

**Assessing Progress in Sustainable Forest Management: Proposed
Criteria and Indicators for the UpperGreat Lakes Region
June 4, 1998**

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Preface and Acknowledgements

This report was written under contract to the Great Lakes Forest Alliance. We have tried to use a format and style that would be attractive and understandable to all readers. We thank the GLFA for the opportunity to do this work, KBM Forestry Consultants Ltd. of Thunder Bay for assistance in collecting relevant reports, and GLFA personnel and associates for steering the project in a positive direction.

Contact Details for Comments on this Report

The GLFA would very much appreciate receiving your comments on how to improve the proposed set of criteria and indicators and their presentation in this report. You may contact the Alliance at:

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1. What is sustainable forest management (SFM)?

The names we give the latest and best form of forest management in North America keep changing. During the 1980s, integrated forest management was in vogue. Now, Canadians speak of sustainable forest management, and Americans use the phrases sustainable forestry and ecosystem management. Here, we consider all these concepts to be the same. They all essentially point to a re-balancing of priorities in forest management. Commodities are still important in the overall scheme of things, but people today want to make sure that forest managers are also addressing a host of non-timber concerns. Many of these have to do with the ecological and social functions of forests.

In this report, we will use the term sustainable forest management, shortened to SFM, and will adopt the definition offered by the Canadian Standards Association in its recently published standard for SFM (1):

Sustainable forest management - management to maintain and enhance the long-term health of forest ecosystems, while providing ecological, economic, social and cultural opportunities for the benefit of present and future generations.

The Great Lakes Forest Alliance defined sustainable forestry this way in a 1997 position paper on environmental soundness of forest policy and practice in the Lake States:

Sustainable forestry means to meet the needs of the present without compromising the ability of future generations to meet their own needs by practising a land stewardship ethic with integrates forest regeneration, nurturing management, growth and harvest for a variety of products and services and the conservation of soil, air, and water quality, wildlife and fish habitat, and aesthetics.

Most definitions of ecosystem management and sustainable forestry are consistent with this. What is critical in any conception of SFM is a balance of ecological, economic and social/cultural considerations. We will return to this thought below.

2. Why is SFM important?

SFM is important because people the world over are acknowledging the vital role forests play in so many aspects of their lives. Anybody's list of

forest values is very long, and includes all kinds of goods and services as well as a range of intrinsic values. This increasing awareness of forest benefits comes at a time when forests in many areas are under great pressure from human activities. There is alarming deforestation in some countries, and in other countries' forests are under pressures from air pollution and overuse.

In the Upper Great Lakes Region, we are particularly fortunate that our forests are, using global comparisons, in relatively good shape. But we can't be complacent - we must make sure they remain in at least as good shape in the future as they are now (indeed, many improvements are probably in order, too), and we must manage them with great consideration for the myriad values people place upon them.

3. Why focus on the Upper Great Lakes Region?

The forest communities in Michigan, Minnesota and Wisconsin have long discussed their common issues and concerns. In the late 1980s, the Lake States Forest Alliance was created as an independent, non-profit organization to promote cooperation among owners, stakeholders and users of forests in the region. In 1997, the Alliance was expanded with the addition of forest interests from Ontario and the name was changed to the Great Lakes Forest Alliance (GLFA). The Alliance membership includes public, private and academic forest-based organizations representing a broad spectrum of perspectives and interests.

The Alliance recognizes the importance of doing a good job of assessing progress in SFM throughout the region. More particularly, it sees the value of a strong set of regionally relevant criteria and indicators (C&I). To this end, the Alliance commissioned a regional forest resource assessment, and then, with that as a basis, prepared a position paper on sustainable forestry.

This represents the next step in this process - the development of a set of C&I-SFM. The purpose of these C&I is to provide landowners and governments with a locally appropriate basis for assessing sustainability. The GLFA will disseminate these C&I as a contribution to the discussions regarding SFM, and to promote education and awareness of SFM in the region.

4. What are criteria and indicators (C&I)?

The term criterion is being used in international C&I discussions to refer to a very broad "basket" of forest values. Forest values are the ways in which (and things for which) forests are important to people. Indicators are measurable characteristics of values.

Criteria and indicators can be readily organized into a hierarchy. Criteria are high in the hierarchy, and indicators are lower. Many people visualize an SFM hierarchy with five levels. At the very top (level 1) of the pyramid is SFM itself, which is the overriding goal.

At level 2 are three "pillars", or value domains, which are widely recognized as supporting the concept of SFM. The criteria, at level 3, represent more discrete descriptions of values within the three pillars of SFM. There is considerable subjectivity in naming the criteria. The main principle should be that each criterion represents a high-order forest value, or a basket of values, which is widely held by the people and organizations which will be using the C&I.

In many sets of SFM C&I, the criteria are each divided into elements. The identification of elements serves two purposes:

- ◆ they provide a more concrete description of the values expressed in the criteria; and
- ◆ they represent a stage in the logical process of identifying indicators for each of the criteria.

Finally, at the base of the SFM pyramid are the indicators, which are the specific attributes, processes, activities or outcomes that will be measured. In a practical set of C&I, it is impossible for the chosen indicators to capture absolutely everything about a criterion or element. However, an indicator set should at least do a good job of representing the associated criterion and elements.

Rather than provide an example, we refer readers to Question #13 below where we present the proposed list of criteria and elements.

5. Why are C&I needed in assessing progress in SFM?

When people make important decisions, they want to make sure they have

considered all the things that are important to them, as well as considering a reasonable range of options for the future. For example, when someone is considering buying a house, there are many important things to consider: (a) price; (b) number of rooms; (c) size of garden; (d) quality of neighbourhood; (e) proximity to schools, place of employment, amenities, public transit; and (f) other factors. Here, we would consider owning a house as one of several values in a happy family life, and the several considerations above as indicators. The indicators, clearly, are vital in making a good decision.

Now we turn our attention to forests. People today want unambiguous evidence as to whether forest managers and owners are achieving reasonable goals and objectives. In what terms are such goals and objectives expressed? Well, goals are appropriately expressed for forest values, and objectives for indicators. Goals show what directions are to be taken for values, and objectives reveal planned-for levels of indicators. While goals can be expressed in qualitative terms (e.g., maintain and conserve soil processes), objectives need to be stated in unambiguous, preferably quantitative, terms.

Here is a forest example. Let's say that wood is a forest value. The goal might be to provide a predictable and continuous supply of quality wood to local processing plants. An appropriate indicator might be volume of poplar veneer logs harvested from the forest each year. An objective might be 10,000 cubic metres each year for the next 50 years.

In sum, if we are to plan forest management in a systematic way to try to meet the wide range of expectations that people have, we must identify a broad suite of criteria and specific values, set a goal and identify at least one indicator for each value, and set an objective for each indicator.

6. What are the characteristics of a good indicator for SFM?

There is virtually an endless number of variables about forests and their uses that can be measured. In choosing indicators for SFM, one wants to make sure that the chosen indicators are good for their intended application. Several papers and reports have addressed the issue of what makes for a good indicator of SFM. We have examined these and drawn out seven key qualities that appeared most consistently:

Relevance to the value - the indicator should be clearly related and

relevant to the value it is intended to represent.

Measurability - The indicator should be measurable on a consistent and reliable basis, with relative ease using well-defined data.

Sensitivity to Change - Indicator must respond to management actions as well as natural changes in the forest.

Practicality - An indicator should not be overly expensive to assess.

Understandability - The intent of the indicator should be readily understandable.

Response Oriented - An indicator should measure a response within the forest or within the economic or social realm, rather than measuring actions or presence of policies.

7. What work has already been done in developing and applying C&I-SFM?

C&I-SFM have become a major pre-occupation of the global forest community during the 1990s. Indeed, they are central to any serious discussions related to sustainable development in general.

Initiatives and developments on C&I-SFM have occurred at international, national, regional and local levels. According to the Food and Agriculture Organization (FAO) of the United Nations (2), there are six international programs dedicated to developing and using broad-scale C&I-SFM. Of most relevance to North America is the Montreal Process, which began as follow-up to an international seminar of experts in Montreal, Canada, in September 1993. Other international C&I-SFM programs include the Helsinki Process (for European boreal and temperate forests), the Tarapoto Process (for Amazonian forests), the Central American/ Lepaterique Process, the process for Dry-Zone Africa, and the process for the Near East region.

Similar efforts are being undertaken nationally in many countries, including Canada and the United States. Canada was one of the first countries to publish a nationally endorsed set of C&I-SFM for application at the provincial/state and national levels (3). These C&I-SFM, developed using a stakeholder and expert consultation process, contain six criteria and 83 indicators. In the U.S., the American Forest & Paper Association

established the AF&PA Sustainable Forestry Initiative (4), at the core of which is a set of principles and implementation guidelines for SFM. The guidelines commit the AF&PA members to report publicly on their compliance and progress relative to the principles, and such reporting requires the establishment and measurement of relevant indicators of SFM.

8. How do C&I-SFM relate to forest certification?

People in the forest community are well aware of the dialogues now occurring about forest certification, which is a process whereby an independent organization verifies that a forest is being managed sustainably. One well-known organization in the business of forest certification is the Forest Stewardship Council, based in Oaxaca, Mexico. The FSC, which has published a set of global principles and criteria for forest stewardship (5), plays the role of certifier of certifiers. As such, it accredits audit organizations to examine specific forests for compliance with the principles and criteria, and offers an eco-label to be affixed to forest products the raw materials for which come from the certified forests. But there are other certification schemes, too. In Canada, forest owners and managers can consider registration of their forest-management systems under the ISO-14000 series of environmental management system standards (6), or the more specific SFM standard of the CSA (1).

Let us be very clear about the following point - in some certification schemes (e.g., the CSA standard), C&I are a basic requirement; however, use of C&I does not mean that a forest manager is considering certification. In other words, some certification schemes require C&I, but use of C&I does not necessarily imply (or require) certification. We have made the case above that C&I are required elements of any systematic approach to SFM.

9. How was this project carried out for the Upper Great Lakes Region?

The GLFA contracted a consulting team consisting of Jeremy Williams and Chris Wedeles, both of Arborvitae Environmental Services Ltd., Peter Duinker of Thunder Bay, and KBM Forestry Consultants Ltd. to research and prepare this set of criteria and indicators. The process we designed provided opportunities for the involvement of forest owners, stakeholders, and users throughout the Region. The following steps were undertaken:

1. The GLFA organized two one-day workshops in Duluth, Minnesota and

Sault Ste. Marie, Ontario, in December 1997 where we worked with attendees to develop lists of values judged to be important to their organizations and themselves. About 20 people attended each workshop, and from them lists of values and suggested indicators were prepared (see Appendix 1).

2. We reviewed a wide range of papers and reports related to SFM from organizations in both countries, focusing on those from the three states and Ontario. These included draft sets of C&I SFM prepared by the state governments of Wisconsin and Minnesota, the Sigurd Olson Institute, the American Paper and Forest Association, the Canadian Council of Forest Ministers, the US government, and the Ontario government.

3. We used the values from the workshops as the basis for developing a set of criteria of forest sustainability. Under each criterion, we decided to recognize three spatial scales: state/province; county or forest management unit, and woodlot. At each scale, we identified a number of sub-values, which represent the pertinent aspects of the criterion at that scale.

4. We then used the workshop responses and literature to develop a set of indicators under each sub-value at each scale.

5. The initial C&I structure we developed was reviewed by the GLFA members, and a series of revisions were suggested. The revisions have been incorporated into this, the next draft of the report.

6. GLFA members scored the indicators for their value and utility (see part (13) below), and these have been incorporated into this draft too.

10. How should we think about different forest ownerships and different spatial scales?

In our discussions with the GLFA and at the workshops, we considered at length whether the indicator set would need to take special recognition of different forest ownerships and different spatial scales. We recognized that these two dimensions have a significant degree of overlap - many (if not most) of the smallest parcels of forest, like woodlots, are privately owned by non-industrial individuals, and many of the large forest tracts are owned by governments or industrial corporations. We decided that spatial scale was by far the greater issue with respect to indicator selection, so our indicator lists suggest appropriate scales of application. We have identified

three main levels:

- an entire state, province, or region (the latter loosely defined);
- a county or a forest management unit (on the order of hundreds of thousands, or even a few millions, of hectares or acres); and
- a woodlot (perhaps on the order of tens to hundreds of hectares or acres).

11. What criteria for SFM are recommended here?

We propose five criteria as an organizing framework for SFM indicators for the Upper Great Lakes Region. They are:

- #1 - Maintenance of Biological Resources
- #2 - Maintenance of Soil, Water and Air Quality
- #3 - Provision of Multiple Economic Benefits
- #4 - Maintenance of Community and Cultural Values
- #5 - Society's Framework for SFM

Here is a brief explanation of what's involved in each criterion, plus a list of the relevant elements. Each criterion is relevant at each spatial scale - the state/province, the forest-management unit, and the woodlot. However, that's not true for the elements. Later, when the indicators are described, we indicate at what spatial scales each element is relevant.

Criterion #1 - Maintenance of Biological Resources

The elements are:

Diversity of forest communities

Species diversity

Genetic diversity

Productive capacity of forest sites

Forest Structure

Forest Composition

A major theme in the conservation of biological resources is biological diversity, or biodiversity. Biodiversity is a popular term that can be defined as the variability among living organisms and the ecological complexes of which they are a part (7). It is closely related to forest health in that biodiversity provides a basis for productivity and resiliency. Biodiversity is commonly sub-divided into three inter-related levels: community/ecosystem, species, and genetic. These are levels of biological organization and are not analogous to the three spatial levels used within this framework.

Forest productivity relates to a forest's ecological vitality. Forest productivity suffers if undue levels of stress are put on the forest, which can occur due to high pollution levels, high rates of disturbance, especially human-caused disturbance, or changes in weather patterns, to name a few potential sources of stress.

The diversity elements under this criterion are different across the spatial scales. For the state/province and county/FMU scales, they follow the three standard levels of biodiversity - community/ecosystem, species, and genetic. However, it makes little sense for a woodlot owner to assess species and community-level indicators since the area of many woodlots is so small. However, it is relevant to stratify the woodlot-level indicators under the categories of forest structure and composition.

Criterion #2 - Maintenance of Soil, Water and Air Quality

The elements are:

Water quality

Soil quality

Carbon cycle

Soil, water and air are the fundamental abiotic components of ecosystems and are primary determinants of an ecosystem's characteristics and productivity. Maintaining these elements is a prerequisite for the conservation of ecosystem health. Water quality is influenced by activities

occurring outside the forest as well as by practices undertaken within the forest. Soil quality may also be affected by forces beyond the control of the forest manager, such as the deposition of long-range pollutants, but many of the activities undertaken in forests have soil-related impacts. Air quality is primarily dependent on the outcomes of people's activities outside the forest, and most of its qualities are excluded on the grounds that they are hardly responsive to management actions. Concern for the impacts of human activities on the global carbon cycle is high, and forests are important in that cycle. Since it is worthwhile integrating state and provincial level efforts with those being undertaken at larger scales, the carbon cycle is included under this criterion.

Criterion #3 - Provision of Multiple Economic Benefits

The elements are:

Competitiveness of forest-based industries

Community stability

Goods and services produced

SFM explicitly tries to reconcile the sustainability of forests' ecological qualities with the economic, social, and cultural goods and services provided by them. Therefore, one of the criteria of SFM pertains to the sustainable production of economic goods and services.

Competitiveness is viewed as an important characteristic of a sustainable business or industry. If this is absent, then the business or industry is presumably operating with a handicap not shared by competing firms. Community stability is a very important value, especially in smaller communities. Traditionally, forest-based industries have experienced significant fluctuations in profitability, linked to a relatively volatile price environment. Nevertheless, forest-based industries are often one of the main economic drivers in many rural and northern communities. The indicators identify characteristics of the businesses which tend to promote economic stability.

Criterion #4 - Maintenance of Community and Cultural Values

The elements are:

Historical and cultural values

Affordability of forest land

Personal and spiritual values

Owner responsibility

At the Duluth and Sault Ste. Marie workshops, all participants expressed the importance of forests in shaping the communities where they lived and providing context for the socio-cultural values of those communities. The forests are the reason many rural communities even exist, so sustaining the forest is essential to sustaining the social fabric. Many First Nations communities are also forest-based, and for them the forest provides the vital spiritual, cultural and economic context.

People who live in forest-based communities point to the importance of their lifestyles. This includes not only the recreational opportunities but also the strong connection with the land. Logging was often the impetus for the establishment of forest-based communities, and so their history is intertwined with the history of the forest. The cultural importance of land ownership was emphasized strongly at the two workshops.

This criterion also captures the very personal feelings and sentiments that the forest engendered in workshop participants. It is therefore concerned with the value of forests to the human spirit and sustaining the ability of the forest to continue to provide those experiences. Because the essence here is personal and to a large degree intangible, we have developed indicators which pertain to the features of the forest which are most evocative to the senses, and secondly, which pertain to the ability of people to use the forest.

Criterion #5 - Society's Framework for SFM

The elements are:

Legal framework for SFM

Institutional framework for SFM

Public involvement in decision-making

SFM is not just a technical pursuit occurring in a contextual vacuum. While its main focus is indeed the sustainability of forest ecosystems and the uses and communities that depend on them, it must also be concerned about the ways in which users, managers and other stakeholders organize and control themselves to pursue SFM. This criterion therefore addresses the legal and institutional frameworks for pursuing SFM. It delves into the policies, legislation, regulations and guidelines that drive and direct SFM practices, and looks at how institutions cooperate to achieve SFM. It also examines the quality and quantity of opportunities for the general public to become involved in the planning processes leading to forest decisions.

12. How do these criteria match with other sets?

Readers who are familiar with the SFM-C&I literature will note that the criteria presented here are somewhat different than those adopted in various national and international processes. We believe that the GLFA criterion set well reflects how the forest stakeholders in the Upper Great Lakes Region think about SFM. As it turns out, at the element and indicator levels, virtually all of the forest values covered in other criterion sets are also covered in the GLFA set. We show this with some examples below.

Of particular relevance for the Lakes States-Ontario region are two broad sets of SFM-C&I: the C&I of the Montreal Process (both the U.S. and Canada are signatories) (8), and the C&I of the Canadian Council of Forest Ministers (CCFM) (3). Below we show the relationship between these two criterion sets and the set presented in this report. Note that the Montreal Process and CCFM C&I are intended for use at broad spatial scales (e.g., national level) and may not be most appropriate for use in the Lake States Region.

In Table 1 below, the Montreal Process criteria appear as row titles, and the columns represent the five GLFA criteria. Where there is an X, this means that the GLFA criterion contains all or part of the elements considered under the Montreal Process criterion. For example, the second Montreal Process criterion "Maintenance of Productive Capacity of Forest Ecosystems" has elements that are covered under GLFA criteria 1 and 3.

Table 1. Comparison of the GLFA Criteria with those of the Montreal Process

| Montreal Process Criteria | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Conservation of Biodiversity | X | | | | |
| Maintenance of Productive Capacity of Forest Ecosystems | X | | X | | |
| Maintenance of Forest Ecosystem Health and Vitality | X | | | | |
| Conservation and Maintenance of Soil and Water Resources | | X | | | |
| Maintenance of Forest Contribution to Global Carbon Cycles | | X | | | |
| Maintenance and Enhancement of Long-term Multiple Socio-Economic Benefits | | | X | X | |
| Legal, | | | | | X |

| | | | | | |
|--|--|--|--|--|--|
| Institutional and Economic Framework for Forest Conservation | | | | | |
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The draft set of criteria being considered by the National Association of State Foresters is identical to those of the Montreal Process.

Table 2 shows the relationship between the CCFM criteria and those for the GLFA.

Table 2. Comparison of the GLFA Criteria with those of the CCFM

| CCFM Criteria | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Conservation of Biodiversity Conservation | X | | | | |
| Maintenance of Forest Health and Ecosystem Productivity | X | | | | |
| Conservation of Soil and Water | | X | | | |
| Maintenance of Forest Contributions to Global Cycles | | X | | | |
| Multiple | | | X | | |

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|--|--|--|--|---|---|
| Benefits to Society | | | | | |
| Accepting Society's Responsibility for Sustainable Development | | | | X | X |

13. What indicators have we identified?

Now we present five tables of indicators - one for each criterion. Each table contains the indicators we propose for application in the Upper Great Lakes Region, sorted by element. At this stage, the slate of indicators is large (more than 150 indicators). We were tempted to evaluate the quality of the indicators and reject any that fell short of some quality minimum. Previous experience leads us to believe that the resultant indicator set would consist perhaps 50-75 indicators. However, we fear that our personal priorities regarding indicator usefulness may not match those of forest interests and stakeholders in the Upper Great Lakes Region, so we are reporting the full suite of indicators here.

Our attempt to show an initial assessment of the relative value of the indicators is included in the tables below. We asked members of the Alliance to score each indicator between 1 (lowest) and 3 (highest) for each of the six qualities of a good indicator described in part (6) above. These scores were summed to provide a total score for each indicator. We then calculated the average score from all the Alliance members' scores we received to calculate a composite score for each indicator. These scores were then normalized to 100 to provide a simple conceptual basis for comparing the scores.

What do these scores mean? Well, the method used was anything but statistically rigorous, and we had a relatively small number of samples, so we must be careful not to read too much into the scores. However, they do provide a rough basis to gauge the quality of an indicator. A difference between two indicators of only a few points is probably meaningless because of the approximate methods used, however, a difference of, say, 20 points or more is likely a good indication of a difference in the potential

usefulness of the two indicators.

The three right-hand columns in the tables below show the scale of application of the indicators. As described in part (10), the indicators were developed specifically with three spatial scales in mind: the state or province, the county or forest management unit, and the woodlot. Some indicators apply to only one of these scales, some apply to two, and a small number apply to all three scales. In the tables below, the presence of score in one of the three right-hand columns means that the indicator is intended to be applied at the scale noted by the column.

Obviously work remains to be done to pare the set of indicators down to a more reasonable number. A process such as the one described above, and the feedback to this report should provide a strong basis for identifying the best indicators from the set below.

Table 3. Initial indicators for Criterion 1 - Maintenance of Biological Resources

| Indicator | Explanation | Scale of Application | | |
|--|--|----------------------|----------------|---------|
| | | State/Prov. | County/ FMU | Woodlot |
| Ecosystem Diversity | | | | |
| Proportion of forest in each seral stage | Each stage of succession supports different communities of plants and animals; maintaining adequate area is important for species retention. This indicator may also be compared | 88 | | |

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|--|---|----|--|--|
| | against equivalent values for historical forests. | | | |
| Proportion of forest area in each cover and age-class type | Each cover type and age class also supports different mixtures of species in varying proportions of abundance. Cover type varies within each seral stage, and so the two indicators do not overlap; age class and seral stage are unrelated attributes. | 97 | | |
| Area of primary forest | Forest which originates from natural disturbance is often more diverse than forests originating after human intervention, even when regeneration is unassisted. | 67 | | |

| | | | | |
|--|--|----|----|--|
| Area protected by IUCN standard reserves | The World Conservation Union (IUCN) has developed an approach for classifying reserves based on the level of protection; this provides a useful and credible basis for tracking reserve areas. | 44 | 75 | |
| Road density | This provides a measure of fragmentation and intensity of human use. | | 86 | |
| Patch size distribution: for all forest patches and for old forest | Patch size is a metric which reflects both the nature of the forces which created the forest and the characteristics of timber harvesting. Patch size is closely linked to fragmentation | | 78 | |

| | | | | |
|---------------------|--|--|----|--|
| | n. Old forest is singled out for explicit assessment because the distinction between edge and interior habitat is most relevant for old forests. | | | |
| Average patch size | The average patch size is derived from the size distribution. | | 67 | |
| Patch shape indices | Not only the area but the shape of patches determines the characteristics of the forest communities in those patches. | | 49 | |
| Connectivity index | Connectivity is often measured as the potential for movement and population interchange. Various indices are available. | | 56 | |

| | | | | |
|--|--|----|----|--|
| Fragmentation index | Fragmentation may be assessed from average patch size, road density, or other indices. | | 58 | |
| Percent of forest area grazed | Grazing reduces the diversity of the understory and herbal vegetation in a forest. | | 53 | |
| Species Diversity | | | | |
| Number of rare, threatened and endangered forest species | Species which are classed as rare, threatened or endangered area at some relatively significant risk of extinction and the number of species provides a measure of risk of loss of diversity attributes. | 67 | | |
| Changes in rare, | If additional species are | | | |

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|---|---|----|----|---|
| threatened, and endangered status of forest-based species | listed, or species are classified at a higher level of risk, then the risk of loss of biodiversity is increasing; opposite shifts have a positive interpretation. This indicator requires an analyst to provide more depth to an accounting of rare, threatened and endangered species than a mere listing of numbers provides. | 68 | | |
| Abundance of selected species | Certain species are designated as important to track for a variety of social, economic, and ecological reasons. | 79 | 78 | a |

| | | | | |
|--|--|----|----|---|
| Amount of habitat for selected wildlife species | Habitat is a major determinant of wildlife abundance and population levels. | | 81 | a |
| Health of populations of sensitive species | Species which are most vulnerable to extirpation can be assessed using statistics based on mortality, fecundity, and population structure. | | 71 | a |
| Amount of habitat enhancement work | This indicator is a measure of human efforts to improve or restore wildlife habitat. | | 58 | |
| Genetic Diversity | | | | |
| Proportion of forest species with decreased ranges | Species whose range is shrinking are likely to have less within-species genetic | 68 | | |

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|--|--|----|----|---|
| | variation. | | | |
| Proportion of artificial regeneration derived from acceptable seed zones | The degree to which plantations are established using seed from areas with the same geoclimatic conditions provides a measure of the genetic suitability of plantations. | 67 | | |
| The ratio of number of exotic species: number of native species | The ratio of exotic species to native species measures the degree to which native ecosystems have been disrupted by the entry of new species. Disruptive effects may include the local extirpation of species which are outcompeted or preyed on by the exotic species, and a shift in the | 60 | 56 | a |

| | | | | |
|--|--|----|----|--|
| | distribution of remaining species. | | | |
| Area colonized by exotic or invasive species | The extent to which forest lands have been colonized by exotic or invasive species measures the spatial degree of ecosystem disruption due to the expansion of various exotic species. | 60 | 65 | |
| Proportion of forest area as plantations | This measures the prevalence of plantations in the forest landbase; plantations often have markedly less diversity than primary and even secondary forests. | | 83 | |
| Productive Capacity of Forest Sites | | | | |
| Area of forest not satisfactorily | This indicator measures | 92 | | |

| | | | | |
|--|--|----|--|--|
| regenerated | the extent to which humans and nature are willing (or able) to replace forest lost to various natural and human-caused disturbance processes. | | | |
| Percent of depleted area successfully regenerated | This is the inverse of the above indicator, expressed as a proportion of all depleted area. This measures the effectiveness of all regeneration methods. | 90 | | |
| Percent of depleted area successfully regenerated with artificial regeneration | This indicator reports the prevalence of artificial regeneration techniques. | 72 | | |
| Percent of area depleted area successfully regenerated with natural regeneration | This indicator reports the prevalence of natural regeneration techniques. | 69 | | |

| | | | | |
|---|--|----|----|---|
| Area permanently deforested, by type of loss (e.g. residential expansion, agricultural expansion) | The area of forest that is converted to other long-term uses is one indicator of human pressure on forests. | 83 | 99 | |
| Area of disturbance, by type and severity class | This indicator reports on the extent of each main type of natural and human disturbance; for some, such as insect infestation, a further breakdown by severity class is required to provide a measure of the stress faced by the forest. | 68 | 72 | a |
| Frequency distribution of disturbance areas, by disturbance type | This indicator provides an overview of the manner in which different disturbances affect the forest. | 68 | 67 | |

| | | | | |
|--|---|----|----|----|
| Shape or configuration of disturbance areas, by disturbance type | One can compare natural and human-caused disturbances with this indicator. | 39 | 40 | |
| Area of land afforested | This indicator reports explicitly on one means of increasing forest area. | | 92 | |
| Structure | | | | |
| Density of woody stems by size class | This measure describes the abundance of trees by size class within the forest. | | | 96 |
| Diversity of tree ages | Tree age is only partially correlated to tree size; this indicator measures the degree of ingrowth and small scale disturbance activity in the larger forest. | | | 92 |
| Number of super-canopy trees | Trees which tower above the normal forest | | | 83 |

| | | | | |
|----------------------------------|--|--|--|----|
| | canopy are valuable for several species of wildlife, most notably raptors. | | | |
| Abundance of snags | Snags provide homes for cavity nesters and other species which depend on dead trees for food, nesting or other features and their removal lessens biological diversity within the woodlot. | | | 76 |
| Abundance of Coarse woody debris | Downed logs contribute to diversity, especially for invertebrates , non-vascular plants, algae and bacteria, as well as numerous small vertebrates. | | | 64 |
| Connectedness to forest | Connected forests | | | 72 |

| | | | | |
|---|--|---|---|----|
| on adjacent lands | function as larger, more complete ecosystems, provide travel corridors for wildlife, and are more likely to have a wider variety of species than are isolated forests. | | | |
| Composition | | | | |
| Abundance of selected wildlife species | Certain species are designated as important to track for a variety of social, economic, and ecological reasons. | b | b | 71 |
| Amount of habitat for selected wildlife species | Habitat is a major determinant of wildlife abundance and population levels. | | b | 42 |
| Health of populations of sensitive species | Species which are most vulnerable to extirpation can be assessed | | b | 51 |

| | | | | |
|---|---|--|--|----|
| | using statistics based on mortality, fecundity, and population structure. | | | |
| The ratio of number of exotic species: number of native species | The ratio of exotic species to native species measures the degree to which native ecosystems have been disrupted by the entry of new species. Disruptive effects may include the local extirpation of species which are outcompeted or preyed on by the exotic species, and a shift in the distribution of remaining species. | | | 49 |
| Number of native tree species, by size class | A measure of species richness, for native species only. | | | 85 |
| Function | | | | |

| | | | | |
|---|--|---|---|----|
| Area of disturbance, by type and severity class | This indicator reports on the extent of each main type of natural and human disturbance; for some, such as insect infestation, a further breakdown by severity class is required to provide a measure of the stress faced by the forest. | b | b | 58 |
| Tree mortality by source | Mortality data provide an overview of reasons for tree death and the functioning of mortality-causing agents. | | | 69 |
| Number of livestock days | This measure of grazing intensity reports on the degree of pressure from livestock. | | | 60 |

a - These indicators are also used at the Woodlot level, but for different elements

b - These indicators are also used at the State/Province and/or at the County/FMU level, but for different elements

Table 4. Initial indicators for Criterion 2 - Maintenance of Soil, Water, and Air Quality

| Indicator | Explanation | Scale of Application | | |
|---|---|----------------------|----------------|---------|
| | | State/Prov | County/ FMU | Woodlot |
| Maintenance of Water Quality | | | | |
| Area of forest managed for water conservation | Areas which are of critical importance to maintaining water quality, as well as watersheds used by local communities, may be managed with a primary objective of maintaining water quality. | 85 | 81 | |
| Percent of stream length in forested watersheds in which stream flow and timing has significantly | This indicator attempts to report on the extent to which water flow relations | 61 | 67 | |

| | | | | |
|--|--|----|----|----|
| deviated from the historic range of variation | have been disrupted; flow and timing exercise a strong influence on the habitat characteristics of streams. | | | |
| pH of rainfall | pH is a measure of the acidity of water, and a composite measure of water quality | 63 | 54 | |
| Area of forest managed for water conservation versus area performing these functions | At the county or forest management unit level, this indicator is expressed as the proportion of area important for water quality that is being managed for this purpose. | | 65 | |
| Water conductivity | Water conductivity is one of the single best measures of overall water quality. | | 39 | 37 |
| Suspended sediment | Logging and water | | 59 | 57 |

| | | | | |
|--|---|--|----|----|
| levels | crossings often increase the amount of fine sediment in stream flow, which has negative consequences for habitats of species such as brook trout. | | | |
| Fish species diversity | Changes to the water quality or characteristics of a stream or lake are often reflected in changes in fish populations. | | 54 | 52 |
| Pesticide residue concentrations in surface and ground water | Pesticide residues are found throughout the ecosystem and may cause chronic and acute effects. | | 52 | 43 |
| Water table level | Water tables are affected by human activities and lowering the SEM is | | 50 | 43 |

| | | | | |
|--|---|--|----|----|
| | difficult to reverse. | | | |
| Length of watercourses harvested to water edge | Harvesting to the edge of a stream or lake has many detrimental effects and is generally prohibited in codes of forest practices, yet it continues to occur. | | 65 | 68 |
| Number of water crossings per unit area | Water crossings are point sources of sedimentation, which often continues during use of the crossing. | | | 63 |
| Water temperature | Removal of tree cover over streams and other water bodies contributes to higher water temperatures in the portion of the stream next to which timber harvesting took place, | | | 59 |

| | | | | |
|--|--|----|----|----|
| | and also downstream. Temperature affects growth rates and habitat - cool water species are particularly vulnerable to spikes in water temperature. | | | |
| Soil Maintenance | | | | |
| Area of forest managed for soil conservation | This reflects the fragility of the soil on some sites in many forests, and the recognition of this vulnerability in site-specific management objectives. | 78 | | |
| pH of soil | Acidification is a long-term threat to soil quality. | 44 | 52 | |
| Current annual increment | Growth rates serve as proxies for the productive capacity of the site, although levels of | 64 | 41 | 44 |

| | | | | |
|---|---|--|----|----|
| | growth are also affected by other factors too. | | | |
| Area of forest managed for soil conservation versus area performing these functions | At the county or forest management unit level, this indicator is expressed as the proportion of area important for soil quality that is being managed for this purpose. | | 78 | |
| Pesticide residue concentrations in soil | Pesticide residues may cause chronic effects. | | 50 | 46 |
| Soil fauna - diversity and abundance | Soil fauna contribute to nutrient cycling and overall soil productivity. | | | 50 |
| Soil degradation indices | Compaction, puddling, and loss of organic matter are key causes of soil degradation and productivity losses. | | | 35 |
| Maintenance of Forest Contribution to Global Carbon Cycles | | | | |

| | | | | |
|---------------------------|---|----|----|----|
| Soil carbon pools | A measure of the carbon stored in forest soils. Sequestering of carbon mitigates carbon emissions into the atmosphere. | 47 | | |
| Soil carbon decay rate | A measure of the loss of carbon from forest soils. Depending on a variety of conditions, forests may be sources or sinks of atmospheric carbon. | 43 | | |
| Fuelwood consumption - | Burning wood releases carbon into the atmosphere and human fuel use may be an important contributor to atmospheric carbon in some areas. | 49 | 54 | 37 |

Table 5. Initial indicators for Criterion 3 - Provision of Multiple Economic

Benefits

| Indicator | Explanation | Scale of Application | | |
|---|---|----------------------|----------------|---------|
| | | State/Prov | County/ FMU | Woodlot |
| Competitiveness of Forest-Based Industries | | | | |
| Share of GDP accounted for by forest-based businesses | Proportion of gross domestic product generated by forest industries is a measure of their importance, and, indirectly, their competitiveness. | 85 | | |
| Share of North American and global markets accounted for by forest based businesses | Market share is another measure of importance; changes in market share over time reflect competitiveness. | 82 | | |
| Profitability of forest resource based industries | The ability to create profits implies that the business can generate capital to invest, which contributes | 68 | | |

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|--|--|----|----|----|
| | to growth and maintenance of competitive ability. | | | |
| Value added produced in forest-resource based industries | The choice of products and, to a lesser extent, efficiency of manufacturing indicate how much value a firm can added to the inputs during the manufacturing process. | 76 | | |
| Capital expenditures by forest-resource based industries | Investment in capital is a key to maintaining competitive capability. | 68 | 72 | |
| Weight of final product produced per cubic metre of timber harvested | This measures the efficiency of fibre utilization, which should be higher in more competitive and profitable firms and industries. | | 52 | |
| Rate of return | Some | | | 68 |

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|---|---|----|----|--|
| on investment | private landowners view their holdings as investments. For those who do, rate of return is a critical measure of the attractiveness of the investment, as well as of the affordability of land. | | | |
| Community Stability | | | | |
| Forest based employment - number of full-time employees | Full-time employment is desired by many workers, since it provides a steady income at a relatively high level. This is conducive to family health and community stability. | 91 | 83 | |
| Forest based employment - number of part-time employees | While part-time employment is desirable to some extent, tracking it | 83 | 76 | |

| | | | | |
|---|---|----|--|--|
| | separately and comparing it to full-time employment will provide an indication of trends in community stability. | | | |
| Average income of forest sector employees | People tend to move to where income levels are highest and stable or rising incomes are attractive. The average can also be compared to economy-wide averages to gain a sense of the relative prosperity of a region. | 82 | | |
| Diversity of forest based industry | While a strong industry is a boon, the forest industry is cyclical and a more diverse forest-based economy is likely to | 93 | | |

| | | | | |
|-----------------------------|---|----|--|--|
| | provide a cushion against severe downturns in one or two product areas. | | | |
| Goods and Services Produced | | | | |
| Area of forest land | The ability of forests to provide goods and services is dependent upon how much forest exists. | 85 | | |
| Expenditures by hunters | This is an indirect measure of the value placed on hunting and the level of hunting activity. Hunter expenditures are important to some segments of the forest-based economy, although the local economy primarily benefits from local expenditures | 68 | | |

| | | | | |
|--|---|----|----|----|
| | . | | | |
| Expenditures by anglers | Analogous to hunter expenditures | 68 | | |
| Expenditures on non-consumptive forest use | Analogous to hunter expenditures | 61 | | |
| Volume and value of wood harvested | Tracking the amount of timber harvested, and its value, is vital in gauging community economic opportunities | 94 | 94 | 91 |
| Number of game animals harvested, by species | A measure required in determining harvest sustainability | 74 | 72 | |
| Weight of fish harvested, by species | A direct measure of the harvest sustainability | 54 | 50 | |
| Value of other forest products harvested | A measure required in determining sustainability of production of other forest products such as berries, furs, and mushrooms. | 60 | 67 | 80 |

| | | | | |
|-------------------------------------|--|----|----|--|
| Number and value of recreation days | Recreation usage, and its value, is a complement to timber harvest revenues. | 80 | 80 | |
|-------------------------------------|--|----|----|--|

Table 6. Initial indicators for Criterion 4 - Maintenance of Community and Cultural Values

| Indicator | Explanation | Scale of Application | | |
|--|---|----------------------|----------------|---------|
| | | State/Prov | County/ FMU | Woodlot |
| Historical and Cultural Values | | | | |
| Inventory of historically valuable sites | Historical sites are important to a community's sense of itself and knowledge of these sites' locations is a preliminary step to conserving them. | 87 | 93 | 82 |
| Incorporation of historic values into planning | The extent to which historical sites are explicitly considered in planning. | 83 | 83 | 85 |
| Extent of traditional uses | The degree to which forest uses | 65 | 67 | |

| | | | | |
|---|---|----|----|--|
| | such as trapping, maple syrup production and others uses with strong historical ties are supported and continued. | | | |
| Inventory of sites which have cultural value to First Nations | An inventory is a first step to considering important sites in planning forest use and protecting important heritage sites. | 83 | | |
| Incorporation of First Nation values into planning | The extent to which sites and uses important to First Nations are considered in planning. | 82 | | |
| Affordability of Forest Land | | | | |
| Tax rate on forested land relative to tax rates on other land | Forest land taxes are often an issue for woodlot owners who either do not | 74 | 72 | |

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|---|---|----|----|--|
| | harvest timber or do so only periodically. Tax regimes are a key component of affordability. | | | |
| Percent of forest land owned by industrial private owners | Industrial enterprises are interested in owning forest land where it can be managed profitably; the extent of industrial ownership reflects expected profitability. | 74 | 74 | |
| Percent of forest land owned by non-industrial private owners | The extent to which woodlots are owned by non-industrial private owners is one direct measure of the attractiveness to an individual of owning land. | 76 | 74 | |
| Existence and effectiveness of incentives | The existence of incentives will increase | 74 | 68 | |

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|---|--|--|----|--|
| for forest land management | the affordability of land ownership. | | | |
| Forest land price level | Price levels are reflective of affordability; increasing prices enhance the attractiveness of forest land ownership. | | 76 | |
| Average size of private forest holding | Greater affordability allows owners to maintain the integrity of their holdings. | | 67 | |
| Average length of tenure of forest land | Tenure length is an indicator of the desirability and stability of owning land. | | 56 | |
| Percent of private land covered by integrated resource management plans | Planning is conducive to sound management, which should contribute to income generation where that is an objective. | | 63 | |

| | | | | |
|---------------------------------|--|----|----|--|
| | It is also related to the value of owner responsibility . | | | |
| Personal and Spiritual Values | | | | |
| Number of highway pull-offs | Highway pull-offs provide people with opportunities to view beautiful vistas and appreciate an area's scenic attractiveness. | 65 | | |
| Area of wilderness | The knowledge that wilderness exists, and the direct experience of it, are both important to people's sense of well-being. | 89 | | |
| Percent of roadless forest area | Roadless areas have many wilderness qualities but may not be classed as wilderness - the | 85 | 89 | |

| | | | | |
|--|---|----|----|--|
| | contribution of such areas should be monitored. | | | |
| Presence of spiritually important wildlife species | Species such as wolves and loons evoke wilderness contemplations in many people and the abundance of these species is closely linked with the transcendent quality of the forest. | 57 | | |
| Percent of forest area in parks and ecological and recreational reserves | Parks and reserves are often older primary forests that experience few extractive activities. Many people visit these areas to experience the forest. | 89 | | |
| Road density | Road density provides measure of other human use and the | | 89 | |

| | | | | |
|---|--|--|----|----|
| | capability of the forest to provide opportunities for people to "get away from it all". | | | |
| Average size of non-roaded areas | This indicator adds further insight to road density. | | 61 | |
| Number of First Nation sacred sites conserved | First Nations sacred sites are of obvious importance to those communities and planning should avoid despoiling them. | | 74 | |
| Landscape aesthetic metrics | Various measures of the landscape are used to gauge the beauty of a forest landscape or viewshed. | | 48 | |
| Wildlife viewing opportunities | Marsh board walks, salt licks and other human features enhance wildlife viewing opportunities | | 65 | 70 |

| | | | | |
|--|---|----|----|----|
| | . | | | |
| Number of km of interpretive trails | A measure of the opportunities available to people to learn more about the forest and to experience it. | | 65 | |
| Woodlot aesthetic metrics | Aesthetic metrics appropriate for evaluating attractiveness of a forest stand or woodlot. | | | 59 |
| Weight of litter and garbage per ha | Presence of litter is negatively correlated to aesthetic beauty. | | | 46 |
| Proportion of forest land available for public use | This indicator reports on people's opportunities to use the local forest. | 85 | 82 | |
| Hunter days spent hunting forest wildlife | The amount of actual use for hunting purposes will reflect the quality of the hunting experience, both in terms | 78 | 68 | |

| | | | | |
|--|--|----|----|----|
| | of hunter success, animals seen, and the aesthetic appeal of the forest. | | | |
| Fishing days | Analogous to hunter days. | 67 | 54 | |
| Number of user days for non-consumptive forest use | Analogous to hunter days. | 82 | 76 | |
| Number of campsites | The number of campsite facilities indicates the amount of opportunity available to people to use the forest. | | 63 | |
| Number of km of trails | Analogous to above indicator. | | 67 | |
| Number of facilities for public use | The number of facilities indicates the amount of opportunity available to people to use the forest. | | | 59 |
| Extent to which public use is encouraged | An assessment of the degree to which a | | | 61 |

| | | | | |
|--|---|--|--|----|
| | woodlot owner encourages the public to use the woodlot and derive benefits from that use. | | | |
| Owner Responsibility | | | | |
| Extent of owner integration with county, state or provincial management objectives | The extent to which a forest plan is harmonized with broader land use objectives and the characteristics of the surrounding area improves the quality of the plan and reflects an owner's commitment to sound management. | | | 54 |
| Percent of woodlot available for public use | The degree to which owners encourage public use of their land reflects the extent to which landowners support local community | | | 70 |

| | | | | |
|--|--|--|--|----|
| | values. | | | |
| Existence and degree of adherence to integrated resource management plan | An owner who has a management plan in place and is following it is less likely to undertake activities which reduce the sustainable use of his or her woodlot. | | | 82 |
| Percent of harvested area re-forested | A forest landowner committed to sound forest use will ensure that harvested areas regenerate. | | | 89 |

Table 7. Initial indicators for criterion 5 - Society's Framework for Sustainable Forest Management

| Indicator | Explanation | Scale of Application | | |
|--|--|----------------------|------------|---------|
| | | State/Prov | County/FMU | Woodlot |
| Legal Framework for SFM | | | | |
| Degree to which forest policy supports SFM | Forest managers should have policy and legislative basis for undertaking SFM | 83 | | |

| | | | | |
|--|--|----|----|--|
| Appropriate land tenure rights for SFM | Narrow or restrictive tenure arrangements may not provide forest managers with the breadth of responsibilities required to undertake SFM | 64 | | |
| Adequate cooperation between different land managers | Cooperation between agencies with different land management responsibilities is necessary to undertake meaningful SFM | 64 | 58 | |
| Adequate enforcement of laws and regulations | Enforcement of laws and regulations provides a measure of public reassurance regarding the quality of forest management. | 67 | 58 | |
| Existence of legal mechanisms for local | Members of the public must have appropriate | 74 | | |

| | | | | |
|--|--|----|----|--|
| participation in forest planning | and meaningful opportunities to participate in forest management | | | |
| Existence of municipal laws that support SFM | As above, a legal framework must exist which support implementation of SFM. | 83 | | |
| Institutional Framework for SFM | | | | |
| Existence of an integrated forest or land use plan | Although the existence of a plan does not guarantee high-quality forest management, it is a prerequisite. | 91 | 93 | |
| Existence of codes of best forest practices | Codes of best practice describe state-of-the-art practices and set a high standard for industrial forestry practitioners | 80 | | |
| Degree of support for SFM among forest user associations | Industry and forest-user associations are key participants | 68 | | |

| | | | | |
|---|--|----|----|--|
| | in undertaking SFM; their support is vital. | | | |
| Absence of gaps in management responsibility | Gaps in management responsibility may create situations in which resources are not receiving adequate, or appropriate management attention. | 57 | 65 | |
| Quality of data required to support SFM | SFM is best supported by high-quality data. | 65 | 54 | |
| Existence of state-of-the-forest or-environment reports | These reports can be important in educating the public about the state of the forest resources, and they are indicative of an understanding of the importance of such reports by governments | 91 | | |

| | | | | |
|--|---|----|----|--|
| Regular and comprehensive audit or assessment program | Audit and assessment programs are cornerstones of many SFM systems. | 96 | 94 | |
| Effectiveness of education and public awareness programs | Attempts should be made to educate and inform the public about SFM practices being undertaken, and their importance. | | 56 | |
| Number of forest professionals employed | An approximate indicator of government and corporate commitment to SFM. | | 74 | |
| Extent of co-management agreements with First Nations | First Nations often have legal and cultural rights and interests in forest land management, and these can be respected with co-management agreements. | | 69 | |

| Public Involvement in Decision Making | | | | |
|--|--|----|----|--|
| Extent of public participation in policy making and planning | Members of the public must have appropriate and meaningful opportunities to participate in setting forest policy. | 89 | 78 | |
| Extent of public participation in monitoring management outcomes | Public trust is engendered if they can play a role in monitoring management practices and outcomes. | 80 | 78 | |
| Inclusiveness of public participation processes | Broad and open public participation is required, not only to engender trust, but also to ensure that high quality input is obtained. | 76 | 72 | |
| Extent of First Nations' participation in decision making | First Nations may have legal rights to participate in decision-making, and they often bring unique and | 82 | 68 | |

| | | | | |
|--|------------------------|--|--|--|
| | important perspectives | | | |
|--|------------------------|--|--|--|

14. How should this set of C&I-SFM be used?

This set of C&I has two functions. First, it is the GLFA's hope that forest owners and managers throughout the Upper Great Lakes Region will consider using some or all of them in their own pursuits of SFM. Users should really consider their first applications as experimental because most of the indicators have never been used in this way before. The best outcome would be that the indicators are applied in a variety of situations, and users get together periodically to share their experiences so all the indicators get thorough evaluations of their utility in SFM. Strong indicators will get continued application, while weak ones will be strengthened, modified or discarded.

The second function of the indicators is to serve as a basis for further defining the concept of SFM. The indicators identify what's important to people about forests, and discussions about them will provide a focus for improvements in forest management.

15. How can this set of C&I be improved right now?

The C&I in this report are proposed based on the literature of the region and discussions with some forest stakeholders. No doubt knowledgeable readers will immediately see that some good indicators are missing, some weak indicators are included, and some indicators are described in an awkward or ambiguous way. We appeal to you for suggestions to improve the set - any number of comments, by any means of communications, are welcome. Just note your improvement suggestions right in this paper, or write them down on another piece of paper, and send them back to the GLFA by fax or mail. See the contact information in the preface.

16. What literature did we consult?

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