

Review

Local level criteria and indicator frameworks: A tool used to assess aboriginal forest ecosystem values

M.C. Adam^{*}, D. Kneeshaw

Centre d'études de la forêt, Université du Québec à Montreal, C.P. 8888, Succ Centre-ville, Montreal, Que., Canada H3C 3P8

Received 23 March 2007; received in revised form 29 November 2007; accepted 28 December 2007

Abstract

Although the importance of aboriginal knowledge, values and perspectives in sustainable development has been recognised for many decades, worldwide examples exist showing that aboriginal involvement is less than effective. How and where to include aboriginal needs and goals has however been problematic. Ultimately, aboriginal forest values need to be considered with scientific strategies and their role and compatibility with forest conditions needs to be explored. Criteria and indicator (C&I) frameworks can be used as a platform to include community needs and goals in management decisions. This review compares aboriginal forest ecological perspectives defined by Canadian local level C&I frameworks with non-aboriginal local level C&I frameworks to identify their differences at the indicator level. Three major themes mark the differences between aboriginal and non-aboriginal indicators: (1) aboriginal frameworks introduce ecological indicators of cultural importance; (2) there is an aesthetic concern for forest operations especially if they affect cultural owners; and (3) indicators regarding the access to resources are more complex and include the sustainability of the productivity, proximity, integrity and quality of resources used in traditional activities. Results show that First Nation forest sustainability issues are in effect a combination of forest conditions and values. Inclusion of forest values in C&I frameworks is necessary because: (1) aboriginal communities do not dissociate culture from the environment and thus forest values from forest condition, (2) they have an impact on resulting forest management strategies and decisions, and (3) they offer a holistic approach to sustainability issues and a better picture of local environmental contexts.

© 2008 Elsevier B.V. All rights reserved.

Keywords: Aboriginal; Forestry; Criteria and indicators; Integration; Forest values; Forest conditions

Contents

1. Introduction	2025
2. Methods	2026
2.1. The Canadian context of aboriginal integration efforts in forest management.	2026
2.2. C&I frameworks and definitions.	2026
2.3. C&I framework comparison strategy.	2027
3. Results	2030
3.1. Selection of aboriginal priority criteria	2030
3.2. How are the extracted aboriginal indicators different?	2032
4. Discussion	2032
4.1. The role of aboriginal forest values in the principle of ecological sustainability	2032
4.2. Integrating aboriginal forest values in the principle of ecological sustainability	2033
4.3. The potential implications of integrating aboriginal forest values into forest management strategies	2033
5. Conclusion	2035
References	2035

^{*} Corresponding author. Tel.: +1 514987 3000x4819; fax: +1 514 987 4647.

E-mail addresses: adam.marie-christine@courrier.uqam.ca (M.C. Adam), Kneeshaw.Daniel@uqam.ca (D. Kneeshaw).

1. Introduction

Inclusion of communities in forest resource development and conservation has been touted as a central component to achieve sustainable forest resource development (Clark and Dickson, 2003). For example, community forestry projects worldwide (Carabelli et al., 2007; Hartanto et al., 2002; Lawrence et al., 2006; Mendoza and Prabhu, 2000) have been initiated to decrease the marginality of resource dependent communities and increase the participation of local communities which are most affected, and can benefit from forestry decisions. The participation of local communities requires the interpretation of local needs and goals which can be difficult. Compounded with local contexts, cultural and worldview differences have rendered the integration of aboriginal communities especially problematic. Several initiatives with indigenous people's organisation have been made relating to traditional forest knowledge and development efforts (ICSU, 2002). However even today, failure to address the particular values and needs of aboriginal cultures in sustainable forest management is noted at the global level (Ross and Smith, 2002; Natcher et al., 2005; NAFA, 1993; Parrotta and Agnoletti, 2007).

Specifically, aboriginal people feel very little control or influence on forest practices and on development initiatives (Bradshaw, 2003; Côté and Bouthillier, 2002; Hawley et al., 2004; Hickey and Nelson, 2005; Papatie, 2004). The degree of aboriginal influence varies worldwide. Problems range from unrecognised aboriginal resource rights and title in New Zealand (Coombes, 2007); to lack of community participation, ineffective leadership and tenural security in India (Murali et al., 2003). Research efforts have attempted to understand the convergence and divergence of traditional knowledge versus science such that aboriginal perspectives and values can be better integrated (Hawley et al., 2004; Ettenger et al., 2002; Moller et al., 2004; Lévesque and Montpetit, 1997; Davidson-Hunt and Berkes, 2003). Some studies have also reviewed partnerships between industry/government and aboriginal/forest dependent communities in forestry to assess their involvement in management decisions (Bhattacharya and Basnyat, 2003; Murali et al., 2003; Hickey and Nelson, 2005; Ross and Smith, 2002; Natcher et al., 2005; Sherry et al., 2005). However, the above research efforts have only served to justify the importance of aboriginal perspectives and the need for ongoing efforts towards effective community management (Sheppard and Meitner, 2005; Lewis and Sheppard, 2006; Parrotta and Agnoletti, 2007). Worldwide examples indicate that present aboriginal engagement in management is less than effective, and increased and broader aboriginal participation is necessary.

Where and how to include aboriginal forest values and needs has been problematic. The use and compatibility of aboriginal forest values with scientific strategies measuring forest conditions has been difficult. More specifically, the incorporation of local forest development goals implies the inclusion of local knowledge, opinions and values in management decisions along the side of science and technology regarding forest

conditions (Turnhout et al., 2007; Clark and Dickson, 2003; Wu, 2006). Criteria and indicators (C&I) frameworks serve as the medium within which social values merge with scientific knowledge of environmental conditions to monitor and influence trends in forest practices (Hartanto et al., 2002). In fact, development of C&I has been the most popular method to conceptualize, evaluate and implement sustainable forest management (Woodley et al., 1999; Bass, 2002) as more than 150 countries have developed their own specific sets (Castañeda, 2000; Holvoet and Muys, 2004). Although C&I frameworks offer a platform to include community needs and goals, to date they have been criticised for not fully identifying culturally important landscapes as central considerations for future management decisions (Parrotta and Agnoletti, 2007). Efforts to include aboriginal ecological issues and environmental values would confront the compatibility issues of aboriginal forest values. However, studies on these issues have been limited.

The reasons for which aboriginal ecological issues and environmental values have been overlooked in C&I are twofold. First, some research findings show that aboriginal ecological needs and goals correspond well to non-aboriginally developed sustainability frameworks. In Canada, Sherry et al. (2005) found a high correspondence between Tl'azt'en (aboriginal groups in BC, Canada) principles of ecological sustainability and the Canadian Council of Forest Ministers' (CCFM) template, Local Unit Criteria and Indicators Development (LUCID) test, and the Centre for International Forestry Research (CIFOR) generic template. Also, while studying indigenous cultural techniques to manage harvest, Moller et al. (2004) concluded that there is a surprising level of agreement between science and traditional ecological knowledge. Second, there is concern that inclusion of aboriginal holistic perspectives in ecological standards will lead to qualitative indicators which are viewed as difficult to measure and apply to forestry prescriptions (Rollins et al., 2001; McCool and Stankey, 2001). According to Kneeshaw et al. (2000), the nature of indicators must be scientific, linked to forest management and quantifiable. To these authors, integrating the holistic aboriginal environmental perspectives is a challenge due to difficulties in defining aboriginal ecological frameworks for appropriate use in decision making.

However, a large pool of researchers also believe that scientific frameworks such as C&I frameworks used today, illustrate natural ecosystems as discrete and hierarchical categorizations as opposed to connections and continuous gradations (Bunnell and Huggard, 1999). They believe this to be a reductionist approach to science and framework development preventing effective information sharing and communication among aboriginal communities and forest managers. Researchers have also found difficulties translating aboriginal values into this hierarchical system of frameworks due to holistic patterns of aboriginal worldviews (Parrotta and Agnoletti, 2007). Some aboriginal communities believe that there is no separation between society and individual, culture and nature, nor society and environment (Davidson-Hunt and Berkes, 2003). There are conflicts regarding the role of

aboriginal environmental perspectives in ecological frameworks which need to be resolved to be able to contribute to aboriginal interests for increased involvement and respect in forest management.

This study will review ecologically related C&I as an expression of aboriginal environmental values and ecological parameters to answer the following questions:

- Do aboriginal indicators differ from non-aboriginal indicators in the principle of ecological sustainability? It is presumed that understanding these differences will show the importance of aboriginal forest values and environmental perspectives, as well as the necessary changes which need to occur in forest management decisions.
- How are the aboriginal indicators different in terms of their nature (quantifiable or qualifiable) and role in frameworks? The nature of these indicators as a function of good ecological standards of sustainable forest management indicators (Kneeshaw et al., 2000) will help determine whether they can be included in frameworks.
- Will aboriginal indicators have an effect on forest management strategies and decisions?

Ultimately, this comparison will seek to understand differences between aboriginal and non-aboriginal needs and goals using indicators of ecological sustainability.

2. Methods

This review will compare aboriginal versus non-aboriginal indicators of ecological sustainability in one region (Canada) and at the local level of application of C&I frameworks. These limits have been imposed to avoid differences attributed to the global context (Holvoet and Muys, 2004).

2.1. The Canadian context of aboriginal integration efforts in forest management

In Canada, 80% of aboriginal communities are located in productive regions of the boreal and temperate forests (Hickey and Nelson, 2005) and are faced with forestry operations near or on their traditional lands. Their presence in such areas offers a social context justifying the need for their consideration in the study of sustainability. Gladu and Watkinson (2004) mention that “through their forest practices, their unique connections to the land and their local and traditional knowledge, aboriginal people of Canada can contribute significantly to sustainable forest management.” Furthermore, legislative mandates exist recognizing aboriginal forest goals, access, and participation in forest management (Ross and Smith, 2002). “The involvement of indigenous peoples in the management process is being recognised as both an unrelinquished right (e.g., Report of the Royal Commission of Aboriginal Peoples in Canada 1997), as well as a necessary factor in achieving sustainable environments (e.g., Brundtland 1987) . . .” (Natcher and Hickey, 2002). In light of their vested interests and rights in forest management, the integration of aboriginal people to forestry decisions

is nationally recognised. Development of forest management based on aboriginal ecosystem perspectives is necessary to help decision makers assume the responsibility of Canadian legislation and mandates.

2.2. C&I frameworks and definitions

A few aboriginal communities in Canada have begun the process of defining local level C&I frameworks.

Local level framework: A set of objectives and actions defined by a community to respond to and monitor potential forest management development efforts in their land such that they will be sustainable. It serves as a platform for dialogue between the community and managers.

The following aboriginally defined frameworks were used for this comparison: Little Red River Cree Nation (LRRCN) (Natcher and Hickey, 2002); Tl’azt’en local level C&I of John Prince Research Forest (JPRF) (Sherry et al., 2005); Waswanipi Cree Model Forest (Canadian model forest network, 2000); Objectifs de Protection et Mise en Valeur des Premières Nations (OPMVPN) forestry toolbox (Assembly of the aboriginals of Quebec and Labrador, 2004); and the forest ecosystem strategy plan for the Innu in Labrador district 19 (Crown Five Year Strategy Plan, 2002) (Fig. 1). These aboriginal C&I frameworks were chosen for comparative purposes because:

- The criteria and indicators were selected by aboriginal communities living on and from the forest.
- The frameworks demonstrated local level ecological indicators (either as indicators, critical elements, forestry objectives or local values).
- Frameworks approached the issue of ecological sustainability which encompassed the following issues within their criteria: ecosystem and species diversity and function; access to resources; and recognition and respect for aboriginal roles in sustainable forest management.

These frameworks were compared to non-aboriginally defined local level C&I frameworks: North American Test of Criteria and Indicators of sustainable forestry framework derived from the CCFM and CIFOR (Woodley et al., 1999); and Forest Stewardship Council (FSC) Canada Working Group National Boreal Standard (Forest Stewardship Council Canada Working and Group, 2004).

It should be noted that each framework operated within its own C&I hierarchy and category definition. The multiple definitions for C&I render framework comparisons difficult so the following definitions were used for this study:

Criterion: Category of conditions or processes by which sustainable forest management may be assessed (Canadian Council of Forest Ministers, 1995). This study particularly looked at concerns directly or indirectly pertaining to the following criteria: ecosystem function and diversity, land-

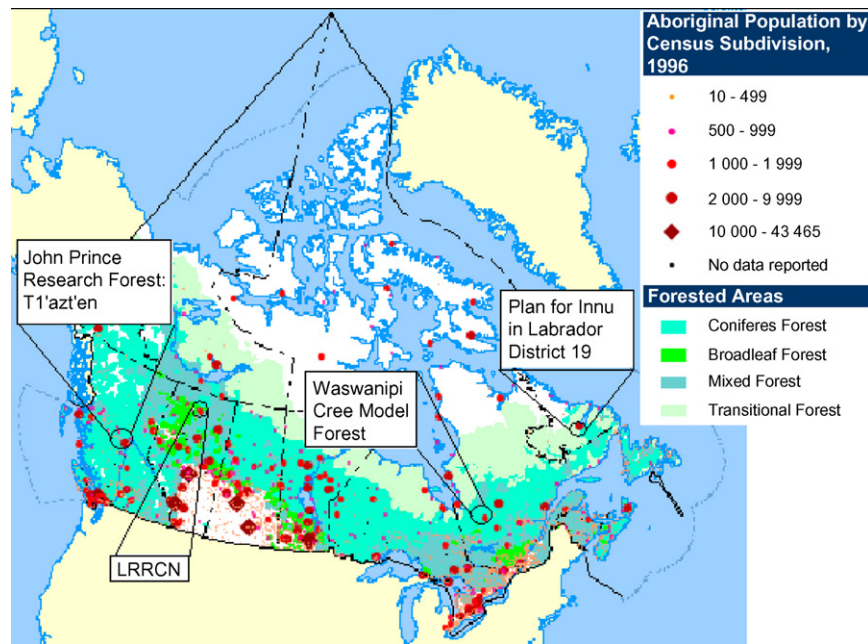


Fig. 1. Aboriginal populations and forested areas (atlas.nrcan.gc.ca) and origins of the aboriginally defined local level criteria and indicator frameworks. *Note:* The frameworks which were not included on this map were developed for application at the local level but without a particular community in mind (FSC, the North American Test of Criteria and Indicators of sustainable forestry framework, and OPMVPN).

scape patterns, native species diversity, incidence of disturbance and stress, genetic diversity and physical environmental factors.

Indicator: Definition of quantifiable or qualifiable variables which can be measured and described.

Verifiers: Variables which, when observed periodically demonstrate trends. Verifiers vary regionally according to ecosystem and social situations.

Due to the regionality of compared C&I frameworks, objectives and desired trends are included within criterion and indicators. Table 1 shows the hierarchy of each framework and how the criteria, indicator and critical local values used in this study compare.

2.3. C&I framework comparison strategy

Comparison between aboriginal and non-aboriginal C&I frameworks occurred in many steps. It is important to note that issues covered and methods of C&I development varied amongst frameworks. Differences in the development of frameworks may lead to variability of themes and organisation of issues covered within-and-amongst aboriginal versus non-

aboriginal frameworks. Tables 2 and 3 describe important framework differences noted to appropriately set the context of comparison. Comparability of C&I used in this study were thus carefully evaluated. First, all C&I were translated to fit a common framework hierarchy. Second, each criterion was assessed to ensure that they could be compared across frameworks. Third, different aboriginal ecological indicators were extracted and their nature identified.

Indicators were grouped and translated according to C&I defined in Table 4. Some frameworks included criteria specific to aboriginal issues. The following three criteria were extracted from these framework sections and included for comparison in order to consider all criteria relevant to aboriginal issues of ecological sustainability: forest management provides ongoing access to resources; recognition and respect for aboriginal roles in sustainable forest management (aboriginal rights, treaty rights and aboriginal values); and preserving the aesthetic quality of the area (sites of particular vocation, hunting grounds) for its enjoyability, visual framework and to diminish negative visual impacts of forestry operations.

Distribution of indicators across the ecological criteria framework developed in Table 4 was assessed to ensure their comparability. This comparison assumes that a criterion is an

Table 1
Hierarchy used for comparing aboriginal and non-aboriginal frameworks and its equivalence to the compared C&I frameworks

Hierarchy used for comparison	Amalgamation of C&I appropriate for the North American test	Tl'azt'en C&I, AFPP	Little Red River Cree Nation (LRRCN)	OPMVPN forestry toolbox ^{1a}	FSC boreal standard	Waswanipi Cree Model Forest	Forest ecosystem strategy plan for forest management district 19 ^{1b}
Criterion	Criterion	Criterion	Critical element		Criterion	Criterion Goal	Objectives
Indicator	Indicator	Indicator	Indicator	Objectives	Indicator	Indicator	Actions
Verifiers		Critical local value	Local value/goal		Verifiers		Specific

The objectives (1a) and actions (1b) were considered as indicators. These were grouped by theme and a criteria and indicator were defined for each group.

Table 2
Background information on the origins of the Aboriginally defined C&I frameworks used in this study

	Waswanipi Cree Model Forest (WCMF)	Tl'azt'en C&I, AFPP	OPMVPN forestry toolbox	Little Red River Cree Nation (LRRCN)	Forest ecosystem strategy plan for forest management district 19 (2003–2023)
Purpose of efforts	“Maintain and enhance the quality of the area within the boundaries of the WCMF which is known as Eeyou Istchee, to benefit aboriginal and other users and to assure the economic, social and cultural development of the Waswanipi First Nation”	“Integrate and enhance traditional and scientific approaches to understanding human relationships with the land”	Define sustainable development strategy based on aboriginal preoccupations	Better understand the interface between community members and their environment	“To create an ecosystem-based forest management plan for Labrador that protects ecological and cultural integrity, productive capacity, resiliency and biodiversity while advancing economic opportunities for the sustainable development of forest-based industries.”
Type of management agreement (year)	Model forest Canada led by aboriginal people (1997) but initiated by the government model forest project ^a	Co-management experiment between the University of Northern British Columbia and Tl'azt'en band members (1999)	Department of Indian Affairs and Northern development who began a national consultation process on sustainable development among First Nation and the Inuit (1996) which was taken over by the Assembly of First Nations Quebec and Labrador	Cooperative resource management with Government of Alberta (1991)	Forest process agreement between the province of Newfoundland and Labrador with the Innu Nation (2001) which led to the Forest ecosystem strategy plan and Five year operating plan
# Criteria/# indicators (incomplete/complete) ^b C&I principles	4/69 (complete and inspired by CCFM) Ecological, economic, decision-making and social	17/52 and 143 critical local values (complete) Decision-making, social, economic, management and ecological	50/160 (incomplete and not initially intended as C&I) Objectives and actions required for various types of First Nation territories (ancestral, community, family, hunting and trapping territory)	6/62 (incomplete) Management, community access and protection of land, treaty rights, traditional practice, economic and decision-making	21/147 (complete but not initially intended as C&I) Ecological landscapes, cultural landscapes, economic landscapes, ecological research and monitoring, cultural research and monitoring
References	Canadian model forest network (2000), Gladu and Watkinson (2004)	Sherry et al. (2005), Karjala et al. (2004), Karjala and Dewhurst (2003), Grainger et al. (2006)	Assembly of the First Nations of Quebec and Labrador (2004), First Nation of Québec and Labrador sustainable development institute (2006)	Hickey and Nelson (2005), Natcher and Hickey (2002), Natcher et al. (2005)	Crown Five Year Operating Plan Forest Management District 19A (2002), Crown Five Year Strategy Plan Forest Management District 19A (2002)

^a All other C&I efforts were initiated by the aboriginal communities.

^b Complete frameworks include social, economic and ecological principles in the framework (otherwise the framework is considered incomplete).

Table 3
Background information on the non-aboriginally defined C&I frameworks used in this study

	Amalgamation of C&I appropriate for the North American test	FSC boreal standard for Canada
Purpose of efforts	To test the use and relevance of criteria and indicators for the concept of sustainability at the local management unit level	To serve as a basis for certifying forests within the Canadian boreal forest. Mission: To promote environmentally appropriate, socially beneficial, and economically viable management of the forests of Canada through standards and their application".
Framework development strategy	A team of experts evaluated and reviewed the following C&I national level frameworks: (1) those that emerged from the CIFOR Phase I synthesis; (2) CIFOR's basic assessment guide for human well-being; (3) Canadian Council of Forest Ministers (CCFM) Criteria and Indicators of Sustainable Forest management in Canada (which are similar, but not the same as, the Montreal Process—see following paragraph); (4) local/regional indicators including the Idaho Forest Practices Act; and, (5) the Greater Fundy Ecosystem Guidelines developed for the Fundy Model Forest.	The framework was developed by the FSC Canada Working group composed of eight elected members representing the aboriginal, environmental, economic and social sectors; the FSC Boreal Coordinating committee; and provincial/territorial initiatives. The framework is guided by the following: "Vision: Healthy forests providing an equitable sharing of benefits from their use while respecting natural forest processes, biodiversity and harmony amongst their inhabitants
# Criteria/# indicators (incomplete or complete framework ^a)	20/57 Covering ecological, economic, decision-making and social sustainability; and can be applied at the local level (complete).	102/201 Covering ecological, economic, decision-making and social sustainability (complete).
References	Woodley et al. (1999), Hoekstra et al. (1998)	FSC (2004)

^a Complete frameworks include social, economic and ecological principles in the framework (otherwise the framework is considered incomplete).

issue for which the number of indicators included reflects a degree of reflexion. A lack of indicators in one criterion prevents comparisons. More specifically, few indicators may reflect gaps in the reflexion made for the criteria because a complete C&I framework (one which covers all sustainability issues from social, economic to ecological) was not developed by all groups. However, it does not necessarily mean a lack of

interest in the issue. On the other hand, a high number of indicators within a criterion shows a high level of reflexion on the issue, and the criterion is viewed as a priority and can be extracted for further comparison of its indicators.

Based on the extracted criteria, all indicators were listed and compared to see whether they were covered, not covered or partially covered across C&I frameworks. Indicators which were

Table 4
Criteria and relevant themes for indicators used as a base for comparison of frameworks

Criteria	Extracted indicator themes
Ecosystem function is maintained	Quality (aquatic, forest, etc. . .), river buffers, fragile and special ecosystems, regeneration, refuge habitats, structure, productivity, down and coarse woody debris, rehabilitation and restoration of damaged sites
Landscape patterns support native populations	Corridors, fragmentation, protection of refuge habitats and structure and their spatial distribution, spatial distribution (habitat, residual forest, cover, cut blocks, roads, . . .), forest cover
Native species diversity is maintained	Number of species and their habitat when a specific species is mentioned, vegetative or faunal classification, protected areas, and species interrelationships
Ecosystem diversity is maintained	Age structure, ecosystem types, structural classes, forest conversion, representation of special sites, selection of protected areas
Incidence of disturbance and stress	Stability, erosion, fire, noise, pollution, environmental impact assessment, damage by harvesting. Includes human and natural disturbance, stress and pollution
Genetic diversity is maintained	Exotic species, population size and connectivity, reproduction, gene frequencies
Physical environmental factors	Physical integrity, microclimates, soils, ecosystem events
Forest management provides ongoing access to the resource	Access, proximity (distribution), quality, ownership, fair and secure use rights, subsistence, non timber forest products, conflict resolution over use rights
Recognition and respect for Aboriginal roles in sustainable forest management (Aboriginal rights, Treaty rights and aboriginal values)	Cultural geography, socio-ecological roles, artifacts, environmental impact assessments on values, compensation over traditional ecological knowledge
Preserving the aesthetic quality of the area (sites of particular vocation, hunting grounds and landscape) for the enjoyability of the area, its visual framework and to diminish the negative visual impacts of forestry operations	Trap-lines, cultural sites, managed sites

The first 7 rows refers to the criteria of ecological sustainability, while the 8–10 includes criteria which were specific to First Nation issues and/or frameworks. Extracted indicator themes are general terms used to describe the indicators found in the frameworks and allowed them to be pooled together within one criteria or another.

neither covered by FSC nor the North American test of criteria and indicators of sustainable forestry framework were defined as different aboriginal indicators. This difference is limited to the principle of ecological sustainability and the three criteria which were added for this study. The contrary (indicators not included in aboriginal frameworks but included in the FSC and the North American test of C&I) was not found in this comparative study. The indicators were then evaluated as either being expressions of forest values which are influenced by concerns for community and cultural sustainability, or forest conditions influenced by ecological concerns as dictated by science.

Values are cultural ideas about desirable goals and appropriate standards for judging action (Tindall, 2001).

Forest values are expectations of what should be provided by forests (Kneeshaw et al., 2000).

Forest conditions are the results of forest management (Kneeshaw et al., 2000).

The different aboriginal ecological indicators were then discussed based on the study objectives to determine their difference, their nature and role, and how they affect forest management decisions.

3. Results

3.1. Selection of aboriginal priority criteria

Based on the distribution of indicators within the criteria shown in Fig. 2, the following criteria have been justified as priority for comparison in this study. The criterion for the maintenance of species diversity and landscape patterns consistently included more indicators in aboriginal than in non-aboriginal frameworks (Fig. 2). Although not very different than non-aboriginal frameworks, the ecosystem function and diversity criterion had the second most indicators of any of the evaluated criteria (Fig. 2). It is revealing that in combination, between 80 and 100% of aboriginally defined indicators fall

within these two criteria, compared to 50 and 70% for non-aboriginal frameworks. These criteria are therefore seen as priority issues for ecological sustainability from aboriginal perspectives. When comparing indicator distribution from the more complete frameworks (the North American test, FSC, Waswanipi and Tl'axt'en frameworks), a higher percent distribution of indicators in the criteria pertaining to resource access and aboriginal land rights and aesthetics was found in aboriginally defined frameworks (1 and 33% versus 1 and 6%). Complexity is shown by an increased amount of indicators per criterion thus demonstrating more issues which need to be resolved.

Some criteria level differences between aboriginal and non-aboriginal frameworks have been noted. Criteria such as genetic diversity, physical environmental factors, and incidence of disturbances and stress include fewer indicators in aboriginal than non-aboriginal frameworks (Fig. 2). Although many indicators do not surface within these criteria, they may still be important to aboriginal peoples. The indicators and their associated concerns could be found in other criteria. For example, a genetic concern such as genetic variability for population viability may have been expressed by aboriginal peoples as a concern for population distribution and availability. Aboriginal frameworks showed some concerns for species quality (in terms of resource access) and species health (found in the criterion for the maintenance of species diversity) which may in effect relate to genetic concerns. The ecological elements for concern in genetic diversity, physical environmental factors and disturbances seem to be expressed at a scale and within a perspective which is culturally defined. This exemplifies some of the challenges of including aboriginal worldviews into the sometimes reductionist and cartesian scientific ways. Results show some difficulty in introducing holistic aboriginal environmental perspectives to criterial hierarchical level of framework development. Therefore, room for cultural expression and hierarchical flexibility is needed within C&I frameworks to ensure that all issues are covered explicitly.

Based on the criteria identified in the previous paragraphs, the extracted aboriginal indicators are shown in Table 5. Criteria of

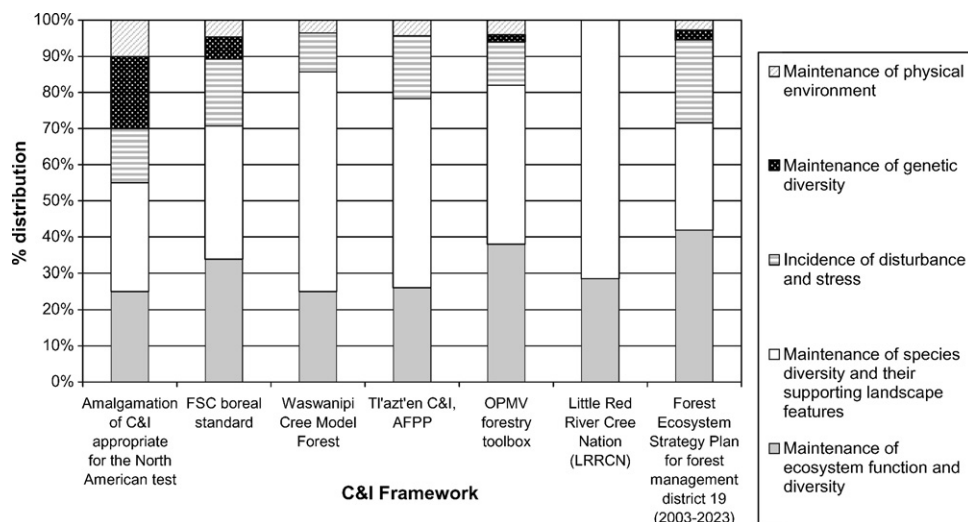


Fig. 2. Percent distribution of indicators by ecological criteria and framework, with the agglomeration of indicators for the ecosystem and species criteria.

Table 5
Aboriginal indicators extracted from the principle of ecological sustainability (n = not covered, p = partially covered, y = covered by frameworks)

Criteria	Indicator	Amalgamation of C&I appropriate for the North American test	FSC boreal standard	Waswanipi Cree Model Forest	Tl'azt'en C&I, AFPP	OPMVPN forestry toolbox	Little Red River Cree Nation (LRRCN)	Forest ecosystem strategy plan for forest management district 19 (2003–2023)
Maintenance of species diversity and their associated landscape	Use of traditional or community knowledge of species occurrence, frequency and distribution	n	p	y	n	n	n	y
	Protection of culturally important ^a species	n	n	y	y	y	y	y
	Maintaining species diversity (biodiversity—species interrelationship)	n	n	p	y	p	n	n
	Maximizing species availability	n	n	p	n	y	n	n
Ecosystem function and diversity	Conservation of specific important habitats and cultural sites	n	p	n	y	y	y	y
	Favor the diversity of species composition, and forest habitats	n	n	y	p	y	n	y
Forest management provides ongoing access to resources	Monitor new knowledge and changes in traditional use patterns ^b	n	p	y	y	n	n	y
	Protect hunting and trapping areas	n	n	y	y	y	y	p
	Ensure the quality of resources	n	n	y	n	y	p	p
	Ensure the quality of the traditional resource use activities ^c	n	n	y	p	y	y	n
	Ensure proximity of resources	n	n	y	n	y	y	n
Preserving the aesthetic quality of the area ^d	Diminish the negative visual impacts of forestry operations	n	p	n	n	y	n	y
	Consult with cultural owners to modify operations such that they are acceptable	n	n	n	n	n	n	y

^a Some species are viewed as important culturally, regardless of their regional status as either endangered or at risk.

^b This can also be expressed as a means to identify the economic versus cultural potential of the land and balancing the two.

^c This could include the visual experience (expressed with the maintenance of forest cover) and remoteness.

^d Preserving sites of particular vocation, hunting grounds and landscape for the enjoyability of the area, its visual framework and to diminish the negative visual impacts of forestry operations.

ecological sustainability are ordered by those which include the most-to-least aboriginal indicators which are different:

- preserving the aesthetic quality of the area (sites of particular vocation, hunting grounds) for its enjoyability, visual framework and to diminish negative visual impacts of forestry operations;
- maintenance of species diversity and landscape patterns;
- forest management provides ongoing access to resources;
- maintenance of ecosystem function and diversity.

3.2. *How are the extracted aboriginal indicators different?*

Based on the extracted aboriginal indicators shown in Table 5, aboriginal indicators which differ from non-aboriginal frameworks in this study do not reflect issues pertaining to forest conditions. More specifically, they do not seem to raise ecological issues which have been overlooked by non-aboriginal frameworks. From this point of view, aboriginally defined ecological frameworks compared in this study correspond well to non-aboriginal ecological perspectives as mentioned by Sherry et al. (2005) and Moller et al. (2004).

Instead, the different aboriginal indicators extracted for comparison are culturally motivated reflecting community sustainability issues pertaining to ecology. Three major themes mark the differences between aboriginal and non-aboriginal indicators. First, aboriginal frameworks introduce indicators relating to culturally important species, habitats and ecosystems which are found in the criteria for maintenance of species diversity and landscape patterns, and maintenance of ecosystem diversity and function. More specifically, most non-aboriginal frameworks choose the species, their habitats and ecosystems to be maintained based on their ecological status. In the case of species diversity this could be species at risk, rare species, surrogate species, indicator species or keystone species. Aboriginal frameworks add the importance of certain forest habitats, species and cultural sites. Maintaining their availability and distribution is important to aboriginal communities regardless of their ecological role in maintaining diversity or ecosystem function. Second, there is an expressed aesthetic concern for forest operations especially if they affect cultural owners. More specifically, there is a marked concern for the enjoyability and maintenance of remoteness of cultural activities such as hunting, trapping or camping. Third, the criterion regarding access to forest resources seems consistently more complex in aboriginal frameworks. This criterion combines issues of resource sustainability with access sustainability to include indicators of productivity, proximity, integrity and quality for resources used in traditional activities.

4. Discussion

4.1. *The role of aboriginal forest values in the principle of ecological sustainability*

This review has shown that on a superficial level aboriginal and non-aboriginal frameworks are equivalent in terms of

issues pertaining to forest conditions. However, there is a recurrent cultural nuance found in the different aboriginal indicators extracted in this study which is largely motivated by traditional activities such as trapping and hunting. This is consistent with other research showing that individual values are expressed through cultural and social meaning (Lawrence et al., 2006). Predominance of this cultural motivation is evidence that aboriginal ecological sustainability requires the increased inclusion of forest values. Inclusion of forest values with forest conditions reflects the notion that biological, cultural and historical landscapes are all associated in aboriginal frameworks. Categorization into ecological, social, and economic principles has resulted in the isolation of each issue, and problems in including issues of interdisciplinary nature. To isolate indicators of ecological sustainability as strict forest conditions within the science of ecology would be inappropriate and overly reductionist for aboriginal ecological perspectives.

The extracted aboriginal indicators may be found in other non-aboriginal principles and criteria and are therefore not unique to aboriginal frameworks. However, their location within frameworks can lead to differences in strategies used to resolve associated issues. For example, game species are culturally important species. Consequently, their habitats are culturally important and impose resource access issues for aboriginal peoples. Game species are thus included in three criteria of aboriginally defined frameworks reviewed in this study: maintenance of species diversity and associated landscape patterns, maintenance of ecosystem diversity and function, and maintenance of access to resources. In non-aboriginal frameworks, game species may be sufficiently included in the principle of sustainable economic and social benefits with subsequent indicators monitoring laws and economic benefits (CCFM, 1995). The isolation of game species indicators within this principle will not resolve aboriginal requirements to ensure that forestry decisions do not impede on the sustainability of these species in their environment. More specifically, they do not account for game species distribution within areas of traditional practices, nor ensure habitat quality to maintain their populations, nor guarantee sustained access to areas which traditionally support these species. Contrary to framework requirements of horizontal consistency where elements of sustainable forest management should neither overlap nor be duplicated in frameworks (Holvoet and Muys, 2004), we argue that each principle and criteria reflects a motive and strategy to resolve issues. The repetition of indicators within and across principles is important to ensure a better picture of associated resource issues. Strict isolation of forest values into criteria category in C&I frameworks does not account for their link to forest conditions. It is thus important to include both forest conditions and values within certain criteria to ensure that objectives are achieved. Aboriginal cultural nuances link with forest conditions and thus offer a better picture of local goals and objectives pertaining to aboriginal expectations when faced with forest practices.

The theory of visible stewardship (Sheppard, 2003) and the aesthetic indicators raised in this review also justify the need to

include forest values. Their importance in forest management lies in their cultural-ecological correlation. Hart (2000) identified beauty and life affirming qualities of nature as a good indicator for community sustainability. Aesthetics and ecological sustainability in forested areas generally correspond positively. Sheppard et al. (2001) mention that people appreciate a healthy sustainable landscape if it matches certain biological or culturally determined preferences. He also argues that the more extensive the departure of forest management interventions from natural processes/conditions, the uglier it is perceived by people. Furthermore, aesthetics have been shown to be a determinant expression of cultural preferences. In effect, culture filters landscape perceptions (Berninger et al., *in press*). An aesthetic reaction can be seen as: “a set of inclinations, however intuitive or unconscious, which might influence the direction people choose not only in physical environment but also in other domains” (Nassauer, 1995). Therefore culture and aesthetics, as well as ecology and aesthetics, are correlated. Culture and ecology are also correlated. Landscapes are cultural constructions and not simply compositions of biological diversity or physical terrain (Infield, 2001; Nassauer, 1995). Communities thus have physical expectations regarding outcomes of sustainable management. According to Sheppard (2003) and the theory of visible stewardship, forest management will not be perceived as sustainable forestry unless obvious and sustained commitment to people, their place, and the ecosystem under their control is demonstrated. Aesthetics can thus be seen as the medium by which culture and ecology interact. To communities, aesthetics is the physical manifestation of ecologically sustainable forest management. To ecology, it is the expression of cultural landscape preferences. Such links could resolve the reductionist and biocentric perceptions of C&I frameworks by creating connections between C&I hierarchical levels.

4.2. Integrating aboriginal forest values in the principle of ecological sustainability

During the review, it was believed that a larger proportion of qualitative indicators would be observed due to cultural motivations found in our extracted indicators. However, inclusion of indicators pertaining to forest values does not greatly affect the nature of indicators as shown in Table 6. On the contrary, the criterion for resource access in non-aboriginal frameworks focussed on qualitative indicators such as maintaining fair and secure access to resources, respecting clear ownership and use rights and maintaining traditional institutions related to resources. Aboriginal frameworks on the other hand made special attention to the resources they need to access and traditional methods by which they have been used (productivity, proximity, and quality). These different aboriginal indicators are in fact more quantifiable than non-aboriginal counterparts. Therefore concerns for the compatibility of indicators based on forest values versus those based on forest conditions may be unfounded if the issues translate to preferences for quantitative indicators which are more easily measured (CCFM, 1995; Kneeshaw et al., 2000). It should also

be noted that the extracted aboriginal indicators which are qualitative (Table 6) are motivated by concerns over traditional practices. These are based on a history of tradition which is organised by historical local institutions ensuring fair and secure access for all community members (Leroux et al., 2004). The governing traditional institutions managing the landscape for traditional activities have been organised over generations. The nature of these indicators can thus be considered observable and measurable. Therefore, inclusion of forest values should not be presumed difficult or less effective for C&I frameworks.

4.3. The potential implications of integrating aboriginal forest values into forest management strategies

The extracted aboriginal indicators could influence the definition of conservation, maintenance and protection in forest management strategies. In some cases, although conservation of land is deemed a necessary step for maintenance of aboriginal culture, subsistence and traditional lifestyles (Papatie, 2004), strict protection of important forest conditions may not account for other culturally motivated indicators. For example, monitoring and ensuring species diversity and ecosystem sustainability issues in protected areas alone does not accurately account for aboriginal needs such as hunting and trapping. Trap-lines are geographically organised according to traditional systems, and will only be as good as the species and habitat diversity they hold. It is impractical to attempt to conserve all trap-lines under protected areas as their areas may be too extensive and inhibit resource development over the whole territory. Furthermore, conservation may not be compatible with traditional activities which involve the extraction of resources such as trapping and hunting. If only partly conserved, development of protected areas may require the formation of new local institutions to organize community landuse patterns, if permitted within the protected areas. Also, conservation strategies devised to maintain and protect species and ecosystem diversity may need to be revised to ensure sustainability (quantity, quality and distribution as seen in Table 5—the criteria for resource access) of culturally important species, habitats and ecosystems used in aboriginal traditional activities. Perhaps these issues may be best addressed by the use of appropriate silvicultural systems and forest management units compatible with traditional activities thus ensuring a proper forest habitat for the viability of important species and activities.

The inclusion of indicators pertaining to traditional activities will affect how forest managers use indicators. More specifically, indicators of forest values cannot be viewed as variables whose trends will only be observed after management decisions have been made. Because forest values set a context and picture of community goals and objectives, they need to be accounted for throughout management processes from inventory to monitoring phases. More specifically, these indicators exhibit temporal and spatial dynamics which may not respond at the same scale as the impacts of many forest management strategies. For example, in the criterion for resource access,

Table 6
List of potential verifiers for the unique aboriginal indicators to determine whether they are quantitative or qualitative in nature

	Indicator	Potential verifiers			
Quantitative + qualitative	Use of traditional or community knowledge (TK) of species occurrence, frequency and distribution	Degree of use of TK	TK of species occurrence	TK of species frequency	TK of species distribution
Quantitative	Protection of culturally important species	Population in protected areas	List		
Quantitative	Maintaining species diversity (biodiversity - interrelationship)	Species richness and diversity	Movement and migration		
Quantitative	Maximizing species availability	Distribution of species	Distribution of diversity		
Quantitative + qualitative	Conservation of specific important habitats and cultural sites	Habitats in conservation areas	List	Cultural sites in conservation areas	
Quantitative	Favor the diversity of species composition, and forest habitats	Habitat diversity on landscape	Species diversity on the landscape		
Quantitative + qualitative	Monitor new knowledge and changes in traditional use patterns	Population habits on land	Percent land occupation by activities		
Quantitative	Protect hunting and trapping areas	Hunting and trapping sites are protected			
Qualitative	Ensure the quality of resources	Animal and plant health			
Quantitative + qualitative	Ensure the quality of the traditional resource use activities	Visual	Size of land used	Remoteness	
Quantitative	Ensure proximity of resources	Monitor species and habitat condition in traditional use lands	Distance to traditional practice sites		
Quantitative + qualitative	Diminish the negative visual impacts of forestry operations	Buffers along protected areas, buffers along harvested areas	Alternative silvicultural techniques	Site restoration: greening up. . .	
Qualitative	Consult with cultural owners to modify operations such that they are acceptable	Traditional landuse patterns	Participation		

aboriginal issues are dominated by the expected effects of forestry operations on species relocation. Although some resource species may benefit from forestry operations, species distribution patterns will change according to forestry operations and may not be advantageous to traditional activities. For example, aboriginal people are concerned with moose population distribution following forestry operations (Jacqmain, 2005). To some degree, moose populations can profit from forestry operations such as clear cutting because the shrub layer diversity of recent cutovers provides a good source of food. Although a typical moose range will vary in habitat type, moose range will occupy 20–25% recent cutovers (Potvin et al., 1999). However, moose spatial distribution patterns may change such that family hunting grounds become less productive depending on the location of recent cutovers. It is therefore important to aboriginal communities that traditional activities persist under changing spatial parameters such as the population distribution patterns of important species. More species, more habitats and more ecosystems need to be considered when prescribing forest harvest plans. Extracted aboriginal indicators therefore offer new tools to managers to organise forest practices in accordance with traditional practices.

Also, rather than focusing on each forest value as conservation issues, multiple-use forestry strategies seeking to understand and maintain the role of traditional activities under a changing landscape could be used. Conservation of aboriginal patterns of activities may ensure the continuity of traditional activities. It may thus be worth including community landuse patterns and traditional activities in inventories to ensure that they are accurately monitored. Although historically and traditionally relevant, they are not static. The practice of traditional activities will vary amongst generations (Natcher et al., 2005; Nassauer, 1995). Understanding these landuse patterns over time will help determine priority areas for community needs. Therefore, forestry operations will also be affected with increased parameters to inventory in order to identify available land for harvesting such that management is more holistic.

Traditional activities are not limited by the description of their component parts and distribution across a community's territory. The sustainability of the "experience" of traditional activities also needs to be considered and maintained such as conservation of remoteness and enjoyability (as noted by the aesthetic indicators extracted in Table 5). In this review, the criteria for preserving an area's aesthetic quality was expressed by the need for buffers, corridors, alternative silvicultural techniques, harvested site restoration and maximizing continuous forest cover in areas which are used or in close contact to communities. Some changes may be imposed on silvicultural techniques and planning of harvest sites to minimize aesthetic impacts near cultural owners and ensure that community "experience" of traditional activities is minimally affected.

5. Conclusion

In this review, analysis of non-aboriginal C&I frameworks is in agreement with the general conclusions of Parrotta and

Agnoletti (2007) in that they fail to address particular values and needs of aboriginal cultures. More specifically, aboriginal ecological indicators extracted in the aboriginal frameworks of this study demonstrate an expressed need to incorporate aboriginal forest values which stem from a different worldview than that which traditionally governs forestry. Aboriginal community relationship to land is closely tied to their culture, tradition and subsistence methods (Davidson-Hunt and Berkes, 2003; Karjala et al., 2004; Lévesque and Montpetit, 1997).

C&I frameworks prove to be a valuable medium within which social values merge with scientific knowledge of environmental conditions to monitor and influence trends in forest practices. As shown in this review, the impact these aboriginal indicators may have on forestry strategies offers an avenue for changes in forest practices which better consider aboriginal environmental perspectives. In the principle of ecological sustainability both forest values and conditions should be included but be explicit in their goals. The inclusion of forest values offers a holistic approach whereby conditions and values are included in C&I frameworks to resolve sustainability issues. This agrees with Yamasaki et al. (2001) who argue that forest values should be included in order to create a better picture of local environmental contexts.

The inclusion of forest values with forest conditions in C&I frameworks may resolve associated criticisms of reductionism by preventing the isolation of principles into strict ecological, social and economic issues of sustainability. Comparison between aboriginal and non-aboriginal ecological indicators serves as a justification for potential development and integration between ecology and culture, as well as ecology and community. The explicit inclusion of forest values with forest conditions may serve to connect what otherwise has been criticised as a long list of unconnected indicators (Kneeshaw et al., 1999). For example, the extracted indicators agreed with the theory of visible stewardship (Sheppard, 2003) thus showing a need to physically express sustainable forest management according to community expectations. Aboriginal forest values were also shown to be quantifiable and thus their inclusion in C&I frameworks seems justifiable from a strategic perspective.

In conclusion, C&I frameworks offer a valid platform to include aboriginal values and needs. What remains to be answered is how these values will be translated into effective management strategies which respect and integrate aboriginal issues.

References

- Assembly of the First Nations of Quebec and Labrador (FNQLSD), 2004. OPMVPN Forestry Tool Box (Steve Morel). URL: <http://www.iddpnql.ca>.
- Bass, S., 2002. Application of criteria and indicators to support sustainable forest management: some key issues. In: Raison, R.J., Brown, A.G., Flinn, D.W. (Eds.), *Criteria and Indicators for Sustainable Forest Management*. IUFRO Research Series 7. CABI Publishing, Oxford, pp. 19–37.
- Berninger, K., Kneeshaw, D., Messier, C. The role of cultural models in local perceptions of SFM—differences and similarities of interest groups from three boreal regions. *J. Environ. Manage.*, in press.

- Bhattacharya, A.K., Basnyat, B., 2003. Empowering people through Joint Forest Management: a study from Madhya Pradesh (India). *Int. Forestry Rev.* 5 (4), 370–378.
- Bradshaw, B., 2003. Questioning the credibility and capacity of community-based resource management. *Can. Geogr.* 47 (2), 137–150.
- Bunnell, F.L., Huggard, D.J., 1999. Biodiversity across spatial and temporal scales: problems and opportunities. *Forest Ecol. Manage.* 115, 113–126.
- Canadian Council of Forest Ministers (CCFM), 1995. Defining sustainable forest management: a Canadian approach to criteria and indicators. Canadian Council of Forest Ministers, Ottawa, Canada. URL: http://www.ccfm.org/ci/framain_e.html.
- Canadian model forest network, 2000. A User's Guide to Local Level Indicators of Sustainable Forest Management: Experiences from the Canadian Model Forest Network. NRCAN, Ottawa.
- Carabelli, E., Bigsby, H., Cullen, R., Peri, P.L., 2007. Measuring sustainable forest management in Tierra del Fuego, Argentina. *J. Sust. Forestry* 24 (1), 85–108.
- Castañeda, F., 2000. Criteria and indicators for sustainable forest management: international processes, current status and the way ahead. *Unasylya* 51 (203), 34–40.
- Clark, W.C., Dickson, N.M., 2003. Sustainability science: the emerging research program. *Proc. Natl. Acad. Sci. U.S.A.* 100 (14), 8059–8061.
- Coomes, B., 2007. Defending community? Indigeneity, self-determination and institutional ambivalence in the restoration of Lake Whakaki. *Geoforum* 38 (1), 60–72.
- Côté, M.-A., Bouthillier, L., 2002. Assessing the effect of public involvement processes in forest management in Quebec. *Forest Pol. Econ.* 4, 213–225.
- Crown Five Year Operating Plan Forest Management District 19A (2003–2008), 2002. Appendix C: Environmental Protection Guidelines for Ecologically & Culturally Based Forest Management in District 19: Stand Level Operation. URL: <http://www.env.gov.nl.ca/env/Env/EA%202001/Project%20Info/1062.htm>.
- Crown Five Year Strategy Plan Forest Management District 19A (2003–2008), 2002. Appendix C: Environmental Protection Guidelines for Ecologically & Culturally Based Forest Management in District 19: Stand Level Operation. URL: <http://www.env.gov.nl.ca/env/Env/EA%202001/Project%20Info/1062.htm>.
- Davidson-Hunt, I., Berkes, F., 2003. Learning as you journey: Anishnaabe perception of social-ecological environments and adaptive learning. *Conserv. Ecol.* 8 (1), 5.
- Ettenger, K. and local elders, hunters and tallymen, 2002. Muskuuchii: Protecting a Traditional Iyiyuuch Wildlife Preserve and Sacred Site. URL: <http://www.gcc.ca/pdf/ENV000000006.pdf>.
- First Nation of Québec and Labrador sustainable development institute, 2006. First Nation of Québec and Labrador Sustainable Development Strategy. URL: http://www.iddpnql.ca/fichiers/strategy_2006.pdf.
- Forest stewardship council (FSC) Canada Working group, 2004. National Boreal Standard. Forest Stewardship Council Toronto, Canada. URL: http://www.fscscanada.org/pdf_document/BorealStandard_Aug04.pdf.
- Gladu, J.P., Watkinson, C., 2004. Measuring sustainable forest management: a compilation of aboriginal indicators. (DRAFT) A Report for the Canadian Model Forest Network-Aboriginal Strategic Initiative.
- Grainger, S., Sherry, E., Fondahl, G., 2006. The John Prince Research forest: evolution of a co-management partnership in northern British Columbia. *Forestry Chronicle* 82 (4), 484–495.
- Hart, 2000. Hart Environmental Data. URL: <http://www.sustainablemeasures.com/> North Andover, MA.
- Hartanto, H., Lorenzo, M.C.B., Frio, A.L., 2002. Collective action and learning in developing a local monitoring system. *Int. Forestry Rev.* 4 (3), 184–195.
- Hawley, A.W.L., Sherry, E.E., Johnson, C.J., 2004. A biologists perspective on amalgamating traditional environmental knowledge and resource management. *BC J. Ecosyst. Manage.* 5 (1), 36–50.
- Hickey, C.G., Nelson, M., 2005. Partenariat entre les premières nations et le secteur forestier: une enquête nationale. Réseau de gestion durable des forêts, Edmonton (Alberta), 34 pp.
- Hoekstra, T.W., Allen, T.F.H., Kay, J., Tainter, J.A., 1998. Criteria and indicators for ecological and social system sustainability; with system management objectives. In: North America test of criteria and indicators of sustainable forestry. USDA Forest service: Inventory and Monitoring institute.
- Holvoet, B., Muys, B., 2004. Sustainable forest management worldwide: a comparative assessment of standards. *Int. Forestry Rev.* 6 (2), 99–122.
- Infield, M., 2001. Cultural values: a forgotten strategy for building community support for protected areas in Africa. *Conserv. Biol.* 15 (3), 800–802.
- International Council for Science (ICSU), 2002. Report of the Scientific and Technological Community to the World Summit on Sustainable Development. URL: www.icsu.org/Library/WSSD-Rep/Vol1.pdf.
- Jacqmain, H., 2005. The Moose Habitat Project: Midterm Report 2004–2005 Presented to the Waswanapi Cree Model Forest and Ministry of Natural Resources, Wildlife and Parks.
- Karjala, M.K., Dewhurst, S.M., 2003. Including aboriginal issues in forest planning: a case study in central interior British Columbia, Canada. *Landscape Urban Plann.* 64, 1–17.
- Karjala, M.K., Sherry, E.E., Dewhurst, S.M., 2004. Criteria and indicators for sustainable forest planning: a framework for recording Aboriginal resource and social values. *Forest Pol. Econ.* 6, 95–110.
- Kneeshaw, D.D., Leduc, A., Drapeau, P., Gauthier, S., Paré, D., Doucet, R., Carignan, R., Bouthillier, L., Messier, C., 1999. Development of integrated ecological standards of sustainable forest management at an operational scale. Working Paper 1999–21 for Sustainable Forest Management Network.
- Kneeshaw, D.D., Leduc, A., Drapeau, P., Gauthier, S., Paré, D., Carignan, R., Doucet, R., Bouthillier, L., Messier, C., 2000. Development of integrated ecological standards of sustainable forest management at an operational scale. *Forestry Chronicle* 76 (3), 481–493.
- Lawrence, A., Paudel, K., Barnes, R., Malla, Y., 2006. Adaptive value of participatory biodiversity monitoring in community forestry. *Environ. Conserv.* 33 (4), 325–334.
- Leroux, J., Chamberland, R., Brazeau, E., Dubé, C., 2004. Au pays des peaux de chagrin: occupation et exploitation territoriales à Kitcisakik (Grand-Lac-Victoria) au XXe siècle. Les Presses de l'Université Laval, Le Musée Canadien des Civilisations, Québec, Canada.
- Lévesque, C., Montpetit, C., 1997. Toward the integrated and sustainable management of forestry activities in Eeyou Astchee: the development of a body of cultural, social and economic criteria and indicators. James Bay Advisory Committee on the environment, INRS Québec.
- Lewis, J.L., Sheppard, S.R.J., 2006. Culture and communication: can landscape visualization improve forest management consultation with indigenous communities? *Landscape Urban Plann.* 77 (3), 291–313.
- McCool, S.F., Stankey, G., 2001. Representing the future: a framework for evaluating the utility of indicators in the search for sustainable forest management. In: Brown, A.G., Flinn, D.W. (Eds.), *Criteria and Indicators for Sustainable Forest Management*. IUFRO Research Series No. 7. CABI Publishing, Oxford.
- Mendoza, G.A., Prabhu, R., 2000. Multiple criteria decision making approaches to assessing forest sustainability using criteria and indicators: a case study. *Forest Ecol. Manage.* 131 (1–3), 107–126.
- Moller, H., Berkes, F., O'Brian Lyver, P., Kislalioglu, M., 2004. Combining science and traditional ecological knowledge: monitoring populations for co-management. *Ecol. Soc.* 9 (3), 2.
- Murali, K.S., Jagannatha Rao, R., Sudha, P., Sangeetha, G., Murthy, I.K., Ravindranath, N.H., 2003. Evaluation studies of Joint Forest Management in India: social and institutional implications. *Int. J. Environ. Sust. Dev.* 2 (1), 19–35.
- Nassauer, J.I., 1995. Culture and changing landscape structure. *Landscape Ecol.* 10 (4), 229–237.
- Natcher, D.C., Hickey, C.G., 2002. A criteria and indicators approach to community development. Sustainable forest management network. Working Paper 2002–2.
- Natcher, D.C., Davis, S., Hickey, C.G., 2005. Co-management: managing relationships, not resources. *Hum. Organ.* 64 (3), 240–250.
- National Aboriginal Forestry association (NAFA), 1993. Strategy: Forest Land and Resources for Aboriginal Peoples. An intervention Submitted to the Royal Commission on Aboriginal Peoples. Ottawa, Ontario. URL: <http://www.nafaforestry.org/publications>.

- Papatie, J., 2004. Vécu et réflexion de la communauté Anicinapek de Kitcisakik avec le régime forestier des Québécois. Commission d'étude sur la gestion de la forêt publique Québécoise. Québec.
- Parrotta, J.A., Agnoletti, M., 2007. Traditional forest knowledge: challenges and opportunities. *Forest Ecol. Manage.* 249 (1–2), 1–4.
- Potvin, F., Courtois, R., Bélanger, L., 1999. Short-term response of wildlife to clear-cutting in Quebec boreal forest: multiscale effects and management implication. *Can. J. Forest Resour.* 29, 1120–1127.
- Rollins, R., Robson, M., Robinson, D., 2001. Towards increased citizen influence in Canadian forest management. *Environments* 29 (2), 21.
- Ross, M.M., Smith, P., 2002. Accommodation of aboriginal rights: the need for an aboriginal forest tenure. Sustainable Forest Management Network, Alberta.
- Sheppard, S., 2003. Knowing a socially sustainable forest when you see one: implications for results-based forestry. *Forestry Chronicle* 79 (5), 865–875.
- Sheppard, S.R.J., Harshaw, H.W., McBride, J.R., 2001. Priorities for reconciling sustainability and aesthetics in forest landscape management. In: S.R.J. Sheppard, H.W. Harshaw (Eds.), *Linking Ecology, Sustainability and Aesthetics*. IUFRO Research Series No. 6, CABI Publishing, Oxford.
- Sheppard, S.R.J., Meitner, M., 2005. Using multi-criteria analysis and visualisation for sustainable forest management planning with stakeholder groups. *Forest Ecol. Manage.* 207, 171–187.
- Sherry, E., Halseth, R., Fondahl, G., Karjala, M., Leon, B., 2005. Local-level criteria and indicators: an Aboriginal perspective on sustainable forest management. *Forestry* 78 (5), 513–539.
- Tindall, D.B., 2001. Variation in public values and visual quality preferences. In: *Visual Resource Management Conference Compendium. Looking Beyond the Trees: Visual Stewardship of the Working Forest*. Kamloops, BC, 17–19 April. URL: <http://www.for.gov.bc.ca/HFD/Pubs/Docs/MR/Rec034.htm>.
- Turnhout, E., Hisschemöller, M., Eijsackers, H., 2007. Ecological indicators: between the two fires of science and policy. *Ecol. Indicators* 7, 215–228.
- Woodley, S., Alward, G., Iglesias Gutierrez, L., Hoekstra, T., Holt, B., Livingston, L., Loo, J., Skibicki, A., Williams, C., Wright, P., 1999. North America Test of Criteria and Indicators of Sustainable Forestry. USDA Forest Service: Inventory and Monitoring Institute.
- Wu, J., 2006. Landscape ecology, cross-disciplinarity, and sustainability science. *Landscape Ecol.* 21, 1–4.
- Yamasaki, S.H., Côté, M.A., Kneeshaw, D.D., Fortin, M.J., Fall, A., Messier, C., Bouthillier, L., Leduc, A., Drapeau, P., Gauthier, S., Paré, D., Greene, D., Carignan, R., 2001. Integration of ecological knowledge, landscape modelling, and public participation for the development of sustainable forest management. *SFM Network Project* 2001–27.