process will be ineffective. In order to balance centralized leadership with grass-roots involvement, leaders will have to consider the entire hierarchy of government institutions (international, national, provincial, and local) in order to develop effective procedures and guidelines for SFM that are suited to the complexities of society.

Streamlining initiatives for the implementation of SFM

There are several certification vehicles currently generating interest in Canada (CSA, ISO, FSC, and the Sustainable Forestry Initiative (SFI)), each developing its own sets of C&I, as well as regulatory and performance-based provincial standards for forestry. As resources and political will are limited, too many concurrent processes run the risk of exhausting both of these. Government could play a leadership role in these matters or at the least work towards a co-ordinated approach. While integration is important, it is simplicity and cohesion that will limit the additional workload for forestry workers, and thus make successful implementation of C&I more likely. Some amount of simplification could be reached through regional agreement on locally appropriate indicator sets.

Balancing uncertainty and the urgency of applying knowledge

Scientific consensus is very difficult or impossible to generate. For example, there are many opinions regarding the means necessary to maintain biodiversity. Meanwhile, forest managers feel an urgent need for knowledge that will serve to change management practices and to answer the demands of society. Many managers feel that even knowledge associated with moderate levels of uncertainty would help the forest industry take steps towards the monitoring and maintenance of forest values. While such knowledge exists in universities and other research institutions, mechanisms for transfer are few (although some notable exceptions exist; see Messier and Kneeshaw 1999).

Integration and collaboration among fields and institutions

Specialist solutions lead to an incomplete resolution of problems. In order to balance values such as wood supply and biodiversity, a multi-disciplinary approach is essential. While ecology has begun to unite biologists from many disciplines, there remains a need to integrate fields outside the biological sciences, such as economics and sociology. Scientific research institutions (e.g., universities and funding agencies) encourage specialization. Leadership on behalf of governments could help to promote such multi-disciplinarity through funding initiatives and other incentives. Sociology must be integrated into forestry research in order to help to understand the processes that lead to the resolution of conflict and the initiation of profound and sustainable change. Also, the costs and benefits of alternative management strategies could be better estimated by assigning a value to non-timber values and elements of the environment (Adamowicz 2001). On a technological level, there is a need to integrate modelling approaches, frameworks, and methodologies for the success of SFM.

Conclusion

Sustainable forest management does not have a fixed endpoint but rather is a process of continual improvement that ensures that we are striving to achieve a set of goals that are determined by advances in science and technology and changes in society. By encouraging researchers to synthesize information and share understanding with industry, existing knowledge can more rapidly and effectively be put into action. Changes within institutions, including government, industry and research structures, may be required to achieve this goal. Information-sharing efforts may be more effective if certain scientists or other specialists are specifically charged with this task. The Swedish Institute for Ecological Sustainability, which seeks to "serve as a bridge between researchers and those who apply these theories" (IEH 2001) through its information officers, may serve as a model for this.

Management by results or an objective-driven evaluation of forest management may aid governments to move beyond the current static regulatory system. Although it may require a surrendering of control over certain intermediate steps, this approach may lead to SFM more directly. Such an approach will also function more effectively alongside adaptive management programs, and allow for the incorporation of advances in technology and scientific knowledge. It will also permit forest managers to take into consideration regional differences instead of applying blanket objectives over an entire province.

Multi-disciplinarity must be enhanced in order to develop a more holistic approach for the development of SFM. Institutions must strive to promote the training of multi-disciplinary researchers. In order to facilitate the development of such expertise, there is a need for models of multi-disciplinary study. Such programs of study could include, for example, diversified curricula, supervision committees composed of experts from many different domains, and study programs that link universities with strengths in different fields and technologies. Multi-disciplinarity will eventually build on itself. As more experience is gained and multi-disciplinarity permeates the scientific outlook, it will become easier to train new scientists. Meanwhile, research institutions must encourage multi-disciplinarity through the development of initiatives and evaluations that acknowledge the time and effort needed to develop truly multi-disciplinary work.

Scientists will generally agree that our knowledge of the forest, of its ecology and responses to management, is imperfect (Simberloff 2001). Meanwhile, decisions about forest management that lead to long-term consequences are being made daily, often without the benefit of an understanding derived from scientific and local knowledge (Franklin 1995). Forest managers require knowledge that can be applied in the field, while researchers are reluctant to commit to recommendations. By defining a clearer vision of what we must pass on to future generations, by committing to a process of adaptive management, and accepting that our knowledge will continue to improve as we perfect our understanding, our interaction with the forest will continue to evolve towards SFM.

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