Current status and future directions of traditional ecological knowledge in forest management: a review

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ABSTRACT

In the last 25 years, the number of published studies that refer to traditional ecological knowledge (TEK) has constantly increased, with now more than 200 papers published each year. The objective of this review was to determine how this knowledge is used in current forest management around the world, and how local communities are involved in forest management planning. Published papers from 1983 to 2005 relating to TEK were found using the *ISI Web of Science* database. Despite the growing amount of literature published on TEK, we found only 21 studies that specifically address forest management *per se*. In these studies, TEK integration took different paths: using traditional management rules as a framework (five studies), using value maps to adapt practices in time and space (three studies), or by a zoning process that divides the land into areas in which different land uses are emphasized (six studies). Some community involvements are "active" with co-management committees composed of stakeholders (including community members), each having a voice; some are "passive" with external managers using criteria and indicators previously developed from community values and objectives. Although important changes in mentality and firm political decisions are still required before more efficient partnership between TEK and western science is reached in forest management planning, our review showed that Canadian initiatives proposed promising processes that could ensure better TEK incorporation and improved community participation.

Key words: traditional ecological knowledge, TEK, sustainable forest management, community participation, first nations, forest management planning

RÉSUMÉ

Au cours des 25 dernières années, la quantité d'études traitant des savoirs écologiques traditionnels (SET) a constamment augmenté, atteignant maintenant plus de 200 publications par an. L'objectif de cette revue de littérature était de déterminer comment ces connaissances sont utilisées aujourd'hui pour l'aménagement forestier à travers le monde, et comment les populations locales sont impliquées dans la planification de l'aménagement forestier. Tous les articles traitant des SET, publiés entre 1983 et 2005, ont été extraits à partir de la base de données *ISI Web of Science*. Malgré l'abondance de littérature publiée sur les SET, seulement 30 études abordaient spécifiquement l'aménagement forestier comme tel. Dans ces études, l'intégration du SET pouvait prendre différentes avenues : s'inspirer des règles ancestrales de gestion (cinq études), adapter les pratiques dans le temps et l'espace en fonction des valeurs à prioriser (trois études), ou en divisant le territoire en zones à vocations différentes basées sur l'utilisation des terres (six études). L'engagement des communautés pouvait être « actif », à travers des comités de co-gestion composés des différents utilisateurs de la forêt (incluant des membres de la communauté), chacun ayant une voix ; ou « passif » lorsque des aménagistes extérieurs utilisaient des critères et indicateurs développés à partir des valeurs et objectifs de la communauté. Cependant, d'importants changements de mentalité et des décisions politiques fermes seront encore nécessaires avant de voir une participation entière des communautés et une incorporation effective des SET et de la science occidentale dans la planification forestière. Il semble, par ailleurs, que plusieurs initiatives canadiennes présentent des processus prometteurs pour s'assurer de l'incorporation des savoirs traditionnels et pour instaurer une gestion participative.

Mots-clés : savoirs écologiques traditionnels, SET, aménagement forestier durable, gestion participative, autochtones, planification de l'aménagement forestier

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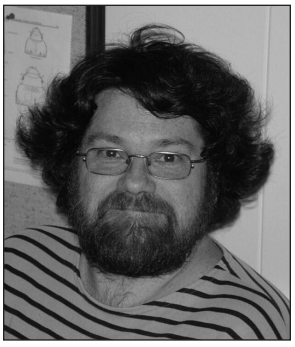

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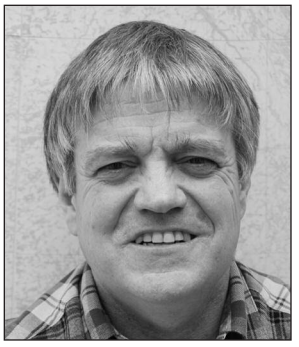

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Introduction

The use of traditional ecological knowledge (TEK) in resource and environmental management is a fairly recent development. Although this knowledge was long recognized by ethnologists, its utility and relevance to applied management appeared only in the early 1980s with the IUCN Symposium on TEK held in Indonesia in 1982 and creation of the TEK Working Group in 1984. Moreover, it is only since the publication of *Our common future* by the World Commission on Environment and Development (UNWCED 1987), which encouraged the use of TEK to solve problems in modern resource management, that TEK finally received its currently widely accepted international recognition (Johnson 1992).

The most commonly accepted definition of traditional ecological knowledge is as follows:

> …Traditional ecological knowledge or TEK is a cumulative body of knowledge and beliefs, handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment. Further, TEK is an attribute of societies with historical continuity in resource use practices; by and large, these are non-industrial or less technologically advanced societies, many of them indigenous or tribal (Berkes 1993).

Ericksen and Woodley (2005) added that Traditional ecological knowledge may or may not be indigenous (in this case named Indigenous ecological knowledge, IEK), but in both cases has roots firmly in the past, contrary to Local knowledge (LK) which is also place-based experiential knowledge, but not necessarily old (i.e., farmers or fishermen) (Joshi *et al.* 2004). Otherwise, the term TEK remains controversial because it could be interpreted as old and static (Lewis 1993). On the contrary, traditional knowledge is highly dynamic and cumulative, and although based on the experience of previous generations, it is verified at each new generation, but added to and adapted to meet present socio-economic and technological changes by adaptive processes and trial-and-error learning (Johnson 1992, Baines and Hviding 1993). Tradition further implies historical continuity of culture and knowledge over many generations.

Traditional People, who could be defined as people living a subsistence lifestyle, close to nature and natural resources, have developed a nested worldview, synthesized by Berkes (1999) in the *knowledge–practice–belief complex*, where knowledge of the land, animals and plants is embedded in a management system with land use practices, which are sustained by social institutions, all being defined by particular ethics and beliefs. Contrary to some scientists' assumptions (Howard and Widdowson 1996), western science views on land use and resource management are also rooted in a culture and system of thought (based on reductionism, experimentation, reason and rationality); consequently, they are not completely value-free (Stevenson 1997).

These fundamentally different worldviews have been one of the major causes of conflict regarding land use and management between managers, scientists and government on one hand and traditional communities on the other hand. However, all systems of human knowledge are created by similar processes and are more alike than a focus on their apparent differences may suggest (Feit 1988). Moreover, western models of knowledge have also changed between centuries, from a dichotomy of organic and inorganic world to a vision where animals and habitat are incorporated in a complex system. When ecological theories were based on climax equilibrium and maximum sustainable yield, TEK was firstly regarded as superstition by most scientists, and consequently of no practical use for current management issues (Howard and Widdowson 1996).

Recently, new paradigms that introduce concepts like complexity, system dynamics and resilience have led scientists to widely accept new approaches such as adaptive and sustainable management (Holling 1986, Holling *et al.* 1998). Western scientists now encourage the preservation of ecosystem integrity, even after resource exploitation (Regier 1993), which is considered as the fundamental principle of ecosystem-based management (Hunter 1999). These approaches also include a broader view of the connections between ecosystems and societies, which encourage more public involvement, especially where Traditional Peoples are connected to the ecosystems in which they live. These new concepts appear to be reducing the distance between science and traditional ecological knowledge (Davidson-Hunt and Berkes 2001). However, if the concept of knowledge is understood with regards to how we know (instead of what we know) through peoples' relationships with their environment, and not as an objective truth, then there is a common ground to enable multiple perspectives to contribute to ecosystem management (Woodley 2005).

Traditional Peoples' ecological knowledge systems are based on survival and success in hunting, fishing, gathering and trapping, which ensure a sustainable use of resources.

Local land use practices allow communities to remain economically and socio-culturally viable, while at the same time ensuring that there is a stable foundation for the well-being of future generations. This understanding of sustainability is notably similar to definitions expressed by the Brundtland Commission (UNWCED 1987) and Agenda 21 (UNCED 1992). The need for traditional knowledge incorporation and community involvement in resource management is recognized by the Rio Declaration, the Convention on Biodiversity and different national strategies around the world. The New Forest Code (1994, cited in Poissonnet and Lescuyer 2005) in Cameroon, the Strategy for the Involvement of communities and voluntary agencies in the Regeneration of Degraded Forests in India (1990, cited in Martin and Lemon 2001), as well as the Canadian National Forest Strategy Coalition (2003) are recent examples of this worldwide trend. In forest management, the Forest Stewardship Council (FSC) and other certification agencies especially encourage participation of indigenous communities in co-management committees to obtain sustainable forest management labels.

Sustainable forest management can be defined as maintaining and enhancing the long-term health of forest ecosystems for the benefit of all living things, both nationally and globally, while providing environmental, economic, social and cultural opportunities for the benefit of present and future generations (CCFM 2000). This definition implies respect and protection of the ecosystem *per se* (species and natural processes), but also its multiple uses (timber and wildlife harvesting, non-timber forest products, recreational activities, indigenous traditional activities). Because Traditional Peoples living in forest ecosystems are highly dependent on non-timber forest products (NTFP), research on these products has often been run in parallel with studies on TEK and forest management. Collectively, these studies provide a privileged arena of investigation in which ecology, TEK, and timber and NTFP harvesting can be brought together in a sustainable forest management framework (Davidson-Hunt and Berkes 2001).

Considering the recent recognition of TEK in forest resource and environmental management, how are such considerations currently integrated into forest management planning? In this paper, we propose 1) a review of case studies around the world that try to integrate TEK and that involve communities in forest planning and management, and 2) a synthesis of different processes that have been developed to promote efficient participation of communities and inclusion of their knowledge in sustainable forest management.

Methods

In this study we do not intend nor pretend to do an exhaustive review of all TEK-related work, which would include reports and unpublished theses. Our intent was specifically to review published case studies, easily available worldwide, which justify our choice to use a recognized database of peer-review papers published in scientific journals. We therefore used the *ISI Web of Science* online database provided by Thomson Scientific, and we generated a list of published papers from "*Social Science Citation Index*," "*Arts and Humanities Citation Index*" and "*Science Citation Index (Expanded)*" between 1983 and 2005 (done on January 31, 2007), which included the terms "traditional knowledge," "indigenous knowledge," "local knowledge," "environmental knowledge" or "ecological knowledge" as Title or Topic (1805 papers). These databases cover over 8700 leading journals of science, technology, social sciences, arts, and humanities. From this bibliography, we extracted articles with "forest" or "forestry" in the Title or Topic (222 papers). If we define forest management both as the planning of use and the use of the forest for any purpose (wood or NFTP harvesting, hunting, spiritual activities, etc), only 21 articles were specifically related to forest management *per se*. We analysed documents from Asia, Africa, South and North America, with special attention given to how TEK was collected (gathering methods) and how it was really integrated into management decisions. We also evaluated community involvement level (when possible) using Berkes' (1994) levels of co-management: (1) informing, (2) consultation, (3) co-operation, (4) communication, (5) advisory committees, (6) management board and (7) partnership of equals/community control.

There is no "universal" recognized keyword to drive our research in the database, thus some interesting papers could indeed have been missed (for example those using "community-based forest management" or "participatory forest management"). We also acknowledge that literature published in languages other than English/French were not considered in our review.

For the synthesis of different processes enhancing efficient participation of local communities in forest planning and management, we specifically analysed three Canadian initiatives, from papers published in scientific journals (Karjala and Dewhurst 2003, Karjala *et al*. 2004) and also pertinent chapters (Stevenson and Webb 2003, 2004) or reports (Pelletier 2002, Pelletier 2002, Stevenson 2005, Waswanipi Cree Model Forest 2007) (grey literature) not listed in the *ISI Web of Science* database.

Results

Since 1983, 1805 papers on TEK were published according to our initial search within the ISI Web of Science database. Publishing rates have constantly increased in the last 15 years with more than 25 papers per year since 1991, 50 per year since 1995, 100 per year since 1998, and more than 200 per year since 2003 (Fig. 1). Among these contributions, 12% (222 papers) contained forest-related issues, for example, knowledge on natural disturbances (Kovacs *et al*. 2004) or wildlife (Dahl 2005), medicinal plant and non-timber forest product (NTFP) uses (Pakia and Cooke 2003a, b), among others.

TEK-gathering

Nineteen of the retained 21 documents presented a case study, in which a majority (15) gathered TEK. In these studies, only two did not describe the methodology that was used to collect community knowledge or values, even if they mentioned that they created land use and occupation maps (Polansky and Heermans 2004, Sekhar 2004). Eight studies used open-ended or informal interviews to collect traditional knowledge or to gather perceptions of stakeholders involved in management committees. Six were based on group discussions, five were based on participant observations, three were based on non-participant observations, one used questionnaires, three produced value or objective maps, and finally, six

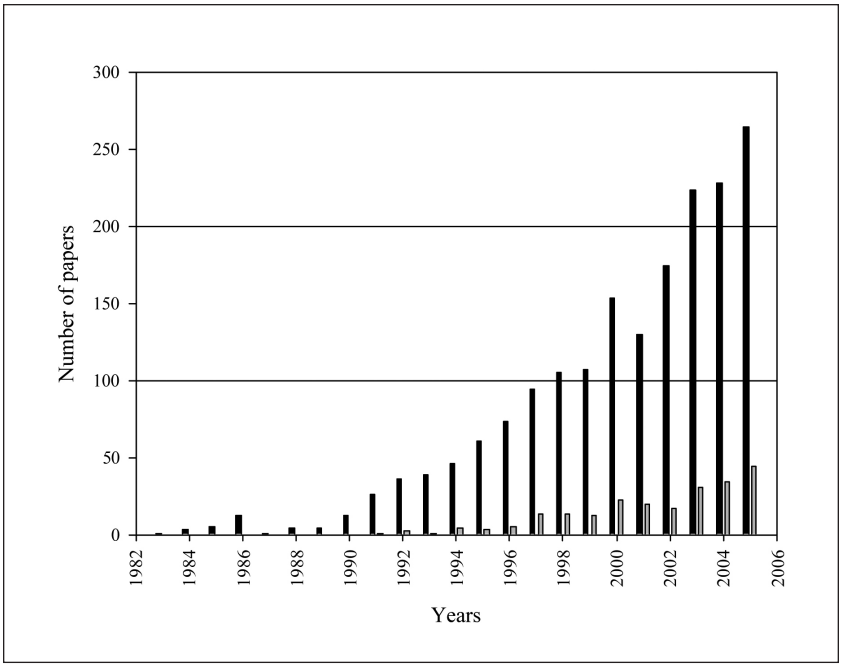

Fig. 1. Progression of the number of published papers that address the issue of traditional ecological knowledge (TEK) in peer-reviewed journals (source: *Web of Science ISI* database). Dark grey: all papers on TEK; light grey: papers that refer to TEK in forest-related issues.

created traditional land use and occupation maps (Table 1). Some described in detail the subjects that were tackled during discussions and interviews (Dei 1993, Wickramasinghe 1997, Karjala and Dewhurst 2003, Herrmann 2005, McCall and Minang 2005, Silvano *et al.* 2005), but others not at all (e.g., Sekhar 2004). Five studies also compared traditional knowledge with scientific data collected in the field (Wickramasinghe 1997, Polansky and Heermans 2004, Herrmann 2005, Robiglio and Mala 2005, Silvano *et al.* 2005).

In order to improve Iranian forest management plans, Ghazanfari *et al.* (2004) used only participant observation to document traditional management practices to increase local community acceptance. Herrmann (2005) used both participant observation and open-ended interviews to document indigenous traditional management of *Araucaria araucana* forests in Chile, the cultural role of this species and perceived risks linked to its exploitation (seed gathering). Moreover, he specifically discussed with participants how TEK could contribute to forest management. In Sekhar's (2004) study, the goal was to compare tree species chosen for planting by local populations in India considering religious, social and economic factors with choices made by scientific experts. She conducted non-participant observations and open-ended interviews, but did not give details on treated subjects. In Wickramasinghe's (1997) case study, group discussions and participant observation were used to document traditional use of forest resources in Sri Lanka and reasons for opposition to an integral conservation project developed after an important degradation of the local forest. In Thailand, Roth (2004) used only focus group interviews with key informants in a similar case of local opposition to a conservation park, particularly in relation to fixed geographical borders, which are not a traditional way of viewing the land. Dei (1993) studied human causes of local deforestation in Ghana using participant and non-participant observations, as well as interviews on traditional harvesting, myths and taboos related to forests, and land use for timber harvesting and agriculture. Natcher *et al.* (2005) used the same approach (participant and non-participant observations as well as interviews) to evaluate satisfaction of stakeholders involved in a committee for co-management of fish, wildlife and other renewable resources in Yukon (Canada). In a study documented by Silvano *et al.* (2005), the Brazilian government wanted to reforest grazing land, in order to protect an important river (for water supply) and create a corridor between two forest areas. The authors used a questionnaire to evaluate local perceptions on land degradation (ecological integrity of the river, water quality and forest ecosystem services). Farmers acknowledged advantages of the surrounding forest ecosystem for livestock, but they were not interested in more protection, because they did not recognize their responsibility in land degradation. Comparisons between local knowledge and scientific data have shown that, for example, farmers have underestimated the issue of water quality degradation in this river basin. This suggests that we need to be cautious and adequately verify information before using it in management strategies (Davis and Wagner 2003).

A second group of articles focused on land use or value maps as tools that should incorporate TEK. In fact, these maps are not outputs but spatial representations of TEK, traditional practices and values. Polansky and Heermans (2004) evaluated the potential use of different high-technology tools (satellite maps, aerial photos, GIS) associated with TEK to improve forest management in Zambia. From panchromatic aerial photos, simplified maps were created, in which land use information (non-timber forest products, agriculture, and zone limits) was added with the collaboration of the local population (no details concerning their methodology). Robiglio and Mala (2005) conducted a similar study in Cameroon, using GIS and TEK (collected from focus group discussions and field trips) to create traditional land use and occupation maps. Karjala and collaborators (Karjala and Dewhurst 2003, Karjala *et al.* 2004) carried out open-ended interviews and meetings with focus groups in order to generate land use and occupation maps including values, needs and perspectives from an indigenous community using criteria and indicators, in a context of conflict between commercial forestry and traditional rights of First Nations in British Columbia (Canada). McCall and Minang (2005) used the same approach (open-ended interviews, focus group discussions) to realize land use maps. Furthermore, they used criteria and indicators developed with the community to evaluate governance of a Cameroon communal forest. Natcher and Hickey (2002) used all available methods to realize land use maps using criteria and indicators developed with an indige-

Table 1. Methodological approaches used to collect traditional ecological knowledge or community perceptions in reviewed studies related to forest management (N = 15). (Six studies were omitted because they presented no case study or no TEK-gathering.)

Articles	Open-ended interview	Group discussion	Questionnaire	Participant observation	Non-participant observation	Value and objective map	Land use and occupation map
Dei 1993	×			×	×		
Robinson and Ross 1997							×
Wickramasinghe 1997		×		×			
McGregor 2002	×					×	
Natcher and Hickey 2002	×	×		×			×
Karjala and Dewhurst 2003	×					×	
Ghazanfari *et al.* 2004				×			
Karjala *et al.* 2004	×	×				×	
Polansky and Heermans 2004							×
Roth 2004		×					
Sekhar 2004	×				×		
Herrmann 2005	×			×			
McCall and Minang 2005	×	×					×
Robiglio and Mala 2005		×					×
Silvano *et al.* 2005			×				×

nous community in Alberta (Canada). Robinson and Ross (1997) proposed also to create land use maps using interviews to gather indigenous values and objectives in Alberta (Canada), with numerous validations during the process. Using open-ended interviews and priority value maps, McGregor (2002) evaluated the satisfaction level of different forest users (indigenous and non-indigenous) who participated in consultations regarding forest planning in Ontario (Canada).

TEK incorporation

Different types of information (traditional management practices, land use, and values) that are contained in TEK may be incorporated into forest management. Traditional management practices could inspire modern management (Berkes *et al.* 2000) to reduce conflicts between stakeholders (Herrmann 2005), or simply because they have often been sustainable for thousands of years (Stevenson 1997). Five studies proposed to incorporate some traditional management rules into modern forest management plans (Wickramasinghe 1997, Ghazanfari *et al.* 2004, Roth 2004, Sekhar 2004, Herrmann 2005). Traditional knowledge of land use can also be helpful in creating a zoning of the landbase to share land between different users or adapt forestry practices for other uses at specific moments. Six studies proposed such an approach (Dei 1993, Robinson and Ross 1997, Natcher and Hickey 2002, Polansky and Heermans 2004, McCall and Minang 2005, Robiglio and Mala 2005). The integration of local values and objectives can also be considered as a means to involve communities in forest management, using criteria and indicators, value maps or both. This can lead to generating land use maps that incorporate spatial and temporal traditional uses. Three studies proposed this approach (McGregor 2002, Karjala and Dewhurst 2003, Karjala *et al.* 2004).

More than half of the studies incorporated TEK in a forest management process (Table 2). A project was aimed at establishing a new forest planning process that would incorporate TEK ultimately (Ghazanfari *et al.* 2004), whereas for others, the integration of TEK is already underway, although at different levels. Some studies have collected information on traditional management practices or traditional land uses, but this information is not yet or not efficiently incorporated within forest management plans, but could be so in the near future (Dei 1993, Wickramasinghe 1997, Polansky and Heermans 2004).

Community involvement

Six studies presented no community involvement in forest management (Dei 1993, Wickramasinghe 1997, Gautam and Watanabe 2002, Polansky and Heermans 2004, Herrmann 2005, Silvano *et al.* 2005) (Table 2). For example, Silvano *et al.* (2005) collected local knowledge to propose reforestation strategies, but the local community did not take part in the development of these forest management strategies. In Herrmann's (2005) study, it was not clear how TEK was incorporated into forest management, although the Chilean government encouraged the local community to reforest clearcuts with cultivated *Araucaria araucana* (*ex situ* conservation). The local community certainly was involved in conservation of this endangered species, but not really in its *in situ* management. In Wickramasinghe's (1997) study, the government of Sri Lanka decided to preserve a forest without accounting for local population dependence on forest resources. Thompson (1999) presented a synthesis of different pilot projects in social forestry in Indonesia, but local community involvement is not described in detail. Nevertheless, it included gathering TEK (on forest and on traditional management) and it was a participatory process.

Table 2: TEK-gathering, incorporation, and community involvement in reviewed studies related to forest management (N = 21). Levels of Community involvement have been evaluated (when possible) using Berkes' (1994) levels of co-management : (1) informing, (2) consultation, (3) co-operation, (4) communication, (5) advisory committees, (6) management board and (7) partnership of equals/community control.

Articles	Country	Case study	TEK-gathering	Gathering description	TEK incorporation	Community involvement	Involvement description	Target community
Dei 1993	Ghana	yes	yes	yes	no	no	–	Local population
Robinson and Ross 1997	Canada, AB	yes	yes	yes	yes	6–7	yes	Indigenous
Wickramasinghe 1997	Sri Lanka	yes	yes	yes	+/-	no	–	Local population
Thompson 1999	Indonesia	yes	no	–	no	yes[a]	yes	Local population
Martin and Lemon 2001	India	yes	no	–	no	5	yes	Local population
Gautam and Watanabe 2002	Nepal	no	–	–	–	no	–	Local population
Klooster 2002	Mexico	yes	no	–	no	7	yes	Local population, metis
McGregor 2002	Canada, ON	yes	yes	yes	yes	4	yes	Indigenous
Natcher and Hickey 2002	Canada, AB	yes	yes	yes	yes	6	yes	Indigenous
Karjala and Dewhurst 2003	Canada, BC	yes	yes	yes	yes	6	yes	Indigenous
Parsons and Prest 2003	Canada	no	–	–	–	economic	yes	Indigenous
Ghazanfari *et al.* 2004	Iran	yes	yes	yes	yes	ultimately 7	yes	Local population
Karjala *et al.* 2004	Canada, BC	yes	yes	yes	yes	6	yes	Indigenous
Polansky and Heermans 2004	Zambia	yes	yes	no	+/-	3	no	Local population
Roth 2004	Thailand	yes	yes	yes	yes	7	yes	Local population
Sekhar 2004	India	yes	yes	no	yes	5	yes	Local population
Herrmann 2005	Chile	yes	yes	yes	no	no	–	Indigenous
McCall and Minang 2005	Cameroon	yes	yes	yes	yes	4	yes	Local population
Natcher *et al.* 2005	Canada, YK	yes	no	–	no	7	yes	Indigenous
Robiglio and Mala 2005	Cameroon	yes	yes	yes	yes	3	yes	Local population
Silvano *et al.* 2005	Brazil	yes	yes	yes	no	no	–	Farmers

[a]This article presents a synthesis of different experiments of social forestry, which is impossible to rank using Berkes' (1994) scale.

It is difficult to draw generalities from case studies as they are each at different stages of development; these include: (a) a call to involve local communities (Dei 1993, Wickramasinghe 1997, Gautam and Watanabe 2002, Herrmann 2005), (b) the development of a future participation process (Natcher and Hickey 2002, Ghazanfari *et al.* 2004), (c) presentation of an active participation process (Natcher *et al.* 2005), (d) evaluation of an active participation process (Martin and Lemon 2001, Karjala *et al.* 2004, Polansky and Heermans 2004, McCall and Minang 2005, Robiglio and Mala 2005, Roth 2004), (e) evaluation of stakeholder satisfaction (McGregor 2002), and (f) a comparison of different approaches that incorporated TEK (Klooster 2002). Furthermore, the autonomy of involved communities and the level of their assimilation into modern ways of life are different. In addition, the ecological, social and political context of each study is specific, including projects of local development using forestry, conservation or restoration projects that are in

conflict with traditional subsistence gathering, agriculture or agroforestry, together with projects of commercial timber harvesting, which limits indigenous rights.

Levels of co-management (*sensu* Berkes 1994) by the local community varied considerably among the studies. For example, the case study presented by Polansky and Heermans (2004) and Robiglio and Mala (2005) were at level 3 (co-operation). Robiglio and Mala (2005) presented Cameroon Communal Forests. This kind of land tenure is quite new and the participation process is probably a work in progress. McGregor's (2002) study concluded that to reach stakeholders' satisfaction, a minimal co-management level requires a mutual exchange of information (level 4: communication), but only if the control of methods of knowledge sharing is relinquished to the indigenous community. Herrmann (2006) suggested also, in a second study, the implementation of a process that represents a minimum of level 4. This level seems to have been attained in another Cameroon Communal Forest (McCall and Minang 2005). The two projects in India reached level 5 (advisory committees), but they were possibly difficult to implement because of differences between the Forest Department and the villagers who depended on trees as a resource (fuelwood, fruits, fodder) (Sekhar 2004). Moreover, Martin and Lemon (2001) explained that these new institutional arrangements often reproduce the social relationships that marginalize certain groups of people, especially women. Processes developed by the different Canadian projects seem to be at level 6 (management board), following Berkes' (1994) scale (Natcher and Hickey 2002, Karjala and Dewhurst 2003, Karjala *et al*. 2004). Natcher and Hickey (2002) presented a management board composed by five community representatives out of 14 members, along with two others from economic development corporations, but final decisions with regards to forest management remained contingent upon the approval of the Minister of Environmental Protection (level 6). Karjala and Dewhurst (2003) and Karjala *et al*. (2004) presented the *Aboriginal Forest Planning Process*, which aims at integrating TEK and western science within a participatory process (using evaluation of management scenarios with different protection levels) in a co-managed research forest (local indigenous community-University of Northern British Columbia). Robinson and Ross (1997) described a parallel consultation process that complements the regular process, providing the community detailed information on annual operating plans, but with no direct participation in their elaboration. Natcher *et al*. (2005) also presented co-management committees including community representatives, which correspond to level 7 (partnership of equals) on Berkes' scale. Roth (2004) suggested that general information provided by foresters and detailed information of a specific area provided by local traditional knowledge could be merged in order to manage a territory (level 7: partnership of equals). Moreover, he noted the importance of having common ground and developing trust among stakeholders. After this, it is possible to find similarities in the different views to start a process of collaborative management, using negotiations. Ghazanfari *et al.* (2004) presented a work in progress, which they hope will reach ultimately level 7. Finally, Klooster (2002) presented a case of strict community control (level 7), with report production and frequent control by community audits in Mexico.

Economic involvement

Only one paper addressed issues of economical involvement of local communities in the forest sector (Parsons and Prest 2003). Parsons and Prest (2003) proposed possible economic partnerships between local communities and industries: opportunities for employment (in sawmills or in different logging contracts), training programs and joint ventures to build—or save—a mill or a value-added production. This represents a form of involvement but this is not participation *per se*, thus it could not be translated on a scale of participation like Berkes' (1994).

Discussion

Enhancing participation: How to facilitate TEK incorporation?

Robinson and Ross (1997) judged that the impact of indigenous knowledge on forest management was, with a few exceptions, negligible. This viewpoint was also expressed more recently by Stevenson and Webb (2003, 2004), indicating that the situation has not really changed over the past decade. According to these authors, the real contributions of indigenous knowledge to sustainable forest management (SFM) have yet to come. Effective policies, institutions and practices need to be developed in order to fully and equitably incorporate local communities into SFM. TEK integration still entails numerous challenges, given that: 1) TEK is disappearing at a fast pace, given that it is passed through oral tradition that may be lost over time—like language, TEK won't survive unless practised—and the lack of human resources to document it before it is lost; 2) there are practical problems in trying to reconcile two very different worldviews and in translating ideas and concepts from one culture to another; 3) there is a problem of attitude that prevents both western scientists and Traditional Peoples from respecting the value of each other's knowledge systems, and among western scientists, between natural and social scientists regarding research methods; and 4) there is a political problem that impedes the development of institutional arrangements that recognize the validity of TEK (Johnson 1992).

To gather TEK, there could be two different approaches: one could involve outsiders (familiarized with community worldview) who could collect traditional knowledge, or, the second could build on local people (familiarized with western science) who possess the knowledge, to transmit it to resource managers. In the first case, numerous methods exist to collect traditional knowledge or community perspectives and values, but not all have the same usefulness for incorporation in resource management. The more global is the understanding of local knowledge the more it could be effectively included in management plans (Ericksen and Woodley 2005). TEK-gathering is often fragmentary, focusing on some specific aspects only. To bypass this problem, researchers usually use more than one approach. The review of methodologies is not exhaustive; for example, rapid appraisal (RRA) and participatory appraisal (PRA) are also largely used. These methods, which allow learning about local conditions in an iterative and expeditious manner, are used in the identification of community problems and for monitoring and evaluation of ongoing activities in different fields (particularly in social and medical sciences; Campbell 2001). In the second case, it is urgent to keep this knowledge alive within traditional communities. There is an unavoidable assimilation of these com-

munities (due to dramatic cultural changes) and then a failure to transmit traditional knowledge to younger generations (due to trans-generation conflicts and state-defined education; Johnson 1992).

The lack of empowerment of local communities in using their knowledge in resource use decision-making is mainly due to the fact that this knowledge does not easily fit into the western scientific paradigm (Stevenson and Webb 2004). Because of its removal from context and subsequent distortion in translation, traditional knowledge loses part of its essence and becomes coarse information (sanitized knowledge). Moreover, when decisions using this information are taken, the absence of TEK holders and users contribute to increase this phenomenon (Stevenson and Webb 2004). Woodley (2005) developed a conceptual framework for representing traditional ecological knowledge that allows understanding how people relate to their environment, instead of documenting knowledge, which could assist in bridging differences in worldviews and epistemologies between researchers and Traditional Peoples. In her framework, TEK emerges from context (history, demographic factors and biophysical features of the place where they live), practice (action, physical interaction and experiential learning) and belief (influence of spirituality and values on how they act within their environment). If context changes in time or space, a process of "reflexivity" allows more factual knowledge to be adapted in a new context. This process, which is considered part of the resilience and adaptive capacity of the community, may be a means to use TEK in a context of resource management (Woodley 2005).

Despite the fact that the *Millennium Ecosystem Assessment* initiative developed a general framework for collecting traditional knowledge and for incorporating it in current management purposes, each local committee had to modify and adapt this framework to fit the local context and then obtain the recognition of the community. However, some recommendations were proposed by Ericksen and Woodley (2005) to incorporate multiple knowledge systems. First, TEK-gathering should be done by an interdisciplinary team composed of ecological scientists as well as social scientists (like anthropologists, philosophers of science or community-oriented researchers) to provide full understanding of local knowledge. All members of this team should endorse the interdisciplinary perspective and be ready to spend time working in close collaboration in a continuous way over years. In-depth understanding of local knowledge by outsiders requires skill, training, respectful behaviour, an open and non-judgmental attitude and experience of the place. Secondly, this team should be constantly assisted by a coordination office that acts as a bridge between scientists and users. On the other hand, all sources of information (scientific and traditional) should be critically assessed and validated through a proposed process including triangulation (cross-validation from different sources) and review by the community as well as stakeholders (Ericksen and Woodley 2005). In order to give the same weight to each type of knowledge, Ericksen and Woodley (2005) proposed a cross-validation process in which local experts validate scientific knowledge and scientists validate local knowledge.

The lack of clarity in the definition of objectives that are pursued by government agencies and industries is undoubtedly at the source of some difficulties limiting the incorporation of TEK into forest management (Robinson and Ross 1997). Officially, governments and industries support the principle of integrating TEK into forest management plans and implement consultation processes with native communities affected by timber harvesting, but precise mechanisms are usually lacking. At best, some projects take inspiration from traditional practices or develop new approaches to reduce conflicts between stakeholders (Herrmann 2005). Even though some initiatives have appeared (Jacqmain *et al*. 2005), it is clear that the integration of these two knowledge systems (i.e., TEK and western science) at a large scale remains a distant goal, because the following conditions must be met: support for the comprehensive documentation of TEK, a recognition of alternative knowledge systems, support for cross-cultural education, and mostly, political recognition of local population claims to land and resources (Johnson 1992).

Between different approaches, the development of land use and occupation maps could also be a good first step to incorporate local population interests and practices, but Natcher (2001) discussed methodological limitations in land use mapping. Among these limitations are financial constraints related to this kind of research, unequal financial support between communities, lack of technical training at the community level to implement locally controlled research, problems of representation of community land use reflecting only one perspective (under-represented factions of the community, like women), problems of "completeness" (a long process, only permitting a small part of the territory to be recorded), and problems of respecting intellectual property rights regarding the information, together with its decontextualization by industry land managers. Moreover, mapping traditional land uses often has failed to recognize the cultural importance of landscapes for Indigenous People, restricting this knowledge to a simple spatial distribution of physical features on the landscape (Natcher 2001). It is the activity *per se* that is valued by local people more than the particular place where the activity occurs. On the other hand, this mapping is important for establishing legally recognized land tenure and boundaries, and also in providing a common ground to negotiate and develop an acceptable strategy for the different stakeholders (Roth 2004). According to Roth (2004), documenting the spatial organisation of environmental practices will contribute to the understanding of the challenges and possibilities to integrate TEK. Effective integration will pass through an analysis of compatibility and convergence between TEK and science inside each of the four spheres of Berkes' (1999) knowledge–practice–belief complex. Roth (2004) further suggested using spatial tools to facilitate the integration of TEK and science through their similarities. Land use maps also present some limits for both industry and government viewpoints: methodological and technical issues (accuracy of the data), accessibility of the data, unresolved issues regarding land claims, the need for government leadership (in developing appropriate policies), differing expectations and agendas, and the need for a global coordinated system for the conduct of land use studies (MacKinnon *et al*. 2001).

Some difficulties with incorporating TEK into forest management are easy to solve, while others are more complex. The first step is certainly the official recognition of the usefulness of TEK in forest management. Next, an in-depth understanding of local knowledge through their relationship with their environment could be collected by an interdisciplinary team

and the establishment of clear procedures to incorporate this information efficiently could be developed, with respect shown to knowledge holders. Because TEK is place-based, processes to incorporate this knowledge also need to be locally developed with the community, even if a general framework could provide a benchmark. Land use maps (to have a spatial common ground of discussion), combined with value maps (to take into account more abstracted concepts and objectives), seem to be positive steps forward in the incorporation of TEK, as long as they are really considered in forest management planning.

How to enhance community involvement in forest planning and management?

Within the boreal forest of Canada, timber harvest planning is contingent on conflicts between commercial forestry and indigenous ancestral rights to access wildlife resources. Several authors have used processes derived from Stevenson's models (Stevenson and Webb 2003, 2004; Stevenson 2005) to analyze the integration of TEK into forest planning. Stevenson and Webb (2003) first described the current status-quo (Fig. 2a), which revealed recurrent problems (as mentioned in the previous section), unacceptable to the majority. However, local communities are not really involved in the process; at best some of their knowledge is considered. First, only a small part of TEK is included in final forest management decision-making, because a large part is not accessible to managers, through either a lack of will or understanding (Stevenson 1996). Second, the data-gathering process of TEK is problematic, because this knowledge is largely oral, taped, "filtered" by the translation process, transcribed and divorced from its original context, which causes important loss of information throughout the process of data acquisition (Stevenson and Webb 2003). Finally, collected TEK is often sanitized and modelled to match a western vision to make it more useable. Moreover, few considerations are given to knowledge holders (non-respect of intellectual property). When it is collected, knowledge becomes information, which is transcribed, and subsequently, this represents the authority reference, excluding knowledge holders. This process represents the current scientific way of knowledge propagation. Results, when published, become universal knowledge and are no longer possessed by an individual or a group, contrary to registered patent.

Stevenson and Webb (2003) proposed a second model that more efficiently incorporates TEK with a real involvement of knowledge holders in decision-making (Fig. 2b). In this model, TEK is considered in its entirety and is equal to western science. The focus is not on how TEK could inform western science, but on the management approaches and ecological relationships that TEK and western science are intended to produce (Stevenson and Webb 2003). Western science emphasizes ecological components so that managers can provide information and knowledge regarding the assessment and management of valued ecosystem components. On the other hand, First Nations (and many Traditional Peoples) valorize ecological relationships (network between the components) so that local peoples can provide wisdom and knowledge relevant to managing valued ecosystem relationships, particularly human–forest resource relationships. The two visions are complementary (Stevenson and Webb 2004). Currently, management considerations almost always focus

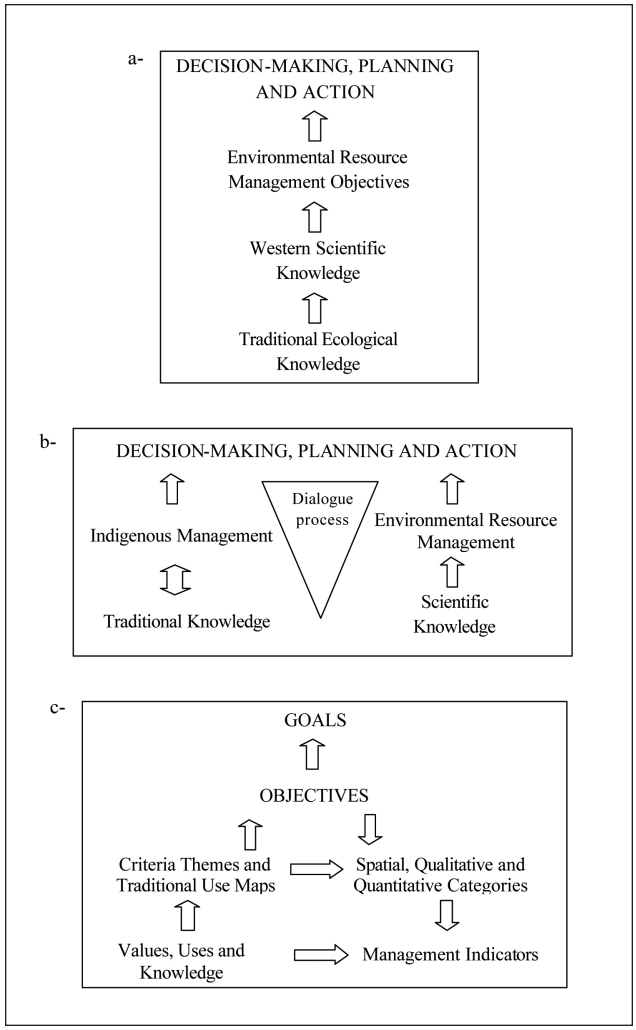

Fig. 2. Models for incorporating TEK in resource management : a) status-quo (from Stevenson and Webb 2003), b) Stevenson's model (modified from Stevenson 2005) and c) Karjala's model (*Aboriginal Forest Planning Process* framework) (from Karjala *et al.* 2004).

on information about the resource and exclude knowledge of the relationships. Stevenson and Webb (2003) also presented a process to establish an efficient participatory management in four steps. First, the communities need to document, assess and prioritize their needs, uses and values with respect to the forest and forest resources. Second, communities develop their land use and forestry objectives, plans, policies and regulations. Third, local communities negotiate with government agencies and industries to agree on effective policies, institutions and strategies that will meet their objectives, rights and interests, with respect to the other stakeholders. Finally, an adaptive management approach is required to modify existing policy and practice when required in the future. This means that Traditional Peoples become stakeholders and have the same weight in all steps of forest management decision-making. During such a deliberative process, each stakeholder has to be open and critical about its role, in order to contribute to the establishment of a successful management plan.

The Waswanipi Cree Model Forest used this approach to build its own action plan. The group proposed a negotiation mechanism for forest management plans with forest companies based on the principle of equality between community representatives and forest companies (Pelletier 2002, Waswanipi Cree Model Forest 2007). The first step documented traditional land use and occupation of the territory. These maps were combined with management objectives and values developed for each season (depending on traditional activities) to develop zoning maps with conservation values to prioritize (Waswanipi Cree Model Forest 2007). In parallel, a diagnosis of the state of the forest was conducted, not only from a forester's perspective but also from the community perspective. For each zone, different management strategies were proposed in a guide to forest companies, who had to produce forest management plans. These plans had to be negotiated until consensus was reached (Pelletier 2002). Some issues were identified during the process, like unequal power between industry and community, communication problems, schedule delays, and management of special issues. The goal was not to move from forestry supremacy with no place for traditional land use to traditional land use supremacy with no place for forestry. This model did not aim at prioritizing community land use while adjusting *ad hoc* forest harvesting, but intended to give equal weight to the stakeholders in multi-use management of the forest.

A similar model was developed by Karjala and collaborators (*Aboriginal Forest Planning Process*) based on criteria and indicators that rank community priorities in the first place (Fig. 2c). First, they proposed to develop land use maps. Second, they compiled values, local needs and perspectives depending on people's age-groups. Third, they developed four thematic maps (fishing, hunting-trapping, plant gathering and cultural sites). Finally, they developed a zoning system and completed maps presenting three categories of criteria and indicators (spatial, quantitative and qualitative) (Karjala and Dewhurst 2003, Karjala *et al*. 2004). The authors have provided a list of problems they encountered throughout the project: lack of human, financial, technical and information resources; mistrust, misuse of information and misunderstandings; difficulty in collecting values and goals without legal and policy provisions; difficulty in identifying important and testable indicators; and lack of power of the community in decision-making.

All these case studies are in the same country and in the same context. Approaches involving local communities were also quite similar and seem to be appreciated by these communities. In all cases, the researchers acted as initiators or at least as mediators (in some countries, it could also be NGOs) among the community, government and industries. This mediation was not obligatory, however, but depended on the context and the capacity of each community. For example, in Thailand, a local community initiated a project of communal forestry (bottom-up project). Despite the fact that community members were highly motivated, legal support was absent, and governmental forest institutions could not transfer appropriate technology to the community. Hence, the scope for developing strategies combining TEK and science is limited, formal institutional arrangements are lacking, and community access to high-level technology is limited (Abdus Salam *et al*. 2006).

Economic involvement

Hickey and Nelson (2005) defined four categories of economic partnership to help communities in choosing which is the best adapted to each situation, depending on pursued goals and objectives. These authors presented a Canada-wide survey of economic partnerships between First Nations and forest companies, including local opportunities for employment, training programs and joint ventures. Parsons and Prest (2003) noted an increase in aboriginal people involvement with professional and technical expertise in forestry. However, access to large amounts of capital necessary to build a mill, for example, are not easily available to small communities. Consequently, an association with an existing forest company is often necessary to initiate such projects (Hickey and Nelson 2005). In doing so, local communities can gain control over where and when logging is conducted, but never over how much area is to be harvested, because the annual allowable cut is determined by provincial governments throughout Canada. In some cases, this cause conflicts inside the community, because people feel betrayed even by indigenous forest companies, as well as by non-indigenous ones. Wyatt (2004) drew up the profile of an indigenous forest company in Quebec (Canada), and showed that indigenous workers are often restricted to road construction, planting and thinning jobs while non-indigenous people are mostly employed in harvesting operations. This lack of local professional skills is one of the most important issues for First Nations local communities as well as financial mismanagement. In another context, Mengue-Medou and Waaub (2005) evaluated socio-economic issues and positive/negative impacts of forest exploitation in Gabon, where public participation is quite low. The establishment of a forest company in the region under study created employment, but not as well as expected, again because of the lack of professional skills in the local population. Finally, there were mostly negative social effects for the local community: population increase with unemployment increase, conflict between villagers who need non-timber forest products and industries who want timber, loss of spiritual and cultural practices, loss of ancestral rights, loss of the social structure of power, increase in the prices for essential foods (Mengue-Medou and Waaub 2005).

There is often confusion between two types of involvement of a local community in forest management: economic involvement could in no case replace involvement in forest planning and management. Economic involvement is important in creating jobs and economic development, but community involvement during the planning process has a greater impact in terms of community empowerment, political power, ancestral territory rights recognition and traditional knowledge recognition. These two kinds of involvement are not exclusive, but there typically is a diversity of opinions within communities, i.e., the young could prefer jobs over recognition of territory rights while elders prefer the opposite (Natcher and Hickey 2002). Nevertheless, creating jobs (for example, trained managers and auditors) inside a management institution represents a form of involvement (Klooster 2002) but it is not participation.

Conclusion

The few attempts at TEK incorporation into forest management could be classified into two categories of results: conflicts between different uses (for example, in the context of

conflict between commercial forestry and indigenous rights for access to wildlife and non-timber forest products), and conflicts between conservation and traditional or commercial use (for example, in developing countries where deforestation is practised to facilitate agriculture). In all cases, conflicts resulted in the dispossession of ancestral lands by local populations. In the first category, Canadian initiatives seemed to be one of the most advanced in terms of community involvement, with several pilot projects already established (seven of the peer-reviewed papers are from Canada, four from Africa, seven from Asia and three from South America). Similar processes have been proposed, where the aim is greater participation of local communities in forest planning and management. All reviewed processes need a long time to be implemented—to adapt a general framework to the local context, which becomes recognized by the community, and to establish mutual confidence among stakeholders. Incorporating TEK in forest management plans could be done with land use maps where commercial forestry, traditional activities, and integral protection are zoned. With respect to traditional activity seasons or wildlife-associated "seasons" (e.g., reproduction, wintering), these zones need not be necessarily exclusive in time and in space. Concrete trials need to be tested; results, successes and failures have to be communicated in order to improve processes and inform other researchers. Considerable effort will be required to reach a high level of participation of local communities and efficient incorporation of TEK. This may only be accomplished through recognition of alternative knowledge systems, a greater open-mindedness, and support for inter-cultural education (in both directions). Important changes in mentality and firm political decisions (through law, which imposes a participation process, for example) are still required before more efficient partnerships between TEK and western science are reached in forest management planning. Concurrently, it will be important to train local people (community members) who will adopt the process and run it once it is functional and well established.

As already noted by Davis and Wagner (2003), who conducted a review of TEK-gathering methodologies, too many researchers are not reporting critical details of their research designs and methodologies. Moreover, several interesting processes and initiatives were not published in accessible papers for others practitioners. We strongly encourage people (researchers, practitioners and communities) working in TEK-related topics and in traditional community involvement in natural resource management, more specifically forest management, to widely diffuse their research and results in peer-reviewed journals worldwide as the end result of any scientific process. A larger diffusion of studies would allow others working in the same domain to benefit from successes and errors made elsewhere. Secondly, this would contribute to increase recognition of TEK value for scientists and practitioners, and hence break down misunderstandings and ignorance related to TEK. As Davis and Wagner (2003) have advocated, it is time to move beyond current preoccupations with regards to theoretical issues and general endorsements of the value of traditional ecological knowledge, and begin the search of processes to document traditional ecological knowledge that efficiently involves local communities, and finally, to diffuse these processes in published and accessible papers.

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